

# Two ONE

A new BBC One documentary on twins reveals just how much our genes influence our thinking. Emma Bayley reports



# brains MIND

**O**n the evening of 27 November 1975, writer and TV personality Ross McWhirter was shot dead by IRA gunmen. At the same time, his twin brother Norris collapsed in his home 48km away, his family thinking he had suffered a heart attack. The story made big news as the McWhirter brothers, editors of the *Guinness Book of Records*, were well known at the time.

But this sort of occurrence is not a rarity among twins: there's the student in New York who woke suddenly, afraid for her twin sister in Arizona, just as a bomb was going off outside her home; the twin brothers who went skiing on different pistes in the Alps and fell at the same time, breaking their legs in exactly the same way. Twins have an uncanny habit of knowing what the other is thinking and doing, to the point where they may experience each other's danger or pain.

## A growing understanding

One might put some of the above down to the close emotional bond that forms between twins that have grown up together. But equally eerie coincidences have occurred in the lives of twins who were reared apart and barely knew of each other's existence until they were reunited in adulthood. Now, science is beginning to shed light on these strange twin tales. Is it something as otherworldly as telepathy, or is it simply that genes play a far greater role in the way we think, feel and make choices than we previously believed?

Twins have long served as a scientific tool for investigating the relative effect of genes and environment on our development and behaviour – Sir Francis Galton was the first to study them, in the 1870s. They are now considered so valuable that researchers refer to them ▶



► as 'the Rosetta Stone' of behavioural genetics, the field of science that looks at the link between genetics and psychology. Simply put, twins hold the key to understanding who we are.

### Peas from a pod

"When we study twins, we are using a great experiment of nature," says Professor Thomas Bouchard, a psychologist at the University of Minnesota and world expert on twins. "Mother Nature has given us identical and fraternal twins and we can use them [to study the effect of genes]."

Twin studies compare the similarities of identical twins (who share 100 per cent of their genes) with those of fraternal twins, who share just half their genes (see 'Twin types', page 48). By studying hundreds of pairs, researchers can disentangle genetic effects from the

effects of shared environments, and give different traits a 'heritability level'. High heritability means individual differences within a population are largely due to genetic factors. Height, for example, has 90 per cent heritability. In comparison, differences with low heritability (such as job satisfaction, which has 30 per cent heritability) are largely due to environmental factors.

But there are criticisms of the twin study design. One is the idea that identical twins behave more alike than fraternal twins because they are *treated* more alike. This is where twins who have been reared apart come in. If twins have been separated at birth and raised in different environments, then the only factor they share is their genes.

In 1979, Bouchard set out to find and study twins who were separated at birth. Inspired by the story of the 'Jim Twins'

**"The data showed us that personality similarities among relatives living together are not due to them living together – instead, they are due to the genes they have in common"**

(see case study below), whose reunion was receiving a lot of press coverage at that time, the Minnesota Study of Twins Reared Apart remains one of the most comprehensive investigations to look at the heritability of psychological traits. Over 20 years, Bouchard and his team studied 126 pairs of twins separated at birth and raised in different families, of which 74 pairs were identical. These reared-apart twin pairs were compared to twin pairs (identical and fraternal) that had been raised together.

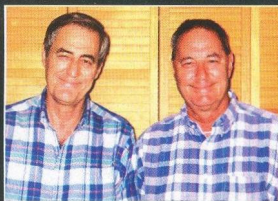
"In the past investigators had carried out twin studies looking at a small array of traits – they might have studied mental ability, or personality, or some social variable," Bouchard says. "We had a very, very comprehensive study, looking at medical, psychological and psychiatric traits. Nobody had studied them all within the same population before."

