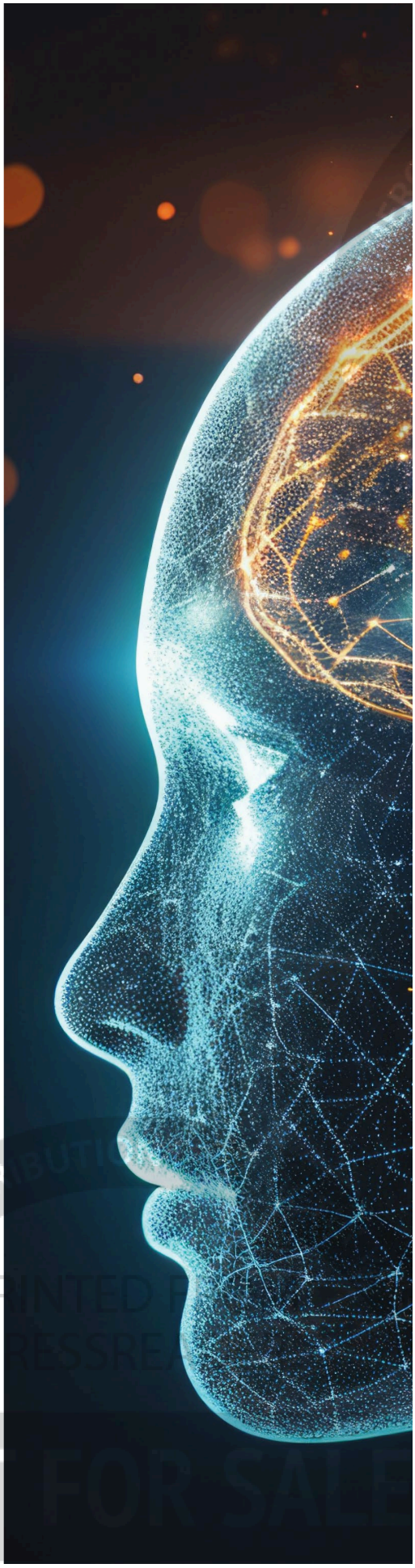
- Genius

SCIENCE

INSIDE THE MIND OF A GENIUS

What's going on inside the brains of those with truly exceptional mental abilities, and why are they so intelligent? Genetic analysis and Einstein's brain are providing us with some answers

WORDS MUN-KEAT LOOI



When Albert Einstein died, his brain became a scientific curiosity. In the months following the famous physicist's death in 1955, pathologist Thomas Harvey dissected it into 240 blocks. Over the years, he distributed tissue samples and photos to a select group of scientists and, gradually, little clues to Einstein's genius emerged.

Humanity is utterly fascinated by intellect, and with good reason – a higher IQ is linked to better jobs, income and health, as well as a lower risk of accidents and premature death. In 1904, English psychologist Charles Spearman noticed that high-school grades in different subjects tended to cluster around the same children – those who were good at maths were usually good at English too. He proposed that there was some common factor, or 'g', for general intelligence, that could explain some of the differences between people's mental abilities.

Although controversial and still debated today, the theory largely stands – with evidence that different skills, including speed of thought and verbal, numerical and spatial reasoning, are all high in certain individuals.

If we can figure out what influences 'g', we can get an insight into to what makes geniuses smarter than the average person, and maybe give us and our children a boost.

Did you know?

There are 86 billion neurons inside the human brain

The crucial problem is, as with most things involving the brain, intelligence is complicated. Brain size was long thought to play a part in IQ, but though there is some association, bigger isn't necessarily better. One of the earliest findings from Einstein's autopsy was that his brain was smaller than most, weighing about 200 grams less than the average 1,400 grams.


DID YOU KNOW?
Age is no barrier to brilliance – the youngest member of Mensa joined at the age of two and a half
GENIUS FACT #01
IQ, or Intelligence Quotient, is the common measure of intellect. It compares a person's mental ability with that of their peers – for instance, does a ten year old perform as well, better or worse than other ten year olds?
© AdobeStock

SCIENCE

NATURE OR NURTURE: THE BIG DEBATE

Is it predominantly genes or environment that lead to genius?



Professor Robert Plomin
King's College London

"My best bet is extremely high IQ will be heritable to the same extent as intellectual disabilities and individual differences in the normal distribution [of intelligence across a population]. I think we're talking about at least half of the differences between people being due to genetic differences."

