BRAZIL AND ARGENTINA: TURNING THINGS AROUND

SPECIAL DOUBLE ISSUE

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Inventions

That Will Change the World

10 Remarkable Ideas That Prove Creativity Is Alive and Well

INCLUDING

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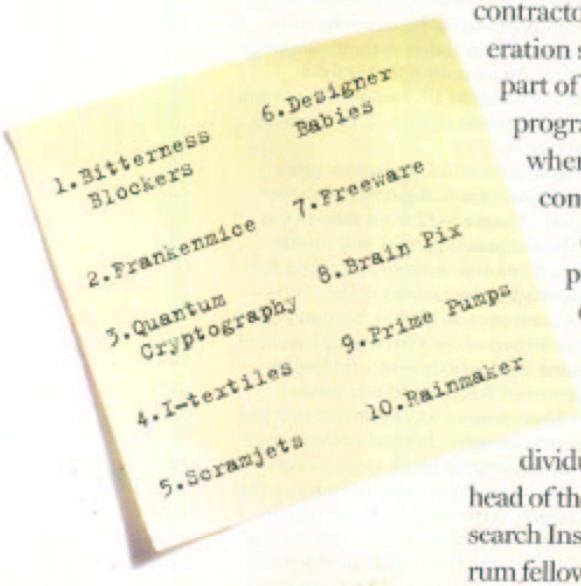
10 Inventions

(that will change your world)

Space exploration is the ultimate megaproject. Idled space shuttles sit in their hangars in Florida like pampered royalty, with white-coated technicians in attendance. The collaboration extends to engineers, contractors and nations. Is all this cooperation such a grand thing? Or is it part of what's wrong with the space program: as sign of what happens when innovation is merely the outcome of meetings?



Some say progress is now the province of groups, and the days of the lone inventor are over. Maybe so. But inventors will never disappear. "The initial flash of an idea is often an individual idea," says Francis S. Collins, head of the National Human Genome Research Institute and World Economic Forum fellow. "So brilliant, creative people are crucial." Since the dot-com bust, such types have continued to ply their craft in labs and basements, producing ideas that seem obscure, even loopy, until a closer look reveals their world-shifting import. Here are 10 such individual visions that may change our collective future. ■

ILLUSTRATION BY MARK BUENOS, PHOTOGRAPH BY DAVID H. DEROSITZ FOR NEWSWEEK

Head Shots

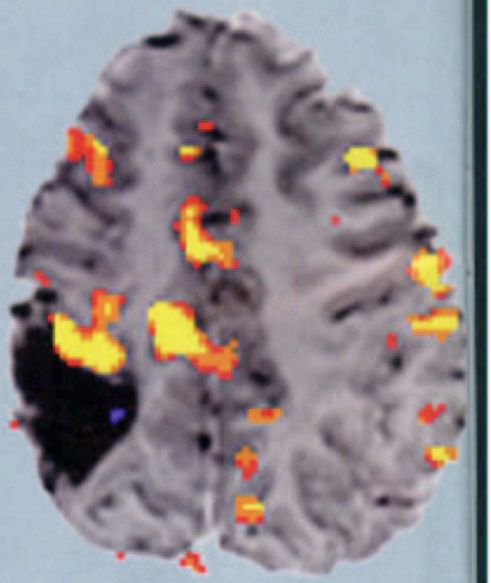
Imaging technology shows what happens when liars lie and patients feel sad

