



VOL TWO / ISSUE THREE

NewScientist THE COLLECTION

BEING HUMAN

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BEING HUMAN

**NEW SCIENTIST
THE COLLECTION**

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Darren Hopes

Welcome to the handbook of you

IF YOU'RE reading this, then you must be a human being. And being human, you may think you know everything there is to know about it. But do you? Do you know, for example, why people have sex in private, why we can't tickle ourselves, or why we yawn, itch and hiccup? Have you any idea how many pairs of shoes or underarm deodorants you'll get through in your lifetime? Do you really know what makes you unique, what your body language says about you, why we are capable of evil and how we read other people's minds?

If you find you need answers to any of these, this issue of *New Scientist: The Collection* is for you. A compilation of classic articles from *New Scientist*, it takes a step back from the everyday chores of being human to tackle the big – and small – questions about our nature, behaviour and existence. Along the way we delve into mind, body, self and emotions, your talents and shortcomings, your relationships and possessions, and how you can make the most of yourself.

Chapter 1 examines human nature. *Homo sapiens* is an animal like no other, but what characteristics really set us apart? Why are humans so nice – and nasty? And what makes each of us unique?

Chapter 2 explores our sense of self. Efforts to create a self-aware robot are starting to reveal its building blocks. But we are more than individuals. In fact, we are so interconnected it may be more accurate to think of ourselves as part of a superorganism.

Chapter 3 gets corporeal. It takes a tour of your body and its curiosities, exploring how humans got to be the shape we are and what your body reveals about you.

In Chapter 4 we delve into the human mind, exploring how imagination, mind reading and

the ability to persuade have been instrumental in our success as a species.

Chapter 5 homes in on our possessions. Our obsession with stuff has deep evolutionary and psychological roots. Possessions are not just useful, they also have meaning for us – and there's a dark side too, leading to behaviours like hoarding and compulsive shopping. Can we move beyond ownership to a post-consumerist culture?

Chapter 6 is about relationships. Why do we have friends and how many do we need? Are male and female friendships different? Has the internet changed friendship? Then there's kin, and questions of how your family and your place within it influence your character and well-being.

Chapter 7 deals with emotions, as you've never seen them before. Here you'll discover what it feels like to live without fear, how to use anger to your advantage, the hidden power of disgust, why rejection feels physically painful, and the strange emotions at the outer limits of our feelings.

Finally, Chapter 8 reveals how we can all get more out of being human. It will help you to identify your hidden talents and be more charismatic. You'll even discover the secrets of success – or at least what success means to you, and how to achieve it. Being human is a privilege. Make the most of it.

Kate Douglas, Editor

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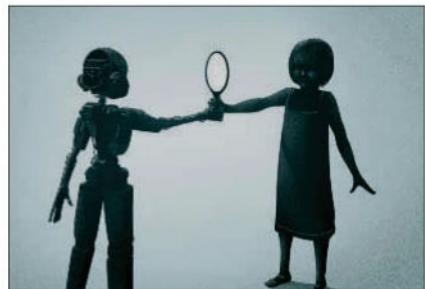
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- A/Prof Charlie Teo, Founder
Cure Brain Cancer Foundation



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BRAIN CANCER

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Yet 90% of Australians are unaware of this fact

*SOURCE CURE BRAIN CANCER RESEARCH OF 1,010 NATIONALLY REPRESENTATIVE AUSTRALIAN ADULTS AGED 18+ JULY 2014

150 117 55 51 49



Brain Cancer



Leukaemia



Heart Disease



Heart Defect



Thyroid Cancer

Number of deaths between 2008-2012

*SOURCE AUSTRALIAN BUREAU OF STATISTICS (2010 – 2014). 3303.0 CAUSES OF DEATH, AUSTRALIA (2008 – 2012) TABLE 1.2 UNDERLYING CAUSE OF DEATH, SELECTED CAUSES BY AGE AT DEATH, NUMBERS AND RATES, AUSTRALIA (2008 – 2012)

Brain cancer is deadly, survival rates are low

90%
OF CHILDREN SURVIVE
LEUKAEMIA

90%
OF PEOPLE SURVIVE
BREAST CANCER

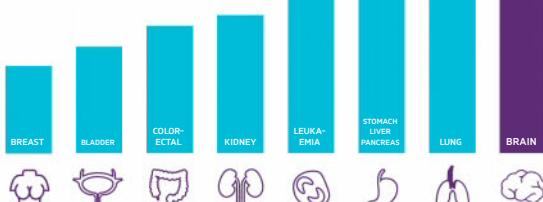
20%
OF PEOPLE SURVIVE
BRAIN CANCER

*SOURCE AIHW NATIONAL CANCER STATISTICS

Brain cancer kills more Australians under 40 than any other cancer.