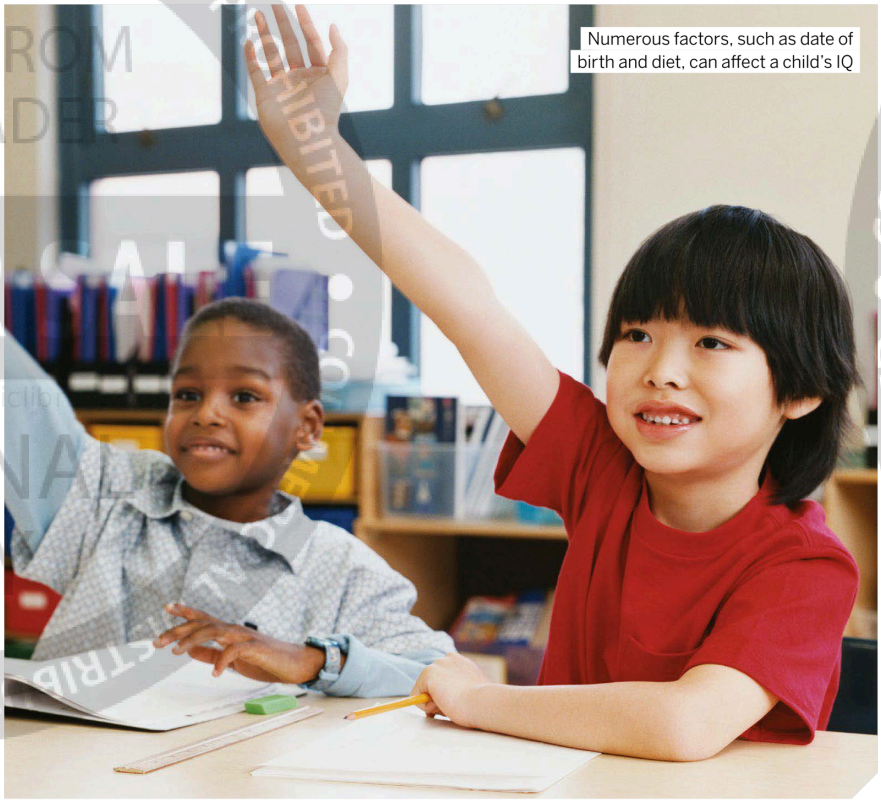


Professor Dean Falk
Florida State University

"Einstein was born with a good brain and good genes underlying that. But he also had a family that nurtured it and allowed him to pursue his intellectual interests. I suspect there are any number of people in any generation that are genetically as well-endowed as Einstein, but you have to have the right configuration of events, and that includes environmental stuff."



Pathologist Thomas Harvey with Einstein's brain



Numerous factors, such as date of birth and diet, can affect a child's IQ

"Brain size was long thought to play a part in IQ, but though there's some association, bigger isn't necessarily better"

What we do know is that our genes play a large part. It's estimated that 50 to 70 per cent of your intelligence is passed on from your parents. Studies of adopted children show that, while a child's IQ may vary, it ultimately ends up closer to that of their birth mother than their adopted mother.

Yet few scientists study genetics at the high end of intellect – most study the lower end, such as those with mental disabilities, perhaps because the effects are easier to distinguish and it's the more pressing social issue. However, Professor Robert Plomin of King's College London has taken up the challenge. In Iowa, a summer camp gathers together academically gifted children with an average IQ of 160 – equal to the likes of Einstein and Stephen Hawking, which is the perfect opportunity to study the genes of geniuses.

Comparing the DNA of 50 children of a similar age and background, Plomin's team scanned for 1,800 genetic markers. But few stood out. The effect of all of them was tiny – the six strongest candidates combined accounted for just one per cent, at best, of the influence on IQ.

Like height and weight, intelligence is part of the mystery of 'missing heritability'. We know it's highly heritable – it's very much passed between generations, in other words – but it's difficult to identify the genes responsible. "We can account for maybe five to ten per cent of heritability, but most of it is missing," says Plomin. "We can't yet identify the specific genes that are involved, and most people think the reason is the effects are so small that you're going to need huge sample sizes to detect them."

