NEWS

An Enterprising Approach To Brain Science

Mobile computing pioneer Jeff Hawkins has had a lifelong fascination with brains. Now he's trying to model the human cerebral cortex—and he's created a software company based on his ideas

BOLD IDEAS COME NATURALLY TO JEFF Hawkins. In California's Silicon Valley, Hawkins is well-known as the inventor of the PalmPilot, the first commercially successful handheld computer, and the Treo smartphone. These devices are rarely out of arm's reach for millions of businesspeople, who rely on them to keep track of power lunches and peek at e-mail during meetings. Hawkins, at age 49, could easily retire. Instead, he's on a mission to figure out the brain.

Hawkins has spent a remarkable amount of time thinking about brains, at least for someone who launched a billion-dollar business and values time with his family. Over the past 20 years, he's spent countless hours poring over research papers, sitting in on neuroscience conferences, and hashing out ideas with academic scientists. "Even at Palm, I had an agreement that I could work part-time on brain research," he says. "It was in my contract."

Hawkins's foray into neuroscience is characterized by the same determination and just-do-it attitude that made him a successful entrepreneur. In the past 4 years, he has founded a small neuroscience institute, published a book outlining his theory on the nature of human intelligence, and founded a start-up company to develop computers that work on the same principles. His aggressive approach disconcerts some scientists, who are used to measuring progress one peer-reviewed paper at a time. Yet several prominent neuroscientists say his ideas on the brain are worth taking seriously, and even skeptics say his enthusiasm and entrepreneurial attitude have enlivened the field.

"Jeff is a very interesting and dynamic person," says Michael Merzenich, a neuroscientist at the University of California (UC), San Francisco, who has talked brains with Hawkins over the past 10 years. "He's one of the dozen or so smartest people I've met in my life." Hawkins brings incredible focus and an entrepreneur's sense of urgency to his endeavors, adds Anthony Bell, a theoretical neuroscientist at UC Berkeley who has worked with Hawkins. "He wants a computer program that works like the cortex, and he wants it now," Bell says. "He wants the brain in silicon."

Academic frustration, corporate success

Hawkins may have acquired the impulse for innovation from his father, a consummate inventor whose creations included a 16-sided,

Mobile man. After designing hand-held computers and smartphones for 15 years, Jeff Hawkins is on a quest to understand the brain.

50-ton boat that floated on a cushion of air generated by a vacuum cleaner motor. Growing up on Long Island, Hawkins and his brothers helped build the craft, which they nicknamed the Bubble Monster. Like his dad, Hawkins grew up to be an engineer.

In 1979, fresh out of Cornell University with an undergraduate degree in electrical engineering, Hawkins read a magazine article that he says changed his life. In an essay in *Scientific American*, Francis Crick, whose interests had recently turned from molecular biology to the mysteries of the mind, lamented the lack of a grand unified theory in neuroscience. Scientists have amassed a wealth of details about brain anatomy and physiology, Crick wrote, but still have no working hypothesis of how the whole thing actually works. To Hawkins, this was a call to action.

In 1980, he tried to persuade his employer, computer-chip maker Intel, to let him start a brain research group, but the company declined. The following year, the Massachusetts Institute of Technology (MIT) rejected his application to pursue a Ph.D. in its artificial-intelligence laboratory. Although disappointed, Hawkins resolved to figure out a way to one day pursue his interest in the brain. In 1986, he tried the academic route once more. This time, he was accepted to a graduate program at UC Berkeley.

Once there, Hawkins sketched out a theory of how the cerebral cortex—the thin sheet of tissue on the surface of the brain—gives rise to intelligence, and he submitted this as his thesis proposal. "They said, 'This is interesting, but you can't do it,' " he recalls. To get a Ph.D., you need a thesis adviser, and no one at Berkeley was doing theoretical neuroscience back then, he says. Hawkins grew frustrated and impatient. "I was technically a student for 2 years, but by the second year, I was just using the library."