*SOURCE AIHW NATIONAL CANCER STATISTICS

Brain cancer costs more per patient than any other cancer



*SOURCE THE COST OF CANCER NSW – REPORT BY ACCESS ECONOMICS, AUSTRALIA WIDE, APRIL 2007

It gets worse. For some forms, such as Glioblastoma or DIPG, survival is much lower.

5%
OF PEOPLE SURVIVE
GLIOBLASTOMA

*SOURCE (OSTROM, Q., GITTLEMAN, H., FARAH, P., ODRACEK, A., CHEN, Y., WOLINSKY, Y., STROUP, N.E., KRUCHKO, C.C., BARNHOLTZ-SLOAN, J.S. (2013). CBTRUS STATISTICAL REPORT: PRIMARY BRAIN AND CENTRAL NERVOUS SYSTEM TUMOURS: DIAGNOSIS IN THE UNITED STATES IN 2006-2010. NEURO-Oncology, 15(2), p50-51.

34%

19%

18%

17%

2%

Prostate

Cancer

Bowel

Breast

Brain

* SOURCE: INCREASE IN SURVIVAL RATES 1982 - 2010. AIHW NATIONAL CANCER STATISTICS

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CHAPTER ONE

HUMAN NATURE

WHAT sort of creature is the human? The obvious answer is a smart, talkative, upright ape with a penchant for material possessions. But what about the more subtle concept of human nature? That is more controversial. Some deny it exists, preferring to believe that we can be anything we want to be. They cannot be right.

Although we exhibit lots of individual and cultural variations, humans are animals, and like all animals we have idiosyncrasies, quirks and characteristics that distinguish us as a species. An invading alien would have no trouble categorising us but, being so close to our subject matter, we struggle to pin down the essence of humanness. Nevertheless, the task may not be beyond us. Anthropologists have identified many “human universals” – characteristics shared by all people everywhere, which constitute a sort of parts list of our species. What if we were to use these to examine the human animal in the same way we would study any other?

As the following pages reveal, what emerges is a suite of characteristics that encapsulate our nature – and a rather peculiar one it proves to be. If you thought you knew what humans were like, then think again.



The nature of the beast

Being one yourself, you might think you know what people are like. Think again, say Kate Douglas and Bob Holmes



Playful

(adj) Full of high spirits and fun

Humans are not nature's only funsters. All mammals play, as do some birds and a few other animals. But no other species pursues such a wide variety of entertainment or spends so much time enjoying themselves. The list of universals includes such diverse extracurricular pleasures as sports, music, games, joking, hospitality, hairdressing, dancing, art and tickling. What sets us apart is the fact that we play with objects and with language, says Clive Wynne at Arizona State University in Tempe. We can also go beyond the literal. "What revolutionises human play is imagination," says Francis Steen at the University of California, Los Angeles.

"We're a playful species," says primatologist Frans de Waal at Emory University in Atlanta, Georgia, and we retain our juvenile sense of fun right into adulthood. The only other primate to do that is the bonobo, perhaps as a result of its relaxed social environment. Human society is also relatively relaxed, de Waal notes, because we have moral codes and laws that promote stability. Crucially for the entertainment industry, we will also happily congregate with unrelated individuals, a situation that would leave both chimps and bonobos tearing strips off each other. Then there's the simple matter of leisure time. In the wild, adult chimps spend ➤

