
Is human brain function largely based on our genes?

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Dr Alex Fornito

PEOPLE differ greatly in terms of how cost-efficient the functioning of their brain networks is — and it's largely due to genetic influences, according to a new study. Researchers from Melbourne, Queensland and Cambridge universities examined how genes influence brain wiring by comparing brain scans of Australian twins. Alex Fornito, of the Melbourne Neuropsychiatry Centre, who led the study, says the results may also help identify the genetic basis of mental illnesses and neurological diseases.

Explain the cost-efficiency idea.

The brain is an extraordinarily complex network, made up of billions of nerve cells interconnected by trillions of fibres. All these connections help parts of the brain communicate, which it needs to be efficient. This is the basis for all our thoughts, feelings and actions; it gives us an integrated picture of the world around us. High efficiency helps us think a lot better.

What's the “cost”?

The brain has this pressure, on the one hand, to make more connections and to make the communication between its regions more efficient but, on the other hand, to minimise the amount of wiring it uses to connect this network because connection is costly in terms of the energy it consumes.

It's about an optimal balance?

This cost-efficiency principle is really a way of the brain trying to get the most bang for its buck.

How did you conduct the study?

We recruited 38 identical and 26 non-identical twins and scanned them using magnetic resonance imaging, or MRI, which allowed us to take detailed pictures of people's brains as they were functioning in real time.

What were you looking for?

Using these scans we applied methods that allowed us to generate fairly detailed maps of human brain connectivity, at a level that allowed us to quantify how cost-efficiently each brain was wired.

And you found?

People did differ quite a lot. And by comparing twins, we were able to estimate how important genes were in determining these differences between people.

Can you explain how?

Identical twins have exactly the same genetic make-up, whereas non-identical twins share on average about 50 per cent of their genes. So if genes were important, we would expect identical twins to be a lot more similar than non-identical twins. And this is what we found. We used statistical models to work out the exact proportion that is attributable to genes.

Which is?

For the entire brain network, about 60 per cent of the differences between people were attributable to genetic effects.

What of the other 40 per cent?

Environmental influences — and this makes sense, because the brain needs to be able to adapt to changing circumstances, otherwise we'd be like pre-programmed robots.

Are there exercises we can do to improve our brain wiring?

This is a frontier area. We know that certain aspects of our brain wiring are quite fixed, whereas others are quite dynamic. For example, if you learn an instrument, over time, wiring in parts of the brain responsible for playing that instrument will become more effective, so the brain does have plasticity. However, no one's really done studies to look at how the cost-efficiency of brain wiring might change in response to learning or practice.

Did you study specific brain regions?

Yes. In regions of the prefrontal cortex — the front part of the brain involved in strategic thinking, planning, memory and things like that — we found that genes explained up to 80 per cent of the differences between people.

And this links to mental health?

Exactly. Some recent work shows that brains of people with schizophrenia are less cost-efficiently wired, particularly in the prefrontal cortex. Our findings point to a potential genetic basis for brain-wiring changes in schizophrenia. Our hope is that the research could be used to identify specific genes that potentially increase the risk of schizophrenia.