

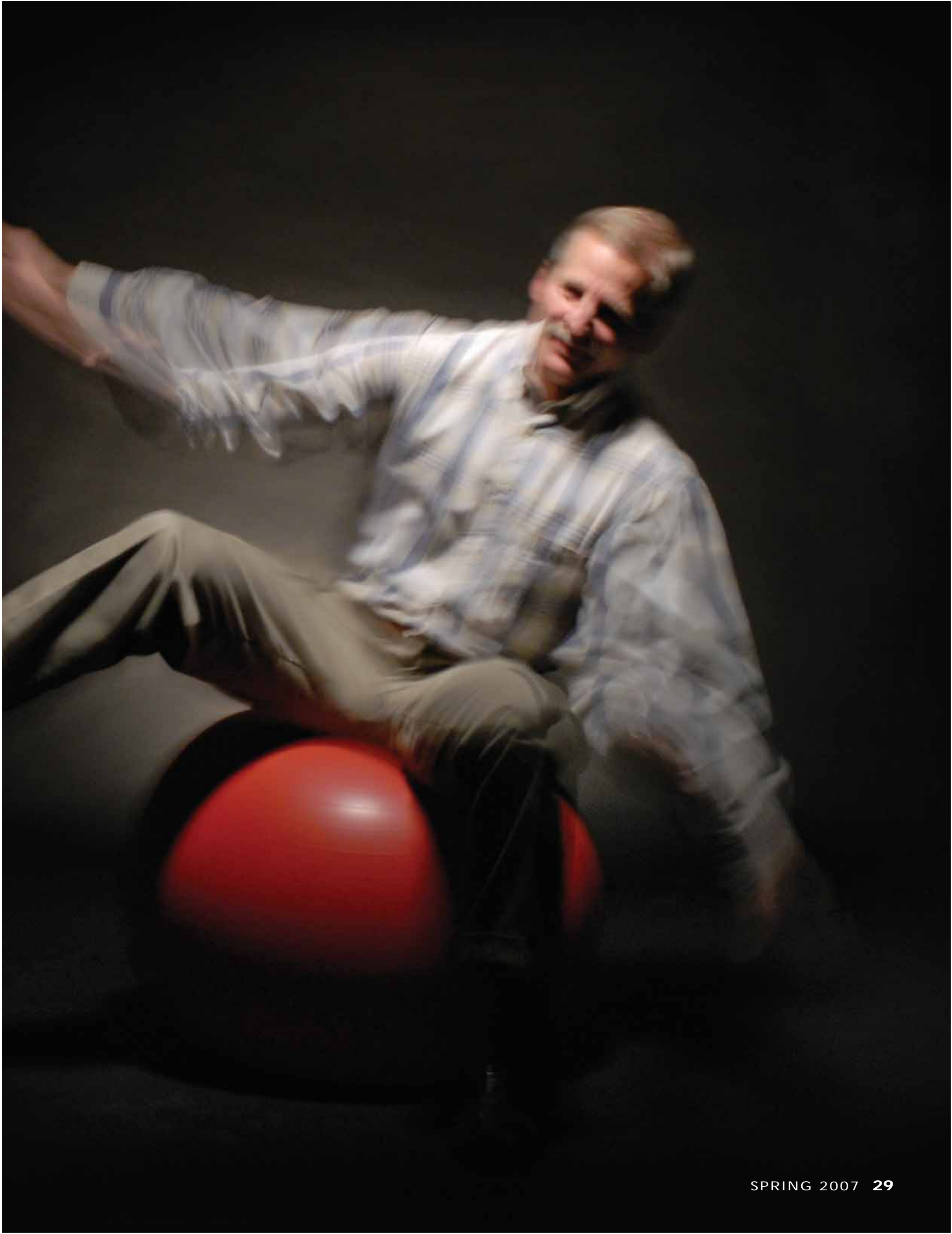
Balancing Act

*Shaken by the realities of
the business world and
the untimely death of
its creator a fledgling
UW Madison
spin off company
is finding balance.*