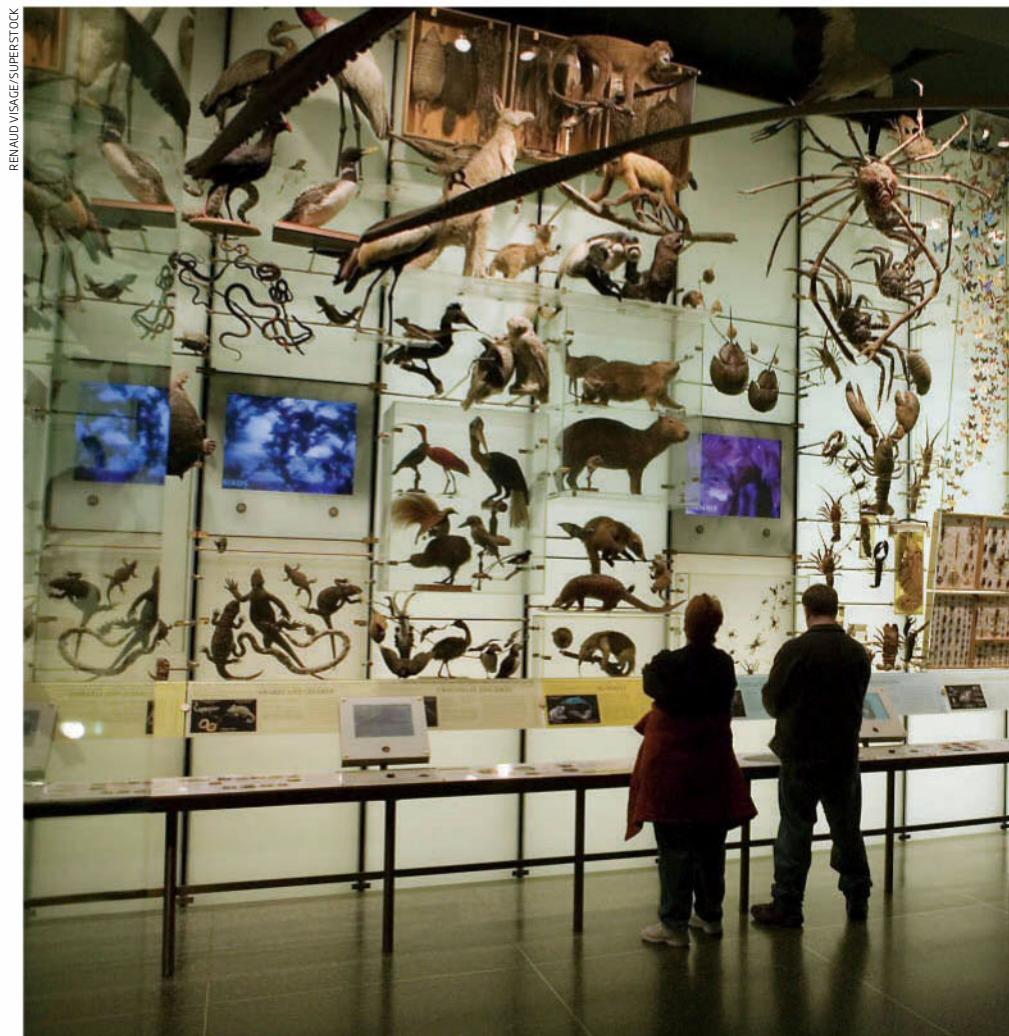
"Play is a sort of simulator that allows us to imagine and try out different scenarios with little risk"



around 8 hours a day foraging. Given more free time, they might play more. De Waal points out that captive apes enjoy computer games and watching TV, favouring scenes of sex and violence, but also appreciating slapstick humour.

But is it just opportunity that allows us to indulge our playful side, or do we actually need more entertainment than other animals? Play isn't simply for fun, notes Marc Bekoff at the University of Colorado, Boulder. He identifies four primary purposes - physical development, cognitive development ("eye/paw coordination" as he calls it), social development and training for the unexpected. Playing is an evolutionary adaptation for learning, agrees Steen. Mammals are born inept but can adapt - playing helps us do that. Noting that human social and physical environments are particularly complex, he sees playing as a sort of simulator that allows us to imagine and try out different scenarios with little risk. "In play we are most fully human," he says.

Bekoff believes social development is the most important purpose of play for humans, not least because it underpins morality. "Young children will not become properly socialised without it," he says. For Robin Dunbar at the University of Oxford, playfulness is a mainstay of social cohesion. "Play often involves laughter, which is a very good bonding mechanism," he says. And physical play - especially coordinated team sports - produces feel-good endorphins. In addition, sports provide a release for competitive urges, says de Waal. "If people watch others playing, that actually improves their own skills," adds Steen. Even entertainment for sheer pleasure has benefits. "It's fun, so it's really good for mental health," says Bekoff.



