Brain efficiency comes from parents

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Clever genes Organisational ability, problem solving, and some mental illnesses can be traced to genetically preordained brain networks, according to a new study.

Published in the *Journal of Neuroscience* (http://dx.doi.org/10.1523/JNEUROSCI.4858-10.2011) , the study provides the first evidence of a genetic effect on how 'cost-efficient' our brain network wiring is, shedding light on some of the brain's make up.

Lead author Dr Alex Fornito, from the Melbourne Neuropsychiatry Centre (http://www.psychiatry.unimelb.edu.au/centres-units/mnc/index.html) at the University of Melbourne, says the findings have important implications for understanding why some people are better able to perform certain tasks than others. It may also help identify the genetic basis of mental illnesses and neurological diseases.

Artist impression of neurons firing in the brain (iStockphoto: W. Sashkin)

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Previous work has shown that people with more efficient brain connections score higher on intelligence tests. It also found brain network cost-efficiency is reduced in people with schizophrenia.

"The brain is an extraordinarily complex network of billions of nerve cells interconnected by trillions of fibres," says Fornito.

"In this network, efficient communication is very important. More connections make the network more efficient, allowing different parts of the brain to talk to each other quickly and effectively."

"On the other hand, it tries to minimise the amount of wiring it uses to connect the network, because each connection is costly in terms of the energy it consumes."

"So some people's brains operate more effectively than others," he says.

Comparing twins with twins

The research team, which included scientists at the University of Queensland (http://www.qbi.uq.edu.au/) and Cambridge University (http://www.neuroscience.cam.ac.uk/) in the United Kingdom, compared the brain scans of 38 identical and 26 non-identical twins.

"Twins provide a nice natural experimental group to work out how important genes are in determining a particular trait," Fornito says.

Identical twins share the same genes, whereas non-identical twins, also called fraternal twins, share about 50 percent of their genes.

"Given this difference," Fornito says, "if genes are important in determining a trait then we would expect the identical twins to be a lot more similar than the non-identical twins."

"So we can use various statistical models to work out the exact contribution the genes make to the trait."

He says how the brain's network is organised has puzzled scientists for years.

"For a long time people have speculated about how these complicated networks might be organised, but it's been very difficult to comprehensively map the brain's connections in living human beings," Fornito says.

Using magnetic resonance imaging (MRI) the researchers measured the cost-efficiency of network connections for the entire brain, as well as for specific brain regions.

Fornito says the MRI scans illustrated where differences in brain network organisation showed up between non-identical twins.

"We found that people differed greatly in terms of how cost-efficient their brain networks were," Fornito says.

It's something we're born with

He says they found on average about 60 per cent of the overall differences could be explained by genes.

"So it is something that we are born with that determines how our brain is wired. But it still allows enough room for the brain to be able to respond to the environment," he says.

But in some parts of the brain the genetic influence was much higher.

"Some of the strongest [genetic] effects we found were in the prefrontal cortex. This part of the brain plays an important role in things like strategic thinking, planning, and memory," says Fornito.

"It's also one of the first to be affected by many mental illnesses, schizophrenia being a key example. So our findings point to a potential genetic basis for these brain changes."

He adds that although genes play a major role, the environment and other factors can influence the timing of when things go wrong in cases of mental illness and other brain disorders.

"Ultimately," Fornito says, "this research may help us uncover which specific genes are important in explaining differences in cognitive abilities, risk for mental illness and neurological diseases such as schizophrenia and Alzheimer's disease."

He says that could lead to new gene-based therapies for these disorders.

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