## CASE ONE

### The Jim Twins

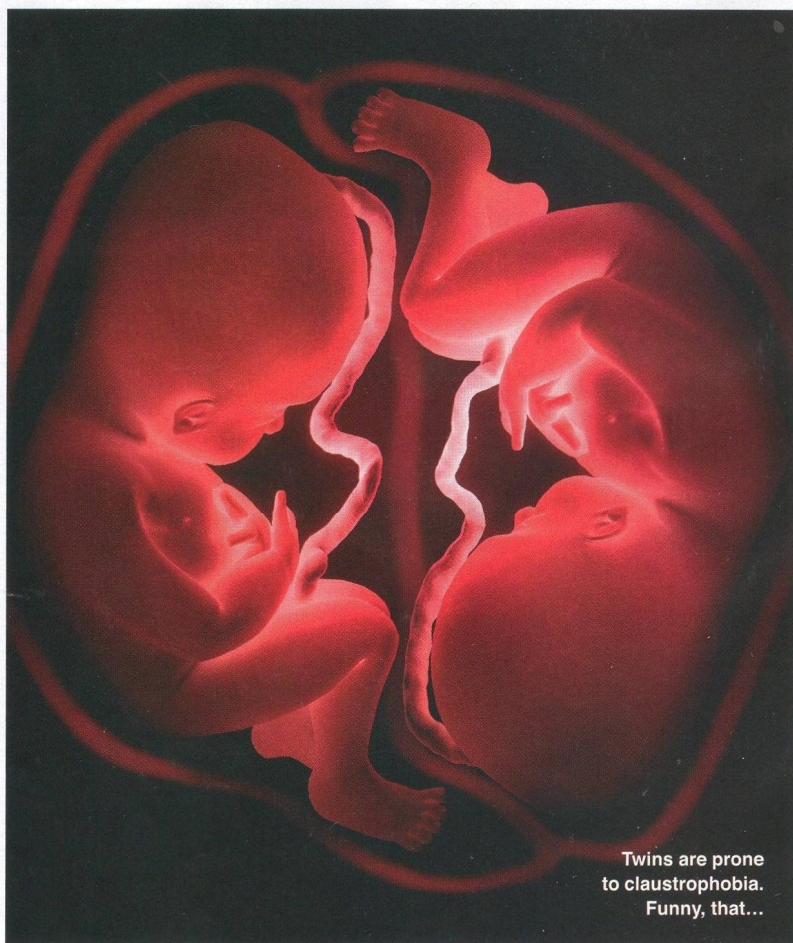
Perhaps the most famous pair of identical twins, whose story inspired researchers to study them

Jim Lewis and Jim Springer were separated when they were four weeks old and raised in different families within 45 miles of each other in Ohio. Lewis learnt about his twin when he was five. Springer found out when he was eight, but believed that his twin had died. On 9 February 1979, they were reunited at the age of 39.



Their physical similarities were uncanny. But it was the similarities in their lives and behaviour that most amazed them (and, later, researchers). Both had dogs named Toy, first wives called Linda and second wives called Betty. One had a son called James Allan, the other had a son called James Alan. They both smoked Salem cigarettes, drank Miller Lite beer, bit their fingernails and built doll's furniture. They each had a light-blue Chevrolet, which they used to drive to the same beach in Florida for holidays.

Thomas Bouchard, a psychologist at the University of Minnesota, studied the personalities and attitudes of the twins and the resulting similarities were again astonishing. In one test that measured tolerance, conformity and flexibility, their scores were so close that it was as if the same person had been tested twice. It was the same story for tests of their brainwaves, intelligence, gestures, likes, dislikes and health.



Twins are prone to claustrophobia. Funny, that...

## CASE TWO

### The Nazi and the Jew

The extraordinary case of identical twins separated after birth and raised in starkly different cultures



Oskar Stohr and Jack Yufe were born in Trinidad in January 1933, the identical twin sons of a German mother and Jewish Romanian father. The twins were separated when they were six months old, after their parents' relationship broke down. Oskar was taken back to Europe where he was raised by his mother and grandmother in German-occupied Czechoslovakia as a Catholic and Nazi youth. Jack was left in Trinidad where he was raised as a Jew by his father. He spent part of his childhood on an Israeli kibbutz, eventually becoming an officer in the Israeli navy. Both suffered from feelings of rejection in their childhood.

They met briefly when they were 17, but were not properly reunited until they were 46, when they agreed to take part in Thomas Bouchard's Minnesota Study. While their attitudes were different, they displayed similarities in personality and idiosyncrasies – for example, both stored rubber bands on their wrists, read magazines from back to front, sneezed loudly in public to attract attention, and flushed the toilet before they used it. They had similar speech and thought patterns, similar gaits, and both liked spicy foods and sweet liqueurs. "The structure of their personality was very, very similar," says Bouchard.