Scientific

(adj) Inclined to the methodical study of the material world

"What sets us apart from other animals? One likely candidate is our drive to ask why"



From earliest infancy, humans are constantly sorting the world into categories, predicting how things work, and testing those predictions. Such thinking, which is the essence of science, is evident in a range of human universals from time, calendars and cosmology to family names and measuring. "Science is basically working at understanding the world around us," says Edward Wasserman at the University of Iowa in Iowa City. And it is not confined to humans – all animals need scientific thinking to survive. "It's in our job description," he says. Pigeons, for example, can learn to discriminate between cars and chairs. Dogs can associate the sound of a bell with food, and when chimps try to extract a nut from a tube, they are performing a simple experiment.

Clearly, no other animal does science to the extent that we do, though. So what sets us apart? One likely candidate is our drive to ask

why. Daniel Povinelli at the University of Louisiana in Lafayette taught both children and chimps to stand an L-shaped block on its end, then secretly substituted an apparently identical block that would not stand up. The chimps just kept trying, he says. "But the kids would stop and turn the block upside down and feel the bottom of it. They'd shake the block, try to figure out what was inside it. They would do all kinds of things in an attempt to diagnose why it wouldn't stand up".

Another possibly unique feature of humans is our ability to grasp abstract concepts. Chimps struggle with this. For example, while they quickly learn that heavy rocks are better for smashing nuts, when it comes to a general understanding of weight, they falter. "If they hear two objects drop and one goes 'bam!' and the other goes 'click' they can't infer that one of those objects will be good for cracking a nut

Legislative

(adj) Having the power to make laws



Humans cannot resist the urge to classify and make connections

The question of whether every human society has formal laws is far from settled, but they do all have rules. This is a peculiarly human trait. Our closest relatives, the chimps, may stick to simple behavioural rules governing things like territories and dominance hierarchies, but we humans, with our language skills and greater brainpower, have developed much more elaborate systems of rules, taboos and etiquette to codify behaviour. Though every society has different rules, they always involve regulating activity in three key areas – a sure sign that these are fundamental to human nature.

For a start, we are all obsessed with kinship, which brings rights, in particular to inheritance of goods and status. "There are always rules about who counts as kin, and what obligations you have to kinfolk," says Robin Fox at Rutgers University in New Brunswick, New Jersey. The rules may favour maternal or paternal links, or treat both equally. Every society recognises the uniquely human concept of kinship by marriage, as well as believing that kinship entails duties to family members – for which there are rules. And all have incest taboos, usually prohibiting sexual intercourse between immediate family (though royalty are sometimes exempted).

After who's who, everyone worries about safety, so every culture also has rules about when one person can kill another. "I don't know of any society

that doesn't condemn murder," says Sally Engle Merry at New York University. "However, what constitutes an illegitimate killing is complicated." In some societies, any stranger is fair game. Others allow killing to avenge the murder of kin, and many allow the group to kill someone who violates its norms. But every group draws the line somewhere.

Every society also has rules governing the use of objects. The notion of private property is by no means universal, but people everywhere do have rules that stipulate who is entitled to use certain things at particular times. These vary widely from a simple first come, first served, to the elaborate system of private ownership in industrialised societies.

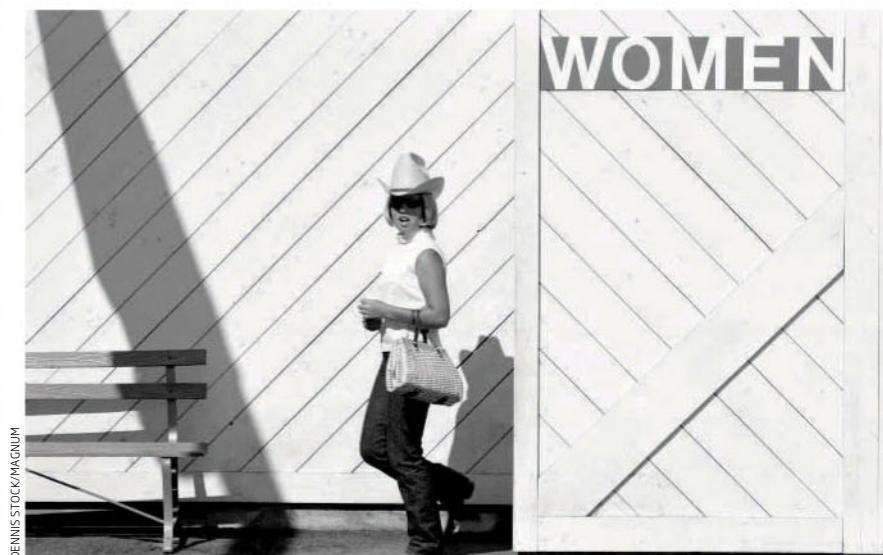
Kinship, safety, stuff. Across the whole range of human cultures this is what our rules say we care about. But perhaps there is a deeper part of human nature that underlies all these concerns: a desire for rules themselves. Rules help us navigate the hazardous waters of interpersonal relationships and provide a framework for knowing how to act, says Justin Richland at the University of Chicago, Illinois. That makes them an essential part of us.