By Carl Zimmer

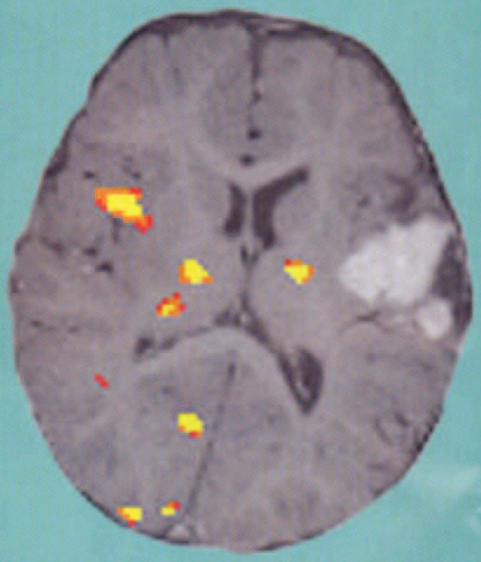
It started as an odd feeling of déjà vu. Over a few weeks, the sensation grew more and more intense, until finally John (not his real name) had trouble concentrating on teaching his grade-school class. Then he started having seizures. His doctors traced the trouble to a tumor in his brain's left frontal lobe. The best option, they thought, was to remove the tumor surgically, and then—just to make sure there were no stray cancer cells—cut away some of the surrounding tissue. The question, though, was how much tissue could they safely remove? No two brains are organized identically—losing one slice of the brain might have no effect on one patient but paralyze the next. Probing John's brain with electrodes might have offered some crude clues, but it would have entailed removing the top of his skull.

The dilemma came to the attention of Joy Hirsch. She's the director of a new brain-imaging laboratory affiliated with Columbia University in New York that is trying to take brain imaging to a new level. She had John put his head in an MRI scanner and run through a series of exercises. He looked at pictures and thought of names. He looked at words and thought of synonyms. He wiggled his fingers. As each task demanded work from his brain, the scanner registered a slight increase in the flow of blood to the active tissue. Hirsch's software crunched through the data and produced exquisitely detailed, rainbow-colored pictures of Smith's brain, which Hirsch spread out on a table. The pictures capture Smith's brain in midthought. They show to within a cubic millimeter—about the size of a peppercorn—where these active regions of the brain are in relation to the tumor. "This is a nice case, as clear as it can be," she says, and marks a rainbow blob with a Post-it note. "They can operate without risk."

The technique of functional neuroimaging has revealed a great deal in recent years about the human brain in general, but little about what patients like John really care about: their own gray matter. Hirsch and her colleagues are pushing to capture the brain's

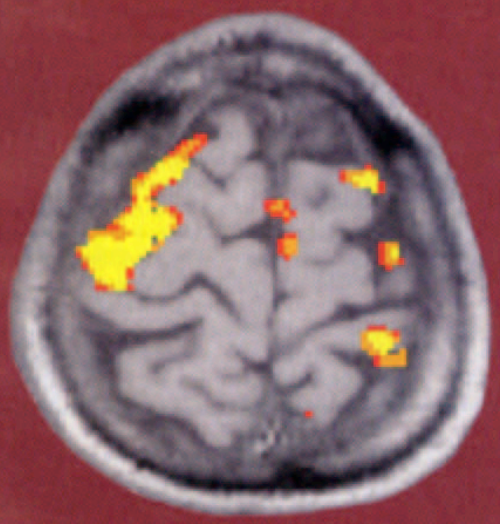


A 16-year-old boy had a stroke in his sensory-information cortex—the small black spots at the top of the large black area

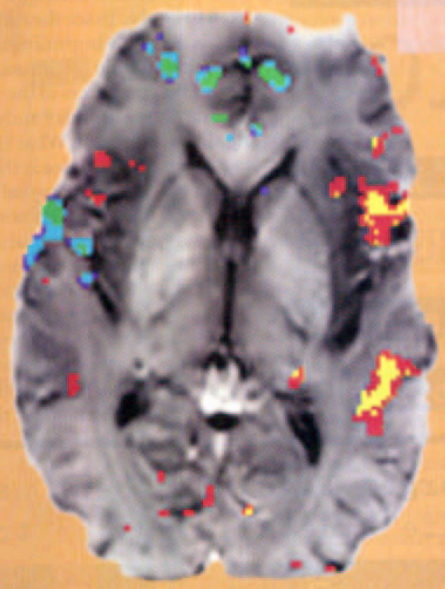


A 15-month-old baby, sedated, hears her mother's recorded voice. A tumor (white) is far from language areas.