By Madeline Fisher PhD'98

Photos by Jeff Miller

On a frigid day in January 2000, Mitch Tyler's world began to tumble. After catching a cold from his eighteen-month-old son, Tyler had developed an ear infection so severe he'd temporarily lost his sense of balance. Now, as the bus he rode to work slid sideways on a patch of ice, he once again felt like he was falling. Objects spun in his vision as if inside a kaleidoscope, and he could no longer distinguish up from down. "You can't tell where your body is lying in space," Tyler says. "It's terrifying." Yet with that dizzying moment also came good fortune, for when Mitch Tyler's world began to tumble, it also began to come together. At the time, Tyler, a UW biomedical engineer, was also working for a small UW-Madison spin-off business called Wicab, founded by Paul Bach-y-Rita, a professor of orthopedics and rehabilitation medicine. Based on Bach-y-Rita's revolutionary idea that one sense could stand in place of another, Wicab (pronounced "wee-cob") was developing



technology that might allow blind people to see by feeling sensations on their tongues. As he made his way to Wicab's tiny rented space on the UW-Madison campus, still reeling from his bus trip, Tyler was suddenly seized by another possibility. A few moments later, he stopped by Bach-y-Rita's office.

"I said, 'Paul, I have this crazy idea,'" Tyler recalls. Bach-y-Rita, who had a penchant for wild notions, smiled and asked, "What?"

"What if the tongue display could represent something as simple as balance?" Tyler asked. "And Paul said, 'You know, I think you've got something there.'"

As someone who had made a career of pushing scientific boundaries, Bach-y-Rita had a knack for seeing into the future. His intuition, in this case, was right on. Today a treatment for balance disorders is the most immediate and practical manifestation of Wicab's unusual technology and the company's first product: the BrainPort balance device.

What Bach-y-Rita didn't anticipate, however, was the winding and uncertain path from Tyler's inspiration to the product's commercialization. Or that the company's growth would require him to put aside his deepest drive as a scientist: to continue exploring.

He also couldn't know that this would be one of the final journeys of his career. When Bach-y-Rita was diagnosed with cancer in 2004, he resolved that Wicab would transform from a research-focused enterprise into what he called a "real business." And before he died in November 2006, he saw it through.

If launching a business is a leap of faith, Paul Bach-y-Rita was well trained for the exercise, having spent most of his career diving off cliffs into unknown waters. Trained as a physician and neuroscientist, Bach-y-Rita was a full professor of visual sciences and physiology at the University of California-Davis when his father suffered a major stroke in the mid-1960s. After witnessing his father's remarkable recovery, he concluded that his knowledge of the brain and how it undergoes

change was incomplete. He soon left UC-Davis and vaulted into a clinical residency in rehabilitation medicine.

The move mystified his colleagues, but to Bach-y-Rita, the choice was clear. He believed rehab medicine would be more open to his ideas than the world of traditional neuroscience — and for that, he was prepared to gamble. "I guess I've always been willing to take a chance and do things that were not within the usual limits," he said in an interview shortly before his death.

Inspired by his father's experience, Bach-y-Rita began investigating the concept of a "plastic" brain, the then-revolutionary idea that the brain can reorganize its functions in response to learning or experience, even at an advanced age and after major damage. This radical notion soon led to Bach-y-Rita's first studies of sensory substitution. He hypothesized that, if deprived of one sense, the brain could learn how to use other senses to compensate for — or even replace — the lost sense. A blind person's brain, for example, could learn how to interpret nerve impulses as visual information even when they came through a completely different sense, such as touch.