"It's the most basic feature of human nature," agrees Fox. "We're the rule-making animal."

Our tendency to play by the rules is a building block of morality

and the other won't," says Povinelli, whereas we can. Crucially, this understanding allows us to use what we have learned in one domain to make causal predictions in another – so, for example, we can predict that something that goes "bam!" will sink, whereas something that goes "click" may well float. Our nimbleness at abstract causal reasoning is tied up with our facility with language and probably underlies many of our other social skills, such as rituals and rules of behaviour, too. Povinelli believes this is what really sets humans apart from even the brightest apes.

There is one more trait that distinguishes us from less-scientific animals: an eagerness to share what we have discovered. Once we figure something out, we announce it to the world, which is why all scientifically minded humans, not just Newton, can stand on the shoulders of giants.



Clandestine

(adj) Secret and concealed, often for illicit reasons



Nothing reveals an animal's nature quite as well as its sexual practices, and humans certainly have some strange ones - even from a biological point of view. Women are continually receptive and have concealed ovulation - that is, there is no external sign that they are in a position to conceive. We are the only monogamous primate to live in large mixed-sex groups - more about these later. But surely nothing is quite as puzzling as our predilection for clandestine copulation. Why do humans have sex in private?

This coyness is not just the consequence of particular cultural or moral views. "It is the rule across all kinds of human societies," says cultural anthropologist Frank Marlowe of the University of Cambridge. There is the odd case of public ritual sex, such as orgies among the Canela of Brazil. But where there is no alcohol - as would have been the case in the past before agriculture - sexual privacy is the norm. What is going on?

"In the context of other primates it's

very interesting," says Clive Wynne at Arizona State University in Tempe. Sneaky mating occurs in species where there is a lot of inter-male competition and males control sex by controlling females, he says. Among orang-utans, alpha males copulate openly but subordinates are so discreet that nobody realised they mated at all until the advent of genetic paternity testing. The situation is similar for gorillas. In bonobos, by contrast, females control the show and sex is a free-for-all. "I've never seen anything that resembles privacy in bonobos," says Frans de Waal of Emory University in Atlanta, Georgia. "I think the origin of privacy [in humans] has to do with competition."

Nevertheless, human sexual politics has become a lot more complicated over time. For a start, women won some control from men by evolving concealed ovulation and continual sexual receptivity to confuse paternity. Then our ancestors did something completely different from other great apes -

"Infidelity is widespread and private sex allows it to occur without loss of reputation"

males and females started sharing parental care. Monogamy was born. Now, infidelity among pairs living in large groups became more risky than ever, with infanticide by males the ultimate price, says Robin Dunbar of the University of Oxford. So there was a need to strengthen the pair bond. "We have this odd thing called love," he notes, adding that privacy may also have emerged as a way to increase intimacy.

Dunbar sees clandestine copulation as a trade-off, because as well as strengthening relationships it makes infidelity easier. David Buss of the University of Texas at Austin thinks that could actually

Epicurean

(adj) Loving food and finer things

Compared with other animals, the feeding behaviour of humans is exceedingly odd. Where they just eat, we make a meal of it. The main difference is down to one of humanity's greatest inventions: cooking. People in every culture cook at least some of their food, says Richard Wrangham at Harvard University. He has made a persuasive case that cooked food, which delivers more calories with much less chewing than raw food, was the key innovation that enabled our ancestors to evolve big energy-hungry brains and become the smart, social creatures we are today. Chimps spend at least 6 hours a day chewing, he notes, humans, less than 1. That leaves a lot of free time for culture.

Culinary culture includes the strange phenomenon of ritualised, familial, food-sharing, otherwise known as mealtimes. Chimps eat their food individually, as they find it throughout the day. "It's not as if chimps ever meet to eat," says Wrangham. But we do. In every human society, people gather in family groups at more or less regular times of day to eat what has been cooked. And wherever you go, these everyday meals tend to be cooked by women. We don't know why - perhaps originally in exchange for men's protection, or because childcare kept women closer to home.