Did you know?
The human brain accounts for two per cent of our weight

For Plomin, the story is of many hundreds, perhaps thousands, of genes affecting intelligence, which is where his newest project comes in. His latest group brings together 2,000 of the brightest people in America, selected from the Study of Mathematically Precocious Youth (SMPY), an effort that's been recruiting maths geniuses since 1972. "We looked at hundreds of thousands of people that they've collected since 1972, then took the few thousand with the

COMMERCIAL DISTRIBUTION IS STRICTLY PROHIBITED FROM PRESSREADER NOT FOR SALE

DID YOU KNOW? The Giga Society is the most exclusive high-IQ group, with just nine members worldwide

WHERE INTELLIGENCE RESIDES IN THE BRAIN

The regions that determine our intelligence quotient (IQ)

While the structure of Albert Einstein's brain is shining some light on the brain and intelligence, other research is peering into the minds of a much larger group of people. One such study analysed the brains of nearly 200 veterans from the Vietnam War with damage to very specific regions due to the penetrating head injuries they had sustained. Neuroscientists in the US took computerised tomography (CT) scans of the veterans' brains and then gave volunteers a series of cognitive tests.

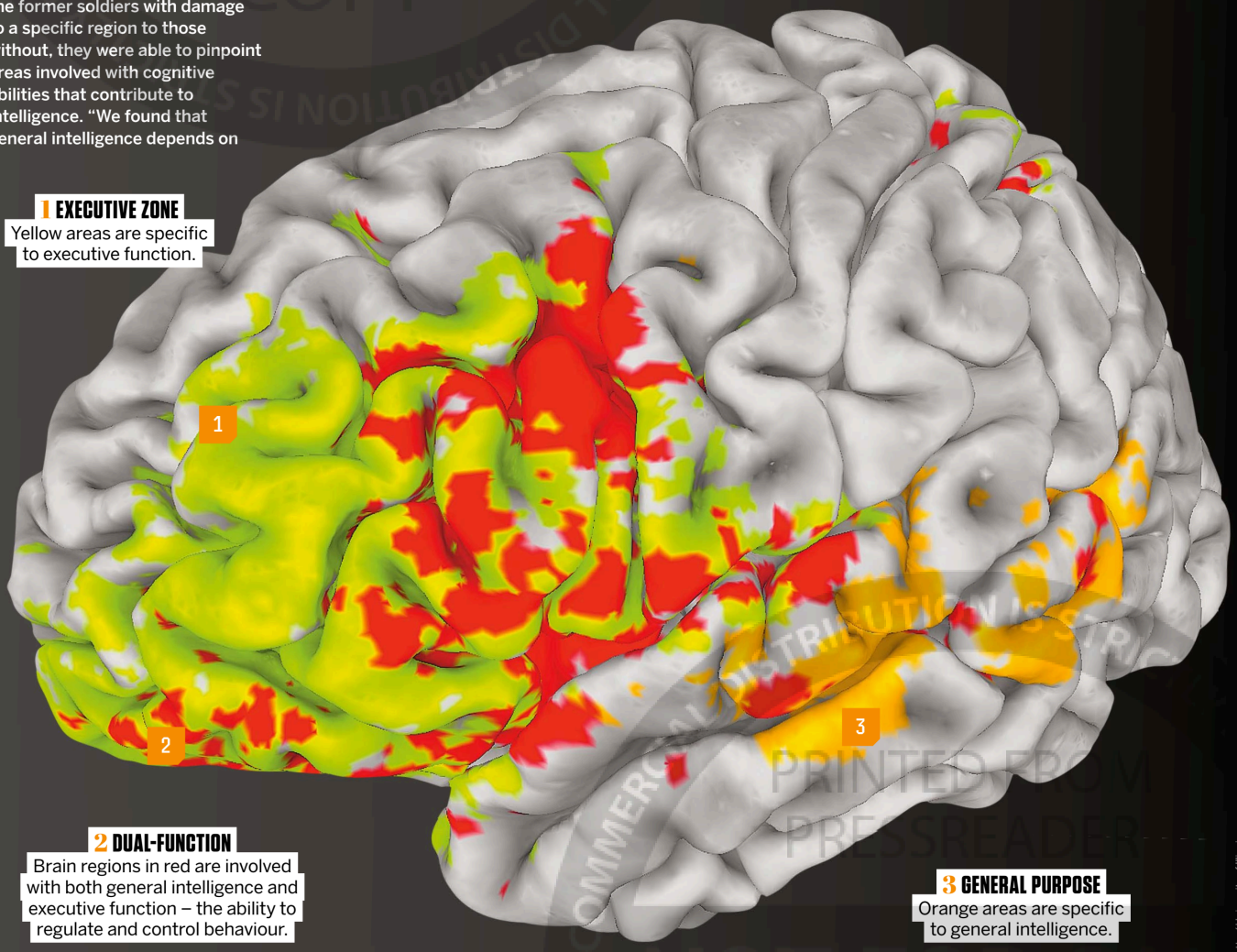
By comparing the abilities of the former soldiers with damage to a specific region to those without, they were able to pinpoint areas involved with cognitive abilities that contribute to intelligence. "We found that general intelligence depends on a remarkably circumscribed neural system," explains Aaron Barbey of the University of Illinois, who led the study. "Several brain regions, and the connections between them, were most important for general intelligence."