Hawkins returned to the high-tech industry, where he'd gained expertise and a reputation for creativity in designing portable computers. Thanks in part to work he did at Berkeley on neural mechanisms of pattern recognition, he owned a patent on a handwriting-recognition program that allowed computer users to enter data by writing on a screen with an inkless pen. Determined to incorporate this software into handheld computers, Hawkins founded Palm Computing in 1992.

In some ways, the timing couldn't have been worse. In 1993, Apple released a handheld computer, the Newton, and it was a colossal flop. Suddenly, no one wanted to invest in mobile computing, Hawkins says. But he stuck with it. One night in his garage, he carved a mockup of the device he envisioned from a block of wood. As his team worked on the interface, Hawkins tested various configurations of buttons and display windows by sticking printouts onto the model. Silicon Valley lore now has it that he would pull the model out of his pocket during meetings and poke at the "screen" with a sawed-off chopstick, pretending to enter appointments. "I just knew it was going to happen," he says.

Time ultimately proved Hawkins right: Palm has sold more than 34 million devices. In 2002, Hawkins felt the time had come to get back to brains. Scaling down his hours at Palm, he

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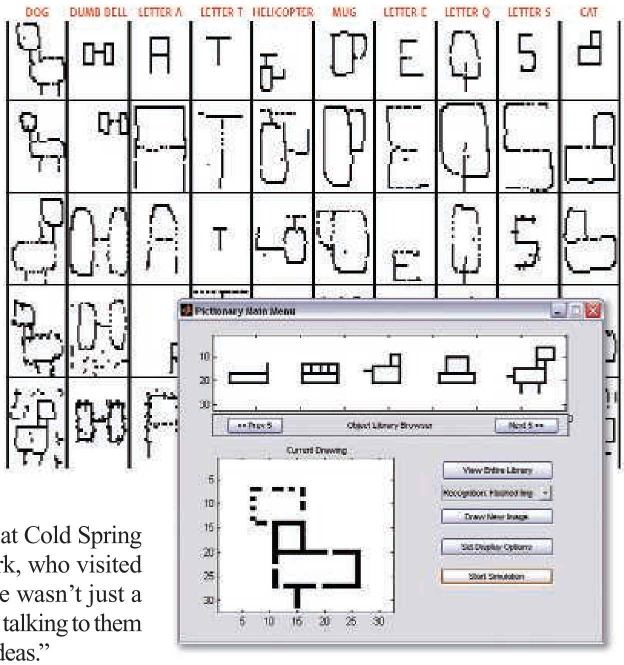
founded (and funded) the Redwood Neuroscience Institute (RNI) in offices above a popular café in Menlo Park, California. The idea, he says, was to bring together scientists interested in creating computational models of the cerebral cortex. The group ultimately consisted of five principal investigators in addition to Hawkins, plus a handful of postdocs. "He collected a great group of very creative people," says Anthony Zador, a computational neuroscientist at Cold Spring Harbor Laboratory in New York, who visited the institute several times. "He wasn't just a manager; he was there every day talking to them about their ideas and about his ideas."

The institute defied categorization. "The atmosphere was a little bit between a start-up, and a think tank, and a research institute," says Fritz Sommer, a computational neuroscientist who left a faculty position at the University of Ulm in Germany to join RNI. "I was kind of an old-school guy, raised in the old German academic tradition, so for me this was something much more inspiring." In the absence of teaching obligations and grant proposals, freeform interactions flourished among the scientists who worked at RNI, says Sommer—and extended to their guests. A visiting speaker was liable to endure a barrage of queries throughout the presentation, making it less like a formal lecture and more like a lively conversation—one that often continued for hours at the café downstairs.

At one meeting, co-sponsored with the American Institute of Mathematics, RNI brought together anatomists, physiologists, and theoreticians who were all studying the cortex. Hawkins asked each group to go off on its own and come up with a list of things the other groups could do that would aid them in their own work. "The scientists were entirely puzzled because no one had ever asked them to do that," says Sommer. "That blew my mind," Hawkins says. "In industry, you're always trying to get help from wherever you can."