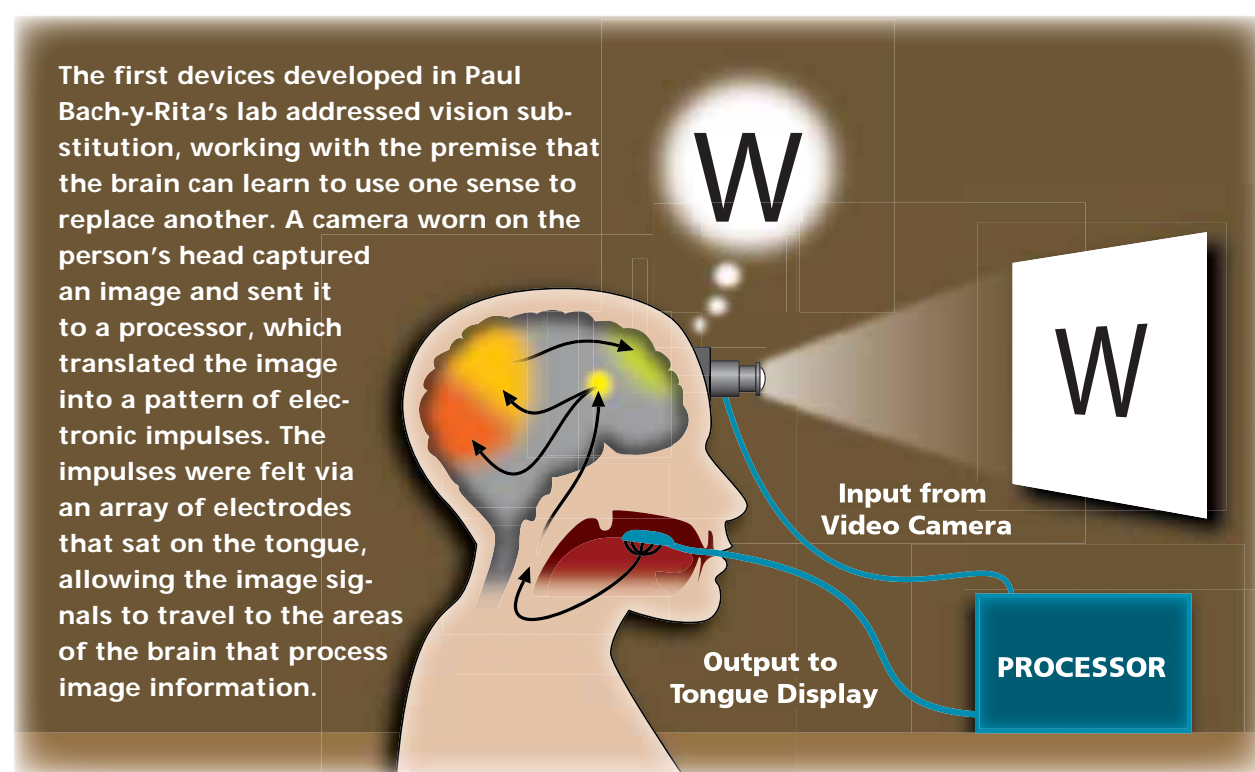
When he arrived at UW-Madison in 1983, Bach-y-Rita began experimenting in earnest with ways to send visual cues

to the brain by stimulating the tactile, or touch-sensitive, nerves of the skin, such as those on the abdomen or fingertip. In the late 1990s, he made another intuitive leap: why not use the tongue? After all, he reasoned, the tongue is much more sensitive to touch than any of the other body parts he'd tried. The saliva in the mouth would also make it much easier to transmit electrical impulses.

Armed with this idea and the sophisticated electronics that had become available, Bach-y-Rita and an engineer/scientist named Kurt Kaczmarek devised a crude "tongue display," a mat made up of 144 electrodes that sat on a person's tongue. When hooked to a camera, the mat converted images into patterns of electrical stimulation, allowing someone to "see" objects by sensing the patterns on his or her tongue. Wearing the tongue display, blind people were able to perceive objects such as a flickering candle or a rolling ball.

The tongue display's potential was enough to convince the Wisconsin Alumni Research Foundation, the university's patenting and licensing organization, to apply for a patent in early 1998. But WARF thought the chances of licensing the far-out technology to an established firm were remote. Officials there presented Bach-y-Rita with the

WORKING WITH THE 'PLASTIC' BRAIN



possibility of commercializing it himself.

Intrigued, Bach-y-Rita invited his other main collaborator, Mitch Tyler, to lunch. By meal's end, they had agreed, almost casually, to launch a company. In honor of his wife, Esther, Bach-y-Rita named it Wicab, her family name, which means "lover of honey" in Mayan.



ANDY MANIS (2)

Whether to launch a company is a question university scientists ponder frequently these days, as more and more of them choose to protect their discoveries through patents. Faculty inventions are often too far ahead of existing markets to be of interest to established companies, and so, for many professors, starting a business may be their best chance of seeing their idea manifest in the world. Many states, including Wisconsin, also hope to entice professors into launching businesses as a means to create high-tech jobs and boost local economies.

To assist faculty members in taking the plunge, WARF waives the licensing fee it normally charges companies to use its intellectual property commercially and takes equity in university spin-offs instead. Since 1994, the foundation has helped forty such businesses get under way, more than 85 percent of which are still operating.