These regions are located predominantly in the frontal cortex, behind the forehead; the temporal cortex, behind the ear and the parietal cortex at the top rear of the head. Also important are the white matter tracts – the long-distance links between these different regions.

More recent research with the veterans by Barbey has shown that both the frontal and parietal cortices are also involved with emotional intelligence – the ability to assess and control the emotions of yourself and others. It shows how closely entwined general and emotional intelligence are inside the mind.

GENIUS FACT #02

The lowest IQ required to be classified as a genius is debated. It's often considered to begin at a score of 140. Others say it begins at 160. A score of 132 on the Culture Fair IQ Test is required to join the UK branch of Mensa.



1 EXECUTIVE ZONE
Yellow areas are specific to executive function.

2 DUAL-FUNCTION
Brain regions in red are involved with both general intelligence and executive function – the ability to regulate and control behaviour.

3 GENERAL PURPOSE
Orange areas are specific to general intelligence.

© Getty / University of Illinois

SCIENCE



Genetics may play a role

DESIGNER BABY GENIUSES

Should embryos with a higher IQ be selected? Gene-editing technologies could one day enable scientists to change 'genetic endowment'. But for now there's not much we can do, bar offering screening for conditions such as Down's syndrome. It's not a simple matter of testing embryos to select for higher intelligence. There are likely to be thousands of genes contributing to intelligence, which makes selecting for the best combination problematic.

"The more embryos you produce, the more you could select for a range of genes with smaller effects that combine to make a significant effect," says Professor Julian Savulescu of the University of Oxford. But you'd have to have thousands to choose from – which is ethically dubious, and limited, since the most one cycle of IVF can produce is 20. Nevertheless, he believes we have a "moral obligation" to ensure that our children have as many gifts as they can, safely, with the use of science.

This could have a wider effect on the population – a US study worked out that a three-point increase in IQ for the whole population could reduce poverty by as much as 25 per cent and the number of males in jail by 25 per cent, while adding 1.5 per cent to the GDP of the US economy.

Savulescu's own studies have discovered that the highest intelligence levels are associated with four times more invention than the average intelligence. "This provides some support to the idea that genius is a socially beneficial trait, as well as one that arguably promotes the wellbeing of an individual," he says. "So there are good reasons to either genetically select embryos or enhance embryos to have higher IQ."

GENIUS FACT #03

The highest IQ is said to be that of William James Sidis. A child prodigy with exceptional mathematical and language abilities, said to have had an IQ of 250 to 300. However, any test records have since been lost.

very highest IQ out of that high sample and got their DNA a couple of years ago," says Plomin.