All the twins took several personality tests, answering more than 15,000 questions on subjects ranging from personal interests and values to phobias, aesthetic judgement and television and reading habits. They were also given medical and intelligence tests, then asked about life history and stresses.

Almost all personality traits, including well-being, alienation, aggression, shunning risk or danger, dedication to hard work, vocational interests, interest in religion, and respect for rules and authority, were found to have at least 50 per cent heritability – that is, they owed as much or more to nature as to nurture. Or put another way, an identical twin raised away from his or her co-twin had about an equal chance of being similar to the co-twin in terms of personality, interests and attitudes as one who had been raised with his or her co-twin.

These results astounded many psychologists – Bouchard included – as until then genes were not believed to play much of a role in personality, and certainly not in social attitudes. "Common thinking or intuition would tell us that if you're raised with somebody you should be more alike than

if you're raised apart," says psychologist Dr Nancy L Segal, who worked with Bouchard on the Minnesota study. "But the data showed us that personality similarities among relatives living together are not due to them living together – instead, they are due to the genes they have in common."

#### Virtually identical

Since working on the Minnesota project, Segal has pioneered the study of 'virtual twins'. These are children who are the same age and living together, but are not genetically related. "Parents may adopt two same-age children or they may ▶



Twins often have similar taste in reading

## ASK THE EXPERT



Prof Thomas Bouchard the world's foremost authority on twins



#### What do you find most amazing about twins?

Everything. It's just stunning to me that two individuals can end up being as similar as they are given the biological complexity that has to be expressed over a lifetime. In my opinion this is still a bit of a mystery.

#### What was the most important finding to come out of your study of twins raised apart?

We studied more traits – medical and psychological – within the same group of twins than anyone else had ever studied before. We found that virtually all traits we looked at were heritable. What's interesting is that this tends to be true across all animal species. So what we really did was confirm within humans what was pretty well known in the animal literature.

#### Was it surprising to discover that many psychological traits are heritable?

When we started our work most psychologists did not believe genes were important for psychological traits. They even argued that serious psychiatric disorders were not genetic, but environmental. A lot of other major twin studies were being done at the same time as ours, all over the world, and all the findings converged on pretty much the same answer, that psychological traits are like physiological traits – they have a genetic component.

#### Which psychological traits do you believe to be the most genetically determined?

Our findings are still pretty crude, but if I had to bet money I would argue human intelligence is more genetic than most other psychological traits. Partly that's because we can measure it with much greater precision. Personality is also very heritable, although not as much as intelligence. And again, studies looking at personality in animals have shown the same thing, so there is evidence that this is a very general phenomenon.

#### What was your most interesting finding?

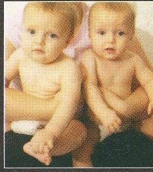
We showed that religiousness is heritable. But it is important to distinguish between particular religions and how religious you are. Which religion one belongs to is almost entirely environmental, but the degree to which one is committed to that religion – which we call religiousness – does tend to be genetic. We had one pair of twins where one was Jewish and one was Christian, but their degree of religiousness was almost the same.

## TWIN TYPES

### Four kinds of twins

#### IDENTICAL TWINS

Making up around a third of all twins, identical or monozygotic twins develop when a single egg fertilised by a single sperm splits in two around the time of implantation in the womb, usually between four and 12 days after conception. The twins share 100 per cent of their genes and are therefore almost always the same sex, except in a few rare cases of genetic mutation.



#### FRATERNAL TWINS

Twice as common as identical twins, fraternal or dizygotic twins develop after two eggs are released and fertilised. The twins share around 50 per cent of their genes, like any other pair of siblings. In rare instances, the second egg is fertilised by sperm from a different man, resulting in twins that are the genetic equivalent of half-siblings. This phenomenon is known as 'heteropaternal superfecundation'.



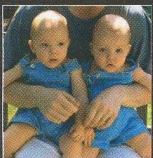
#### MIRROR IMAGE TWINS

Around 25 per cent of identical twins exhibit some form of mirror-imaging in their physical attributes and behaviour. They may have birthmarks on opposite sides of their body, opposite dominant hands, or even mirror-image fingerprints. While no definitive explanation exists, it's thought that this may come about if the fertilised egg splits late – more than a week after conception.