But even with help, running a company is an extremely time-consuming endeavor. Why would a professor with an already demanding slate of administrative, teaching, and research obligations want to take it on? More often than not, it isn't strictly about money, says business professor Anne Miner, who has both studied and acted as an informal adviser to faculty entrepreneurs. Some professors use a business start-up as an applied arm of their campus research programs. Others, at the top of their careers academically, are simply looking for a new challenge.

Then there are those who hope to do a social good. Miner believes Bach-y-Rita fell into this last group. "My sense is that he really wanted to help the world *a lot*," she says.



The team working with Paul Bach-y-Rita, shown above right, first tested the balance device with Cheryl Schiltz, whose body lost its natural balance following an illness. The treatment allowed her — for the first time in three years — to resume a normal life.

In its infancy, Wicab was fueled almost solely by that optimistic spirit. Housed on campus and funded through grants, the company bore a strong likeness to the research program from which it emerged. Ideas flew around the room, recalls Kaczmarek, and although the researchers were careful to distinguish their company and university activities, they reveled in the exchange.

"One minute I might be working on my NIH grant and the next minute I might be talking with Mitch about a better stimulus

protocol for the tongue," he says. Lunches at a small conference table often blossomed into two-hour scientific discussions. And then there was Bach-y-Rita, constantly stirring the pot with his wild ideas.

"It was, as is the case with a lot of small start-ups, a one-big-happy-family kind of scenario," Kaczmarek says. "It was really a glorious time."

In the summer of 2000, Wicab hired Yuri Danilov, a neurophysiologist with vast knowledge of the nervous system, who helped the team envision all kinds of applications for its nascent technology. The scientists began mapping a "star chart" of all the possible uses. Nearest and most obvious were "first order" stars, such as a system to augment hearing, vision substitution for the blind, and an assistive device to help people with damage to the vestibular system, a region of the inner ear critical to balance. From these core applications, the group traced logical paths to scores of more distant possibilities, such as treatments for Parkinson's disease or for children with sensory-motor integration disorders. Eventually, the star chart held more than 170 applications scribbled on several taped-together pages.

Among all the stars, the scientists believed two shone the brightest: vision and, thanks to Mitch Tyler's timely illness, balance. In the lab, they built and tested prototypes for each application. To make the balance device, Tyler purchased a green plastic hard hat and attached a miniature accelerometer, which relayed information through a computer to the tongue display's electrodes. Someone wearing the helmet and standing upright would feel a buzz at the center of his or her tongue. But if the individual swayed, the accelerometer sensed the deviation and sent an error signal, causing the sensation to move left, right, backward, or forward, depending on the direction of the tilt. The person's task was to move in space until the signal became centered again.

"It's like having someone place a finger on top of your head to indicate you're upright," says Tyler. "If you tip your head, you feel the finger slide off to one side, and you naturally move your head back to com-

pensate. It's a very simple concept. You're just correcting for a deviation in your position relative to a marker."

It's easy to imagine this involves concentrating on the signal's location and figuring out how to shift in response. But after a training period of just a couple of minutes, the body reacts to the stimulus without conscious thought. "Once the concept is in place that the stimulation on the tongue means something about your orientation in space, the beauty of it is that it *is* very intuitive," says Tyler. "It very quickly goes from being a conscious process to being subconscious."

When the prototype was finished, Bach-y-Rita went looking for a test subject. From a doctor friend, he learned of a patient named Cheryl Schiltz, who in late 1997 had suffered permanent damage to her vestibular system due to a rare reaction to an antibiotic. For three years, Schiltz had been living in a world seemingly made of Jell-O. Her body's natural balance destroyed, she wobbled with every step, and everything in view jiggled and tilted. She wasn't able to continue working, and even simple tasks such as baking cookies became an ordeal. Worst of all was the sense of isolation.

"You feel like you don't know where you are in space," says Schiltz. "There's not a sense of belonging in your area, in your environment. It's like you're separated somehow."

Schiltz was skeptical when Bach-y-Rita explained how Wicab's device might help restore her world. "My first reaction was, 'I'm going to put something on my tongue and I'm going to get my balance back? Okay ...'" she remembers. "Well, what have I got to lose?"

Leaning on a cane, she walked into Wicab's office in fall 2001 to begin tests with Tyler and Danilov. With the green helmet on her head and the tongue display in her mouth, Schiltz sat and then stood, eyes closed, for trials of one hundred, two hundred, and three hundred seconds. And for the first time in years, she did not sway. With the electrical pulses on her tongue substituting for the signal the brain normally gets from the inner ear, Schiltz kept her balance. It was an amazing result — yet not the most amazing one.