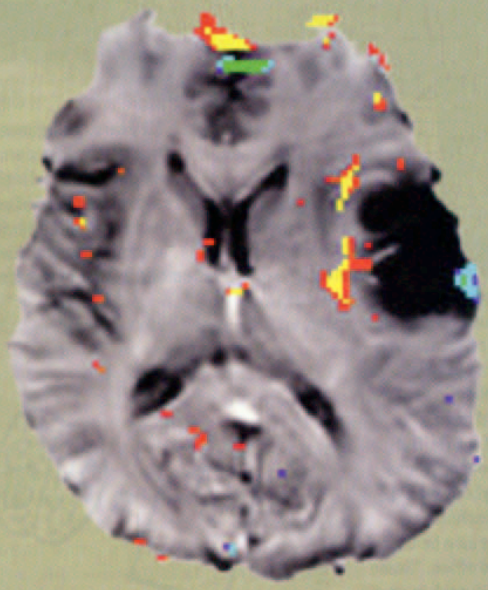
COURTESY OF JOY HIRSCH, PH.D.—DEPT OF RADIOLOGY, CENTER FOR NEUROBIOLOGY AND BEHAVIOR, COLUMBIA UNIVERSITY (6)



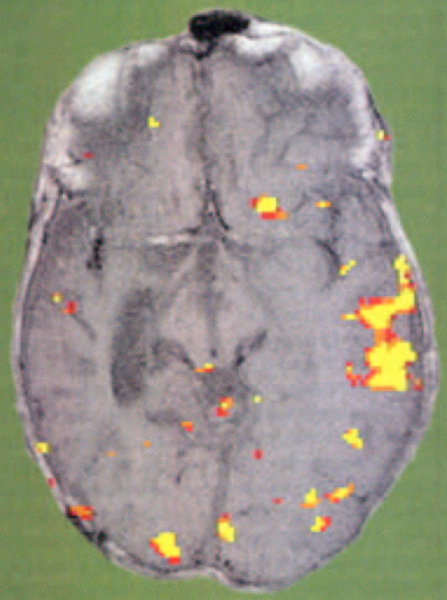
When a patient suffering from chronic pain took medication, brain activity slowed in the area marked by the big yellow splotch



A patient with seizures was asked to name pictures of common objects. Active areas (red and yellow) are language centers.



An Italian woman, 44, living in the States, developed a tumor (black) near her two language areas (yellow-red spots)



When the sister of a 22-year-old comatose patient speaks, the patient's language centers (red and yellow, right) flare up

There are 100 billion NEURONS in a human brain

activity the instant a thought occurs, and in enough detail to be able to see the tiniest of structures. Their work is only now beginning to save surgical patients from paralysis and blindness, but there's more to come. Like computers in the 1960s, brain scanners these days are big, bulky and expensive—and not really all that powerful. What Hirsch and her colleagues would like to see is the brain-scanning equivalent of the Apple II personal computer. In 10 years brain scans may be a common diagnostic tool. Psychiatrists may use them to analyze mental illnesses and identify potential criminals. Police may use them to determine if a suspect is lying.

Brain scientists have come a long way since the early-19th century, when they had to wait until patients died so they could dissect their heads. French physician Pierre Broca used this method on brain-injured people who had lost the ability to speak; they all suffered damage, he discovered, to a patch of tissue along the left side, known now as Broca's area. A century later, scientists began injecting living patients with radioactive chemicals that flagged active portions of the brain—a technique called positron emission tomography, or PET. Because the chemicals took 20 minutes or so to make their way up through arteries in the neck to the brain, PET could only give scientists a blurry picture. "It was awful," says Hirsch, "but it was all there was."

Magnetic resonance imaging, invented at about the same time as PET, was potentially a whole lot faster, largely because it uses a different kind of physics. In MRI, a powerful magnetic field makes some of the atoms in the brain line up like little compass needles. When you wobble the magnetic field slightly, the atoms wobble, too, giving off signals, which can reveal detailed pictures of the

Forget PDAs. The best way to remember life's details may be to record them all.