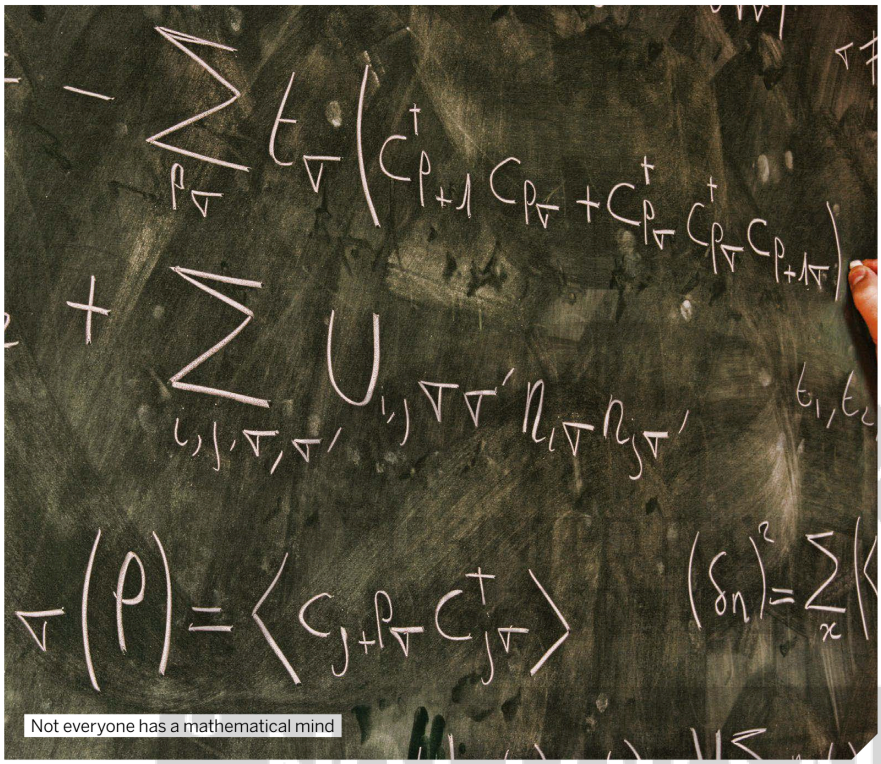
The thinking is this: intelligence, like height and weight, has a 'normal' distribution – plot the IQ of a population on a graph and you get a 'bell curve' with most people around the middle and fewer at the lower and higher ends. By studying the more extreme ends of the scale, we may get clues as to which genes negatively or positively affect intelligence.

"We're not looking for genes for genius, but genes for intelligence in what we hope is an enriched sample for the positive effects of genes," says Plomin. They're now collaborating with a Chinese study of geniuses run by BGI in Beijing, China, to sequence the samples and hopefully find some genes, though Plomin isn't expecting any smoking guns.

"[My hypothesis is] that to be super-high functioning you need most of the positive [genetic mutations] and few of the negative ones," he says. Genetic mutations are more often than not negative, and at best have no effect at all. Those with a higher IQ probably don't have 'genius' mutations, but rather fewer negative mutations, such as those that cause intellectual disabilities, on balance.

"The highest functioning individuals are merely quantitatively, not qualitatively, different from the rest of us," says Plomin. "It's the same genes, but they were dealt a deck that had almost

"We're not looking for genes for genius, but genes for intelligence in what we hope is an enriched sample"



Not everyone has a mathematical mind

DID YOU KNOW? 5,000 years ago, human brains were larger than they are today by around 150 cubic centimetres


Today's scanning technology is giving us new insights into brain structure and intelligence

GENIUS FACT #04

Einstein claimed to think in pictures rather than in words. His theory of general relativity can be imagined in terms of a bowling ball sat on a trampoline, with a marble rolling around in the dip the bowling ball creates.

all 'positive' [mutations] and very few negative ones."

Other scientists believe that looking for genes is the wrong tactic. When it comes to intelligence, most educational research suggests that social factors have a huge say. Although intelligence is highly heritable, having the blueprint alone isn't enough – it's what you do with it, how it's executed and under what circumstances that counts. As the writer David Shenk, author of *The Genius in All of Us*, has put it, we're jukeboxes: our genes don't program us to play one tune; it's what happens after birth that picks the record.

Which brings us back to Einstein. Some of the latest revelations about his brain came from Florida evolutionary anthropologist Dean Falk and her colleagues in 2013. Falk believes that what made Einstein's


Geniuses will usually have fewer negative genetic mutations, rather than more positive ones