Then there's feasting. From sharing the spoils of a good hunt, to celebrating a special occasion, every society does it. And here you are more likely to find men cooking. We even see this in our own backyards, where they do most of the barbecuing. "My own thinking is it has something to do with establishing a reputation as being generous, in control of the high-quality food," says Wrangham.

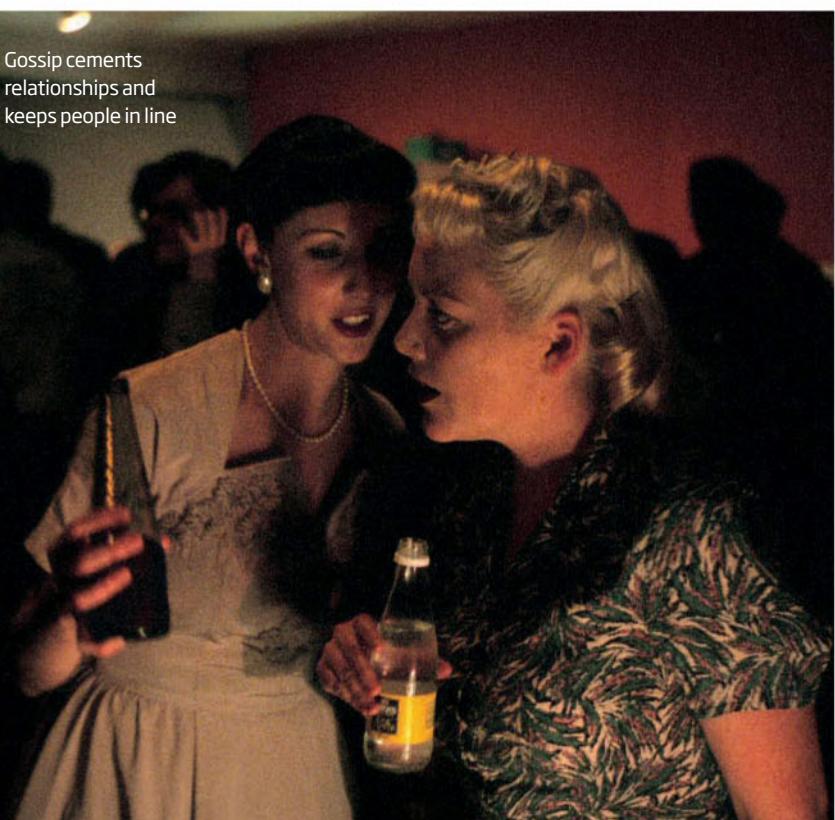
The way humans meet to eat is a big departure from the every-individual-for-itself approach taken by other animals. For us, eating is much more than mere nourishment. "In all cultures, food is used to form social bonds," says anthropologist Polly Weissner at the University of Utah in Salt Lake City. Mealtimes are the centrepiece of family life; feasting bonds friends, colleagues and communities; and we also use food to consolidate more intimate relationships, sharing a fancy meal with that special someone, for example, or giving chocolates on Valentine's day.

So food draws us together, but it sets us apart as well. Every culture has its own food traditions and taboos, which help define the boundaries between "us" and "them". They have distinctive cuisines too. "Ethnic differences are marked by what kind of food you eat," says Weissner. "You are what you eat."



be a benefit. "Humans are socially monogamous, not sexually monogamous," he says. Infidelity is widespread in all traditional cultures, and private sex allows it to occur without loss of reputation. Another very human trait, envy, may also play a part. In his landmark book, *The Evolution of Human Sexuality*, anthropologist Donald Symons suggests that since men can never get enough of it, sex is a precious commodity and therefore best enjoyed covertly to avoid inciting covetousness.

"This is for the same reason that during a famine anyone with food is likely to consume it in private," says Steven Pinker of Harvard University. "A sexual act, even among consenting adults, has a high probability of upsetting someone," he adds. Parents or community members may disapprove and for children it can lead to the creation of rival siblings. So perhaps clandestine copulation simply follows the precautionary principle. "You can't be too careful," Pinker says.



Gossipy

(adj) Tending to talk about others

Language was once thought to be the defining characteristic of humans. These days we are more likely to consider it as part of a continuum of animal communication. Nevertheless, nobody doubts that it has shaped our nature profoundly. Language is central to human universals ranging from education, folklore and prophecy to medicine, trade and insults. Arguably, our way with words reaches its apogee in gossip.