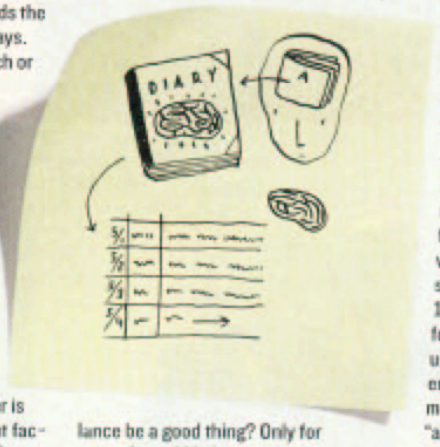
Truly Total Recall

By Anna Kuchment

In 1885 German philosopher Hermann Ebbinghaus showed that two thirds of what we learn vanishes from our brains within an hour. That disheartening "forgetting curve" is the reason we paper our computer screens with Post-it notes, mumble mental shopping lists like mantras and consult our PDAs at every opportunity. Sunil Vemuri, a graduate student at the Massachusetts Institute of Technology's Media Lab, is hoping to fill in the holes left by our sometimes fickle minds. How? "Our focus," he says, "is on audio recording everything in our lives."

Vemuri has spent much of the last year and a half strapped to a microphone and PDA, which picks up every word he utters to friends, colleagues and family and beams the information wirelessly to a server. Voice-recognition software converts the spoken word into text and delivers it to his laptop, where it is cataloged along with hourly weather reports, screen grabs, Internet news sites, his e-mail, every item on his daily calendar and—via a Global Positioning System chip in his PDA—his whereabouts in the lab building. Later, when Vemuri is trying to remember something, he finds the passage in any number of ways. He might do a keyword search or look up a particular date.

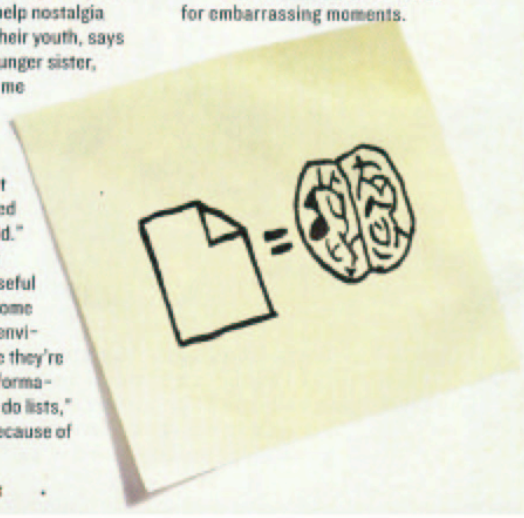
One of Vemuri's goals is figuring out how best to manage all that data. If you're trying to recall what your wife said in a conversation, are you more likely to remember that you talked while walking through Central Park, that it was 50 degrees and partly cloudy, or that you had stopped to buy coffee beforehand? (So far, weather is proving to be a less important factor than location and timing.)



