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Professor uses cutting-edge statistics to unravel the complexity of brain disorders

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When Alan Evans was starting out in the 1970s, researchers didn't ask the boss to foot their bar tab. But that's exactly what some of the coders in his Montreal Neurological Institute lab recently proposed: a 9-to-5 Saturday hackathon, held in an Irish pub a few blocks from the McGill University campus.

"Bleeding-edge coding technology and beer," Professor Evans says with a wry laugh. "What could possibly go wrong?"

Still, he agreed to the idea. When he stopped in at the pub in the afternoon, he half-expected to find a bacchanal. Instead, fingers furiously tapped on laptops as the coders raced to meet their self-imposed deadline to solve some research problem. Come five o'clock, each team presented their work – and sometimes even working prototypes of apps – and talked about how to get their new ideas up and running in Evans' lab come Monday morning.

"If I'd been a more hidebound old fool," Evans recalls, "I would've said 'Absolutely not' to paying for those guys to hang out at the pub all Saturday. But I realized this was probably the most productive day's work in my lab, ever. And they had a ball."

Mathematical whizzes and neuroscience

Openness to change, and a curiosity to explore new paths, may be the defining characteristics of Evans' career. Today, he's internationally recognized for his work in brain imaging; in July 2016, for example, he will be the guest of the U.S. White House Office of Science and Technology Policy, who have turned to his expertise to help them build an open-data neuroscience ecosystem. His 65-person lab brings together the types of researchers who, he says, "would never have talked to each other a few years ago." Some are scientists with domain-specific expertise in certain brain disorders. The others are hackathon-holding computer simulation and mathematics whizzes who "may not know one end of a brain from another—and they don't need to because, whether it's neurodegeneration or aging or development or depression, it's all the same mathematical problem." Together, they create wonders such as the most frequently used spatial reference system for cataloguing structural and function data for normal and diseased brains. Ultimately, their goal is to understand exactly how, and why, disorders occur—groundbreaking knowledge that will underpin improved diagnosis and, hopefully, interventions.

Evans may have recently co-led the "Big Brain Project," an unprecedented map of the human brain with a near-cellular level of detail, but studying the brain wasn't always his goal. The Wales-born Evans did his undergraduate work in mathematics and physics, then gradually started "moving east" into neuroscience. Next came a graduate degree in medical physics, then a PhD in biophysics. But it was a literal move, from the U.K. to his wife's native Canada that proved career-changing.

Mapping the probability of brain activation

In 1979, Evans took a job with Atomic Energy of Canada to work with a prototype PET scanner that had been developed at McGill. After Evans spent five years wearing out the highway between Ottawa and Montreal, the Montreal Neurological Institute's then-director, William Feindel, said, "You really should just stay here." So he did.

Over time, Evans grew frustrated by the limitations of PET images. PET are great at showing metabolic processes – such as when dopamine receptors are activated – but "the rest of the image is pretty fuzzy." MRI scans, on the other hand, give a sharp, detailed look at brain structure. Evans and his MNI were among the early adopters of "brain mapping," or overlaying PET and MRI scans to get a multi-dimensional view of structure and function to create statistical probability maps of brain activation.

But, again, Evans grew restless. "Could we create statistical probability maps of brain structure?" he asked. "What about for disease?" His curiosity led to the creation of a map that showed, for the first time ever, what multiple sclerosis looks like in the brain.

A cluster of factors come together to create brain disorders

Evans' work is contributing to a new understanding of brain disorders. Whereas we had previously thought of disorders as "living" in one part of the brain, which has been altered by one or two rogue genes, scientists are now realizing that disorders are the result of clusters of genes, and clusters of regions and connectivity. "In my career," says Evans, "I've watched as we go from single measurements of brain structure volume to much more sophisticated analysis of brain network analysis organization – and how those networks change during development or disorder."

"What we're doing is applying mathematics, physics and engineering principles to brain sciences," he continues, noting that many other sciences, such as epidemiology and genetics, are going through the same evolution. "We're increasingly turning neuroscience into a more quantitative discipline." Radiology, for example, is basically an expert looking at a single image, then weighing what they see against past diagnoses and experiences. "If you want to do solid science that is not just descriptive and anecdotal, it requires you to understand the basics of statistics."

Merging brain structure, function, and genetic information creates what Evans calls "a data tsunami"—an overwhelming amount of data that causes many people to throw up their hands in defeat. He, however, is excited. The new R&D collaboration between McGill and EMC, for one, promises to ramp up the already great advances in raw computing power. And the creation of the Ludmer Center for Neuroinformatics and Mental Health in 2014, Evans says, exactly embodies the kind of interdisciplinary work needed to make exponential leaps in our understanding of the basic machinery of cell function, and about how different regions communicate with each other at a systems level. The data tsunami can be surfed.

"We're on the threshold of a new era, where information sciences are now being brought to bear to ask questions about the brain that, 20 years ago, we may not have even thought to ask."

"As my wife says, it's taken 30 years for me to become an overnight success."

Provided by McGill University

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