#### POLAR BODY TWINS

Sometimes a single unfertilised egg splits in two and both halves are fertilised. It is not known how many twins fall into this category but they share around 75 per cent of their genes, less than identical twins and more than non-identical twins. In one extremely rare case in 2007, an egg was fertilised by two sperm and then divided to form two embryos. The resulting twins have been labelled 'semi-identical'.



► have a child of their own and adopt another of the same age," explains Segal. What's important about them is they serve as a perfect complement to identical twins reared apart.

If identical twins are alike because of common treatment rather than common genes, then virtual twins should be at least as alike as siblings raised together. But they're not. According to Segal, they're much less alike. "The siblings aren't the same age, they have different school experiences and different peer groups, yet they're more alike than virtual twins who are the same age and have many more experiences in common," she says.

These findings are backed up by a fascinating case that Segal came across, concerning identical twins who were accidentally separated at birth when one was mistakenly switched with another child in Canada in 1971.

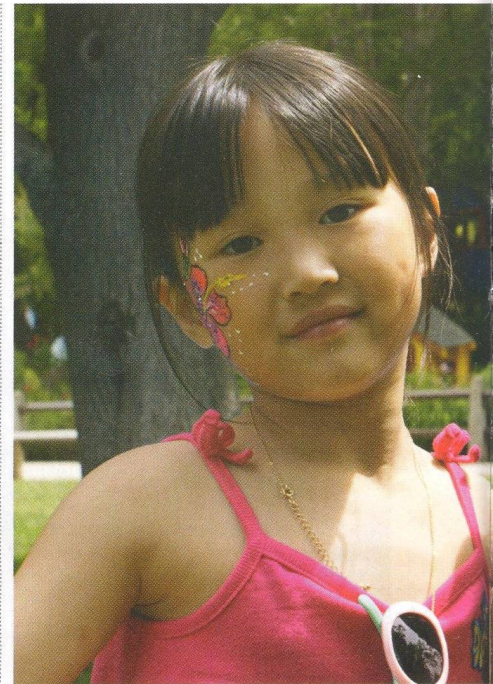
One twin, Brent Tremblay, was brought up alone. The other, George Holmes, was brought up with an unrelated brother, Marcus Holmes – they thought they were fraternal twins but were actually virtual twins. Brent and George met by chance when they were 21, and found that as well as the physical likeness, they shared ideas, thought patterns and a sense of humour. In fact, George was much more like his identical twin, who he'd never met, than the virtual twin with whom he had grown up.

#### Brains in your genes?

Work such as Segal's strengthens the idea that nature plays a greater role in making us who we are than previously believed. But can genetics really explain the extraordinary similarities seen in the lives of twins raised apart? The presumption is that, because their brains are similar, they're responding to environmental variables in a similar way – but nobody knows why.

"All you can have are hypotheses," says Bouchard. "We really don't know how the human brain functions yet. We ascribe these similarities to genetics because the research allows us to, but we don't know how genes actually result in a psychological trait."

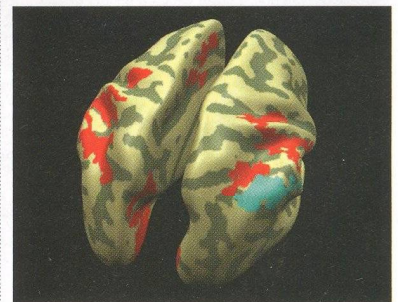
**"The dogma among cognitive scientists has been to say all men are equal in their brains"**



Technology is starting to drop us hints, however. Modern scanning techniques such as fMRI (functional magnetic resonance imaging) are enabling scientists to move the field of behavioural genetics forward by giving a much more detailed picture of how the human brain works. One recent twin study, conducted at RWTH Aachen University in Germany, has been groundbreaking in this respect, being the first to successfully examine the heritability of individual differences in thinking styles.

A team led by Jan Willem Koten studied 10 sets of siblings, each comprising a pair of male identical twins and a non-twin brother. While their brains were being scanned by fMRI they were asked to remember a list of four one-digit numbers. They were then distracted with a side-task, a simple question such as "2 + 4 = 7, yes or no?". Finally, they were shown a number and asked if it was in the original list of digits.