© Getty

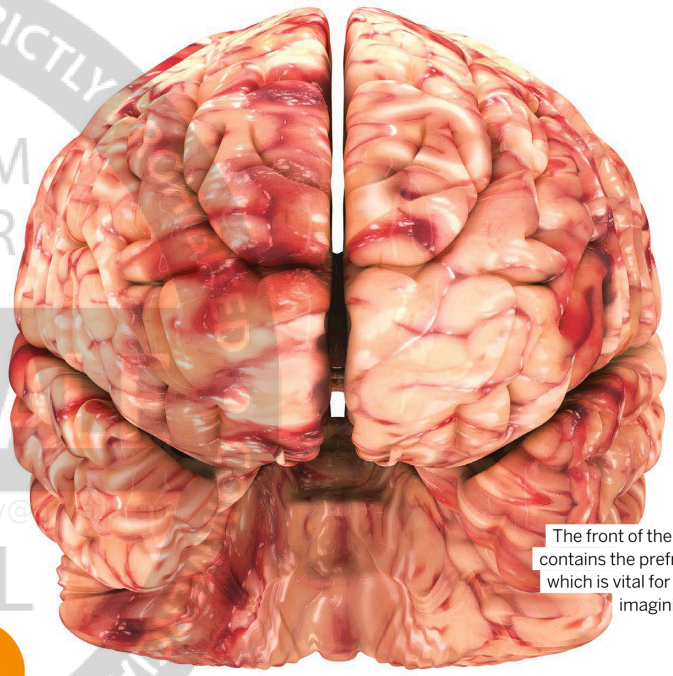
Did you know?

There are no pain receptors in the brain

PRINTED FROM PRESSREADER
NOT FOR SALE

SCIENCE

> "The prefrontal cortex is especially important for thinking about the future, imagining scenarios and making plans"



The front of the human brain contains the prefrontal cortex, which is vital for planning and imagining scenarios

genius was his "natural curiosity of the world" and a family that encouraged it.

"Einstein had a family that nurtured [his curiosity] and in an uncontrolling way allowed him to pursue his intellectual interests. He quit school at one point – he was bored – but that was okay. There was an uncle and his father, who had technical interests, so he was exposed to mechanical things, and a mother who saw to it that he had training in music. So he had an environment that was conducive to self-programming his own intellectual pursuits."

Examining previously unseen photos from Thomas Harvey's collection, Falk found the patterns of Einstein's brain, particularly the cerebral cortex – the outer, wrinkly part – to be unusually complex, giving it an uncommonly large surface area.

"The prefrontal cortex is especially important for thinking about the future, imagining scenarios, making plans," says Falk. "Einstein's was extraordinary – we can tell that just by looking at the surface." These features may have contributed to Einstein's famous thought experiments, such as chasing a light beam, riding an elevator in free fall and rocketing past a clock tower in a streetcar, which contributed to his new thinking on space, time and gravity.

Of course, as Falk puts it: "You have to have good equipment to begin with. Einstein was born with a good brain and good genes underlying that," she says. "But being curious is the key, and pursuing questions that occur naturally to the individual."

GENIUS FACT #05

Every year, the MacArthur Foundation surprises individuals with 'Genius Grants'. Its judging panel picks out people from any field who "show exceptional merit and promise for continued and enhanced creative work".

Did you know?

Francis Galton was the first person to try to test IQ

BECOME A GENIUS WITH A FEW CHANGES

...or at least give your IQ something of a boost

Diet makes a difference to intelligence, particularly in childhood. Studies carried out during World War II revealed that malnutrition can have a significant effect on intellect. A 2010 study of children in Bristol in the UK found a healthy diet of pasta, salads and fruit is associated with small increases in IQ, while an unhealthy diet has the opposite effect. Other studies have shown that supplementing diets with vitamins and minerals increases test scores.

Music has a positive effect on intelligence. Studies in the 1980s reported that playing Mozart to pregnant women seemed to lead to articulate speech in children. Brain scans of young adults reveal that children who learned to play a musical instrument before the age of seven have thicker brain regions that deal with language skills and executive function. Other studies show how those who take early music lessons have more extensive wiring in the white matter linking the right and left hemispheres of their brains.

The evidence that brain-training games can make you smarter is mixed. The BBC's *Bang Goes the Theory* programme teamed up with researchers from Cambridge in the UK to track 11,000 adults over six weeks as they practised a series of online tests. Though there was a small effect, the researchers concluded this was due to their increasing familiarity with the games rather than any long-term rise in 'fluid intelligence'. There is evidence that such games might improve your short-term memory.

Finally, your date of birth can make a difference. Children born in September at the start of the school year in the UK do better in tests. A study of 240,000 Norwegians found that, on average, the eldest child in a family had a higher IQ. It wasn't being born first that mattered, but being raised as the eldest.



© Getty / XXXXXXX