After one of the trials, Danilov removed the device from Schiltz's mouth to see if she could remain still without it. "Don't ask me why," he says, "because it was completely out of protocol." Schiltz indeed kept her balance for a short time, prompting Danilov and Tyler to launch a new set of investigations. Experimenting with different time periods, they found Schiltz was able to retain her balance for about one-third of the time she wore the helmet. After one hundred seconds, she held steady for thirty seconds before beginning to shake. After five minutes, the effect lasted nearly two minutes.

Then one day a visiting colleague asked what would happen if they went beyond five minutes. "That's when we got the breakthrough," says Tyler. After using the device for twenty minutes, Schiltz opened her eyes and tilted her head. "I looked at Mitch and I said, 'Something's different,'" she recalls.

Something was. Schiltz kept her balance for an hour that day. When she realized what was happening, she hugged Danilov and Tyler and burst into tears. "I literally ran around like a crazy lady," she says. "I felt like I was healed."

Subsequent trials with Schiltz and other patients proved twenty minutes to be the ideal "training" time. People enrolled now in Wicab's formal clinical trials train with the BrainPort device for twenty minutes in the morning and afternoon. If the device works as Wicab believes it will, they should be able to maintain their balance for the rest of the day.

The results "blew the doors off all of our expectations," says Tyler. "We never in our wildest dreams imagined we'd have this carryover effect that would be so sustaining."

Moreover, Schiltz has found that after years of training with BrainPort, retention can stretch not simply over hours, but over weeks and months. She has gone for up to four months, in fact, without using the device at all.

EVOLUTION OF AN IDEA

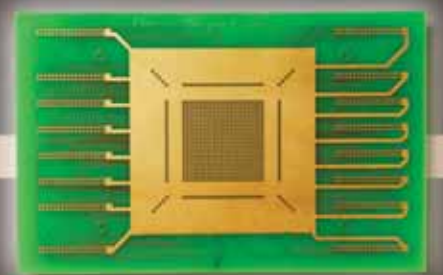
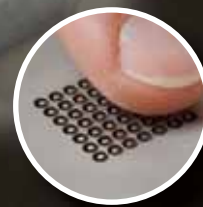
While exploring the concept that the brain can learn to use one sense to replace another, Paul Bach-y-Rita first tested the idea that stimulating the nerves of the skin could send visual cues to the brain. In time, he and his team switched from the finger to the tongue and, as they began to consider commercialization, from vision to balance problems. With each stage of their prototype devices — coupled with the decision to form a spin-off company — came more sophistication and marketability.



The first prototype tactile display with mechanical stimulators (inset) was developed for Bach-y-Rita's lab circa 1986.



By circa 1995, the device evolved into an electro-tactile array for the finger.



Working with the concept that stimulating tactile nerves in the finger could send visual cues to the brain, the team developed a more sophisticated prototype circa 1999.

One day, Schiltz handed Danilov her cane. “I said, ‘You take it. I don’t want it anymore,’” she recalls with a hearty laugh. Today it hangs on the wall of Danilov’s office.



Despite the progress of its scientific studies, by spring 2003 Wicab was still far from being a commercial enterprise that could deliver a product to market. The company continued to live in Bach-y-Rita’s seventeen-by-seventeen-foot campus lab, where an imaginary line separated his university research from his business venture. The scientists were similarly divided. As Wicab’s CEO, Bach-y-Rita still carried his full load of professorial duties. Kaczmarek acted as a consultant to the company while also conducting his own research. And Tyler valiantly tried to keep a hand in the science, even as he was pulled deeper and deeper into daily business imperatives such as payroll, insurance, and taxes.

The company’s attention also was split between its balance and vision applications. Wicab had received a pair of small-business grants totaling \$1.7 million to bring each of the technologies closer to commercialization, and Tyler was both thrilled and daunted by the work ahead.

“I had done a good job, but it was all-consuming,” he says. “At a certain point,

you realize that in order to really push this thing forward, you need to bring in people who understand how the business world operates, how to organize the business in a way that’s ultimately going to be profitable. We as scientists and engineers — we didn’t have the skill set to do that.”