Making predictions

Hawkins spent much of his time at RNI fleshing out the ideas on the cerebral cortex he'd conceived at UC Berkeley decades earlier. In 2004, he published them in a book co-written with *New York Times* science writer Sandra Blakeslee. In *On Intelligence*, Hawkins argues that the nature of intelligence—and the primary function of the cortex—is predicting the future by remembering what has happened in the past.



You call that a dog? A Numenta simulation program (*bottom*) recognizes objects even when they're poorly rendered (*top*).

A key feature of Hawkins's argument is the idea of a common cortical algorithm, proposed in the late 1970s by Vernon Mountcastle, a neurobiologist at Johns Hopkins University in Baltimore, Maryland. Because anatomists had found that the type and arrangement of cells in any tiny patch of cortex is very nearly the same, Mountcastle proposed that every patch of cortex performs the same basic operation. What makes one swath of cortex a "visual" region or a "language" region is the kind of information it receives, not what it does with that information. "In my mind, this is one of the most fundamental breakthroughs in neuroscience," Hawkins says.

He is convinced that the common cortical algorithm performs predictions. In the book, he argues that the anatomy of cortex is well-suited for prediction and describes how circuits of cortical neurons arranged in a hierarchy—in which higher levels constantly feed information back to lower levels—can compare an incoming sequence of patterns (such as a string of spoken words) with previously experienced sequences ("Fourscore and seven years") to predict what's next ("ago"). This memory-prediction framework has evolved to take advantage of the spatial and temporal structure in our surroundings, Hawkins says, which helps explain why brains easily do certain tasks that give computers fits. "There's no machine in the world that you can show a picture of something and have it tell you whether it's a dog or a cat or gorilla," he says, but a person can do this in a fraction of a second.

"His ideas … provide a plausible conceptual framework for a lot of different kinds of data," says Mriganka Sur, a neurobiologist at MIT who studies the cortex. Yet some theoretical neuroscientists, none of whom would agree to be named, grumble that Hawkins's book merely rehashes other people's ideas and that his model isn't concrete enough to suggest experiments to test it. Although there's some truth to that, says Sommer, Hawkins has tied together several existing concepts in an interesting way: "He makes connections and sees the bigger picture that people who are doing research on a particular system of the brain often lose."

Hawkins now believes that the best way to spur interest in his cortical theory is to use it to develop technology. "People work harder and get things done faster if they can see a profit motive," he says. Last year, he founded Numenta, a for-profit company, and handed off RNI to UC Berkeley, along with an endowment to cover much of its operating expenses. Now called the Redwood Center for Theoretical Neuroscience, it's part of the Helen Wills Neuroscience Institute.

At Numenta, Hawkins has worked with Dileep George, a former Stanford University electrical engineering grad student, to develop software based on the memory-prediction theory. Hawkins expects the software to be ready for public release next year. In the more distant future, he envisions intelligent computers that will tackle all sorts of problems. In *On Intelligence*, he imagines feeding real-time data from a global network of sensors into a "weather brain" that tracks weather systems in the same way the brain identifies objects and predicts how they will move across the field of vision. By applying humanlike intelligence to vast amounts of data, such a system could identify previously unknown weather phenomena (along the lines of the El Niño cycle) and make more accurate forecasts, Hawkins speculates. Intelligent systems using Numenta's software might also monitor power grids to help guard against blackouts, or monitor sensors on an automobile and alert the driver to dangerous situations.

It's far too early to know whether Hawkins's vision will pan out. But regardless of whether he succeeds, Hawkins has helped galvanize the theoretical neuroscience field, Zador says: "The fact that he's setting these wildly ambitious goals and has set about achieving them is actually quite refreshing."

–GREG MILLER

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