The researchers found that subjects used different brain areas when



Scans reveal brain activity linked to genes

TWIN  
FACTS

**Claustrophobia** is more common among twins than non-twins. It is thought this may be due to their greater experience of confinement in the womb

The frequency of twin births varies from country to country and ranges from 1 in 80 to 1 in 140. Mothers over 35 are more likely to have twins

There would be many more twin births if it were not for the fact that **one twin is often absorbed** in the early stage of pregnancy

**Fetus in fetu** is a very rare abnormality that occurs when a fetus gets trapped inside its twin, sometimes surviving as a parasite even past birth

In ancient times, **twinhood was interpreted as a manifestation of the supernatural. Many religions have gods that are twins**

According to a 15-year study in Germany, **75.8 per cent of twins are born within 15 minutes of each other. Less than two per cent are born more than an hour apart**

memorising the list of numbers. They either used areas related to language, or areas related to imagery (akin to counting on fingers).

"Those who were language-oriented tended to be slower in the number tasks [because they were confused more easily by the distraction task]. People who were more 'finger'-oriented tended to be faster," Koten says. The twins used the same strategy more often than the brothers did, with estimated heritabilities ranging from 60 per cent to 90 per cent in the three stages of the task.

"This indicates that there are qualitative differences in how people think and that the neurobiological bases of these differences in thinking have a genetic component," says Koten.

This study marks a turning point in the way cognitive psychologists investigate the brain, because it shows that individual differences in thinking are worth examining. Previously, the trend with fMRI data was to look for central tendencies or average performance.

"The dogma among cognitive scientists has been to say all men are equal in their brains," says neuropsychologist Professor Klaus Willmes, who worked on the study with Koten. Although that may be true for some parts, such as the primary auditory and visual cortex, we now know that's not the whole story.

Next, Willmes and Koten hope to use twins to look further into the brain, to tease out which other mental functions might display genetically-determined

## CASE THREE

## The Giggle Twins

Two women raised apart in England who found they had a lot in common when they were reunited aged 40

London-born identical twins Barbara Herbert and Daphne Goodship were separated soon after birth and adopted by two different families. Daphne's adoptive parents were wealthy, and she spent her childhood following pursuits such as horse riding, piano and ballet lessons. Barbara's adoptive parents were less well-off. They were reunited in 1979, aged 40, and took part in the Minnesota Study.

Nicknamed 'the Giggle Twins' by researchers because of their high spirits and identical laughter, the study discovered many similarities not only in their tastes but also in their life events. For example, both became nervous of steps after falling

down the stairs aged 16; both met their husbands at Christmas town hall dances; both had miscarriages during their first pregnancies, then had two boys and a girl. They only differed by one point in IQ tests, despite Daphne's more privileged upbringing.



individual differences. "One might expect to see these differences in the frontal part of the brain – the part used to plan, solve problems and respond to or act on the world," says Willmes.

## What twins can teach us

Through the extraordinary mental likeness of identical twins, we have come to accept that the workings of the human brain, like the workings of the body, are as much driven by genetic factors as environmental ones, and that there are genetically determined individual differences in the way we think.

Yet this likeness, so valued by science, remains a mystery. "We have discovered something interesting, but we can't yet explain it," says Bouchard. It may be that further studies of the kind started by Koten and Willmes will help us to better understand the biological mechanisms that lie behind the striking, sometimes spooky, similarities in twins.

Until we have a definitive scientific explanation, there will still be those who suggest that telepathy is at the root of the strange tales told about twins. But it is far more likely that our nature will continue to surprise us as we learn more about genes and the brain. And in this respect,

twins and their families are one step ahead of the rest of us.

"In my experience, having interviewed so many twins and their parents, I would say they are the smartest people I know," says Segal. "They have no problem with things being genetic – they witness it every day in their home." ■

*Emma Bayley is Focus's contributing editor*

*Twins, a two-part investigation, will be screened on BBC One in October*



## FIND OUT MORE

*Entwined Lives* by Nancy L Segal (Plume, 2000)

An accessible and comprehensive account of twin studies and what they tell us about human behaviour

<http://mctfr.psych.umn.edu>  
University of Minnesota Center for Twin and Family Research

<http://bit.ly/matchingtwins>  
Matching the Twins, a YouTube video clip about Koten's study