At Tyler’s request, Bach-y-Rita began searching for professional management. A couple of interim CEOs came and went. And then, troubled by a persistent cough, Bach-y-Rita went to the hospital in early 2004.

“I went into the emergency room thinking I had bronchitis and came out with a diagnosis of stage IV lung cancer,” he said. “That was ... that was shocking.”

At the time, Bach-y-Rita was given only a few months to live. The prognosis sent the dynamic scientist into a frenzy of sorts, says his wife, Esther. “His first reaction was, ‘I have too many things I still want to do,’” she says. “And Wicab was one of the big enterprises.”

“I decided that one of the things I wanted to do with the months left to me was to make Wicab into a real business,” said Bach-y-Rita, “for the science, but also for my family.”

To help him do that, Bach-y-Rita turned to Bob Beckman, a veteran businessman with a history of making early-stage companies successful. As vice president of finance at Madison’s Lunar Corporation, Beckman had played a

pivotal role in guiding the early-stage medical device company, and its spin-off, Bone Care International, both of which were bought by larger firms. Seeking a new opportunity, he took a suggestion from WARF managing director Carl Gulbrandsen and attended a couple of Wicab company meetings. Quickly he perceived what the star-gazing scientists could not: if Wicab focused exclusively on the balance device, it could bring a product to market in the very near term.

He also realized the market was substantial. Although exactly how many people suffer from chronic balance disorders is unknown, Wicab estimates that one million Americans could benefit from BrainPort — and many more internationally. Moreover, the lack of therapies for patients with severe balance problems means Wicab isn’t confronting the same head-to-head competition faced by most fledgling medical device companies.

To Beckman, the numbers all added up to one thing — a chance to make a difference. “That was very, very intriguing to me,” he says, “because it meant that, if successful, the company would provide a benefit to people who had nowhere else to turn.”

In December 2004, Beckman joined Wicab as CEO, while Bach-y-Rita became the company’s chairman of the board. Sweeping changes took place immediately.

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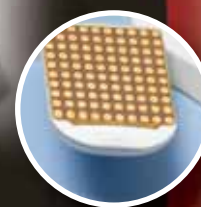
In 1999, the researchers built a “tongue display unit” with a stimulation system (inset) that would sit on the tongue.



In fall 2001, as the researchers began focusing on balance, they used a helmet fitted with electronic tilt sensors that worked with the tongue display system.



The final steps were a major leap: to a small box that hung around the neck (above) and BrainPort, the to-market device.



Balancing Act

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The group's free-flowing, hours-long discussions became succinct business meetings. Beckman began to pursue venture capital from outside investors. He also started bringing in an entirely new team with experience in product development, FDA regulations, and clinical trials. With their roles at Wicab dwindling, Kaczmarek and Tyler eventually returned to the university and to basic research, their first love.

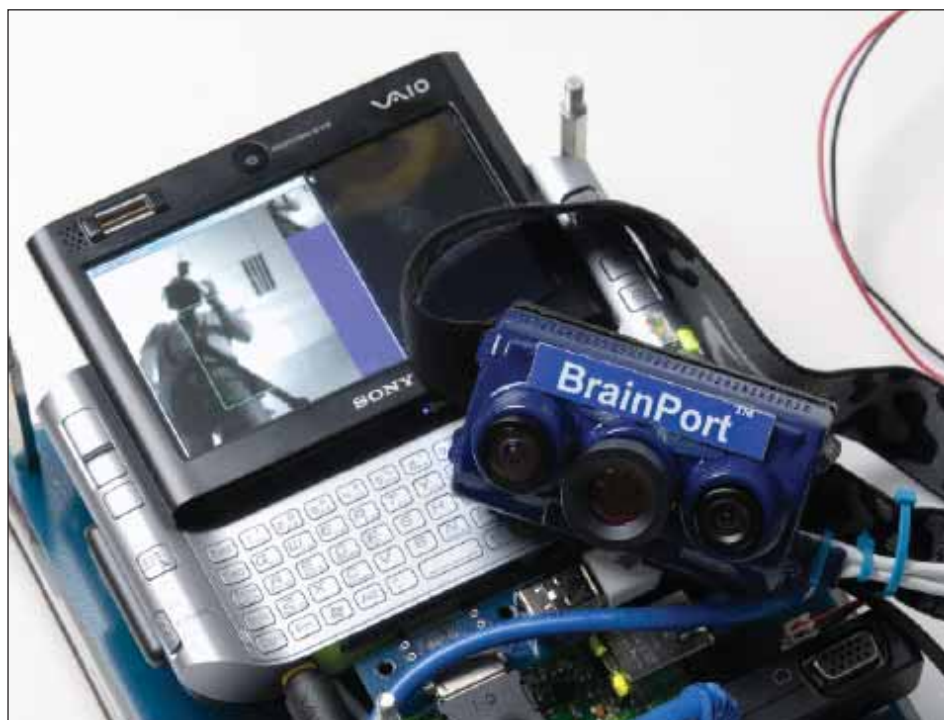
The star chart made its exit, too. "Bob told me, 'You have a lot of good ideas, each of which could be a product,'" said Bach-y-Rita, "but we have to concentrate on one."