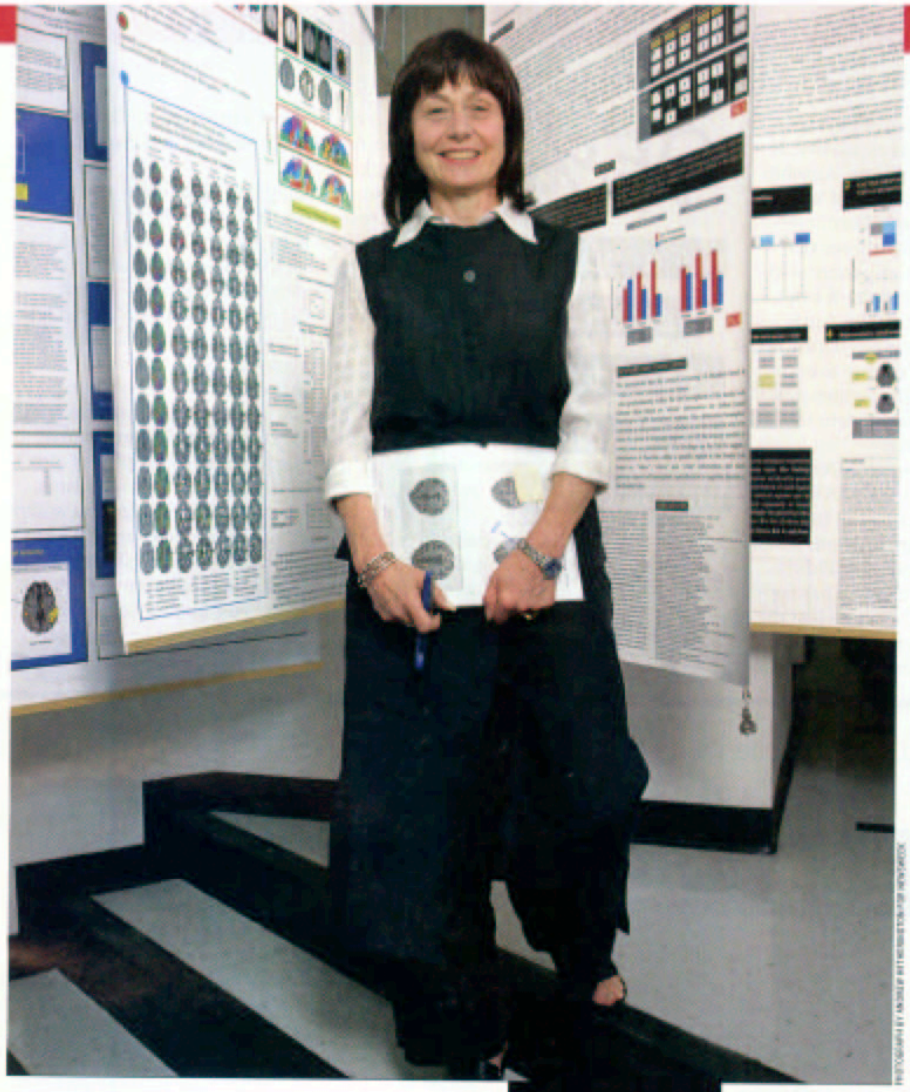
He's also trying to assess the level of social acceptance for audio recording: are we ready to have people walking around taping every moment of their lives—and ours? We may soon be. As security cameras proliferate, people are growing accustomed to constant video surveillance. In the United States, police departments are already experimenting with neighborhoodwide sound pickups that can transmit audio back to headquarters, which could be useful, say, for pinpointing the location of gunfire.

Would constant audio surveillance be a good thing? Only for some. It could help nostalgia seekers relive their youth, says Vemuri. "My younger sister, who often asks me about our childhood, would have a blast with it. But I'm not convinced everybody would." The technology might also be useful at the office. "Some people work in environments where they're given a lot of information, a lot of to-do lists," he says. "But because of the hectic nature of their jobs, they have an inability to write down notes in a timely fashion. A memory prosthesis would allow them to record it and then, later on, have the ability to retrieve it."

Vemuri hopes his memory prosthesis will one day be a wristwatch-size device. But first, there are plenty of kinks to overcome: voice-recognition software now garbles about 90 percent of what he says, batteries last only two hours and memory chips hold only a fraction of the data he would like to eventually store on them. It will be 10 years, he figures, before technology catches up to his vision. Until then, enjoy the upside of your memory's fallibility: that "automatic erase" function for embarrassing moments.



FROM TOP: ILLUSTRATIONS OF KNICKERBOCKER (2), PHOTOGRAPH BY DAVID B. GERSHWITZ FOR NEWSWEEK, ILLUSTRATION BY MARK BROWN



PHOTOGRAPH BY ANGELO BERTOLDI/STAFF NEWSWEEK

BRAIN STUDENT: Joy Hirsch hopes that brain imaging will reveal the 'qualities that make us human'

brain's rough anatomy. But anatomy isn't the same thing as capturing thought in action. When Bell Labs engineer Seiji Ogawa discovered in 1992 that MRI could be tuned to pick up the firing of neurons—the basic mechanism of thinking—Hirsch appreciated the significance. "I thought, 'My God, that's going to change the course of neuroimaging forever'," she says. MRI could now pinpoint the parts of the brain that became active for any given kind of thought, and it could do so relatively quickly, without any radioactive injections. The technology, though, was still not fast enough, and it was crude—which is why scientists needed to average their results over many different brain images.

To catch an individual's brain in midthought, Hirsch invented statistical tools that let her pick out the busy neurons and ignore the brain's ordinary background noise. Then she incorporated these techniques into software that interprets the MRI data. Working with neurosurgeons at Memorial Sloan-Kettering Cancer Center in the mid-1990s, she began to map the brains of surgical patients who had been told their tumors were inoperable. At Columbia, Hirsch has even more powerful equipment that is helping her push MRI technology further. She's using a roomful of supercomputers ("It's never enough," she says with a smile) to uncover heretofore hidden links between different brain regions. She's also combining MRI scans, which tell you where brain activity is taking place, with data taken from electrodes placed on the patient's scalp, which can discern brain events as brief as a thousandth of a second.

One of Hirsch's immediate goals is to help surgeons with more ambitious brain operations. Epilepsy, for example, is often caused by a tiny clump of misbehaving neurons, which are currently impossible to track without opening up a patient's skull. Hirsch, though, recently succeeded in watching the birth of a seizure with her scanner. "Knowing where seizures start is key information," she says. If surgeons could pinpoint rogue neurons, they might be able to destroy them while sparing the surrounding brain.

A bigger ambition is, as she puts it, to uncover "those qualities that actually make us human." Each action or thought—from speaking to feeling in love or adding numbers—brings into play a distinct constellation of brain regions. These networks, scientists have found, are pretty much the same from one person to another, but observing them requires analyzing individual patients as they perform for scientists. By scanning people while they speak, Hirsch has mapped the brain network that generates language. One of the nodes, not surprisingly, is located in Broca's area. When Hirsch scanned people speaking a second language, she found that they use an identical network—except for one crucial node in Broca's area that shifts a few millimeters away. "Somehow the network is switching back and forth between those areas when calling upon those language skills," she says.

Understanding these networks promises to put psychiatry on a new footing. Depression, for example, may come from a defect somewhere in the network that attaches emotional values to specific experiences. If scientists can zero in on the damaged nodes, they may be able to help find more effective medications. "We don't have a well-thought-out rhyme or reason for why we use a drug for particular conditions," says Hirsch. "Doctors and patients have to go through a long trial-and-error process before they find a drug that works for them." Scanning people's brains may make the process less random.

If Hirsch and others can make neuroimaging simultaneously more powerful and less expensive, it stands to become a bigger part of our lives. Antonio Damasio, head of neurology at University of Iowa Medical School and a World Economic Forum fellow, thinks it might lead to neural prostheses that compensate for damage to the brain. A patient with an injury to the motor centers of the brain, for instance, may get an implant that directs the movement in his muscles and limbs. "It sounds a little bit like science fiction," he says, "but it's going to come to pass fairly rapidly." Neuroscientists are also pinpointing brain regions that are most active in those who score highly on intelligence tests.

Will we judge the prospects of our children some day with a brain scan instead of the SATs? Should we peer into the brains of fetuses in the womb? Will criminal witnesses be given brain scans to determine if their testimony is truthful? This is not cyberpunk fantasy. Hirsch's own group has figured out how to spot a lying brain. "Lying is just the same as telling the truth, except it's harder," she says. In certain regions of a lying brain, neurons fire more than in the brain of a truth teller. The pattern is so obvious on Hirsch's pictures that even an untrained eye can see it.

95% of a human brain's structure is formed before the AGE OF 6

Defense lawyers may find brain scans just as attractive as prosecutors. It is one thing to say that your client can't be held responsible for his actions; it's another to point to a brain scan that shows a defect in the way he controls his emotions. Hirsch can't say whether this will come to pass. "But in science, could we reliably predict people that were at risk for aggressive behavior? Yes, I believe so," she says. "If we have to make decisions about therapy, that would be information that might guide us. I think of this more in terms of taking preventative action." Neuroimaging might keep people out of jail by helping them before they even commit a crime.

Hirsch knows she's moving into dangerous waters here. "It is an omen of the future," she says. "We are going to think of our qualities as humans—our social being, our inner selves—more in terms of our physiology." It will then be up to us, not the neuroscientists, to figure out what those pretty pictures mean for our souls. ■