Beckman determined that the company would suspend work on the vision technology, which at first was tough news for Bach-y-Rita to take. Since the earliest days of his research, vision substitution had always interested him the most.

Yet personal circumstance would soon lead him to see things differently. During summer 2005, Bach-y-Rita began having difficulty standing up, and he suffered a couple of falls. At first, the family thought his aggressive cancer therapy had simply weakened him, Esther says. But then another possibility dawned on them. Since one of his cancer drugs was known to damage the inner ear, perhaps his vestibular system had been harmed. A training session with the balance device was soon arranged.

"It just seemed obvious to all of us, including Paul, that this was something he should try," says Tyler.

Schiltz, who had moved from being Wicab's head test subject to its first clinical coordinator, was there to help Bach-y-Rita during an early session. As he stood with the device in his mouth, the man Schiltz considers her hero wobbled so much that she hovered behind him, hands out, to catch him should he fall. Eventually she felt comfortable enough to sit behind Bach-y-Rita in a chair.



With its balance device, BrainPort, now on the market, Wicab is resuming research on vision substitution. Scientists are developing new prototypes that could help the brain work its magic by translating touch into sight.

Twenty minutes later, Bach-y-Rita had recovered his balance in just the same manner as she had years earlier. Witnessing it, Schiltz began to sob.

"What he had done for me, now I was doing for him," she says. "How much more full circle can you get?"



The commercial version of Wicab's BrainPort balance device is now as modern and pleasing to the eye as the company's new home in Middleton, Wisconsin. Gone is the green helmet; the accelerometer it carried has moved inside the mouthpiece. Gone, too, are the computer and bulky metal box to which early prototypes had to be connected. With a miniaturized circuit board about one-third its original size, BrainPort has shrunk to the size of a video cartridge and hangs comfortably around the neck.

With sales of the balance device under way, research has resumed on vision substitution. Just as her predecessors did in earlier years, an energetic young scientist named Aimee Arnoldussen brings blind subjects into Wicab's offices, her work supported by a grant obtained by Bach-y-Rita.

Studies of the balance device also continue. Having stayed with Wicab through the transition, today Danilov

spends much of his time searching for clinical collaborators willing to try BrainPort with their patients. More than one hundred people have now used it, including those suffering from conditions such as Parkinson's, multiple sclerosis, and stroke. Danilov says he has yet to hear of a patient who hasn't experienced some change — whether dramatic or slight — after training with BrainPort.

One monumental question remains. "There's still a great mystery as to how it's achieving its change in the brain," says Tyler. "Clearly it's augmenting brain function in these people's

nervous systems — the sensory-motor integration process. But we don't quite know why or how."

Given his expertise with the nervous system, Danilov seems particularly overwhelmed by the enormity of the questions. If he had a thousand scientists at his disposal, he claims, he could put them immediately to work on two thousand BrainPort-related projects. "Scientifically," he says, "it's like the Klondike or Alaska."

"The future is just phenomenal — what else can we discover with this?" says Tyler. "Paul has given us a great gift, a great vision. And now we get to run with it. That's his legacy."

But no one felt the weight of the implications more than Bach-y-Rita. After his pioneering studies of brain plasticity and sensory substitution, he waited thirty years for technology to catch up to his vision. Even more time would pass before his "crazy ideas" gained acceptance in mainstream medical science. With BrainPort now opening up a wealth of additional possibilities, Bach-y-Rita would have loved nothing more than to chase them all himself. ✍

Madeline Fisher PhD'98 has made a leap of her own — from bench scientist to science writer. She now reports on UW-Madison research for University Communications.