A compulsion to talk about other people is only human. And it is not nearly as frivolous as you might think. Some anthropologists believe we gossip to manipulate the behaviour of others, which may help explain why gossip often takes place within earshot of the person being gossiped about. Among the Kung Bushmen of Africa, for example, that is the case 70 per cent of the time, says Polly Wiessner of the University of Utah. "And I think it often happens in schools here," she adds. "A group of girls will gossip within earshot of the girl they gossip about, intending for it to be heard."

But gossip doesn't just serve to name

and shame. When Dunbar eavesdropped on people gossiping, he found that barbed comments were relatively rare compared with innocuous ones. He believes that gossip is the human equivalent of primate grooming – our social relationships are too numerous to cement each one with time-consuming grooming, so we chat instead. "Gossip evolved for oiling the wheels of social interaction," he says. Even the most powerful movers and shakers depend on it, though they may call it by some other name. After all, says Dunbar, most business could easily be transacted by phone or email, but people still meet face-to-face so that they can bond over casual conversation at lunch or on the golf course.

Wiessner observes that a juicy titbit of gossip is a gift – and, incidentally, gift-giving is another human universal. "In the Kalahari, where I work, it is so boring. [That's why] people talk about other people most of the time." Wiessner goes so far as to assert that a society without gossip would simply dissolve. "People wouldn't have any common interest to stay together." ■



One and only you

No matter how alike two people appear they are in fact as different as different can be. **Caroline Williams** discovers the things that make us unique

LOOK at the people around you and you cannot fail to notice how different they all are. Their faces, bodies, behaviours and personalities all appear to be unique.

Now consider the whole of humanity. There are about 7 billion of us alive now and by some estimates about 100 billion people have lived and died in the past 50,000 years. As far as we know each of them is, or was, a total one-off. The same applies to all those yet to be born.

That is a staggering amount of variation within the archetype we recognise as "human". As we delve deeper into our biology and search for ever more sophisticated ways to verify people's identity, the ways in which we are all unique are being uncovered. Some, like DNA

and fingerprints, are obvious. Others, less so.

So your mother was right: you are very special indeed. But don't just take her word for it. Here are 11 ways in which you are a one-off.

DNA

It's the obvious place to start. And it is also true: DNA does make you unique – up to a point. To get a measure of just how different you are genetically from everybody else try these numbers for size.

In 2001, the human genome project reported that all humans have 99.9 per cent of their DNA in common, leaving just 0.1 per cent to account for all our myriad differences. Since

then, this estimate has been revised upwards to about 0.5 per cent, but even that is a very small sliver of the genome. Is it enough to account for the variation we see?

In theory, yes, in spades. The human genome contains approximately 3.2 billion letters of the DNA code; 0.5 per cent of that is about 16 million letters. The code has four letters, so the number of possible combinations is four raised to the power of 16 million – an absolutely vast number of possible human genomes, more than enough to go around everybody who has ever lived, many times over. The chances of anyone having exactly the same genome as you is zero.

That is even true of identical twins. Although

they are 100 per cent genetically identical at the time of conception, from that moment on their genomes diverge, and the older they get the more individual they become.

In identical twins (and the rest of us too), these differences come from slight changes and chance mutations every time DNA is copied. These can result in single nucleotide polymorphisms (SNPs), where a single letter of the code is changed, and also copy number variations (CNVs), where long sections of DNA are duplicated or deleted altogether.

Something similar happens with what are called epigenetic markers, which help regulate how genes are expressed. Identical twins drift apart on this measure from very early in life, and the rest of us undoubtedly do too, adding another vast layer of potential genetic variation.

What isn't yet known is the proportion of these genetic variations that actually make you different from other people. Many occur in non-coding regions that don't make proteins or regulate gene expression. And even if they are in coding regions, many are likely to be neutral, altering neither a gene nor how it is expressed.

We do know, however, that tiny genetic differences can have large effects on physical traits such as eye colour or susceptibility to disease. So it is safe to say that your uniqueness as a person starts with the genome.

But it is far from being the whole story. Many other factors come into play: the environment, the physical forces that acted on you in the womb and a healthy dose of randomness. A case in point is fingerprints.

FINGERPRINTS

Another no-brainer: everyone knows that fingerprints are unique, so it might come as no surprise that their size and shape is largely determined by genes. But the developing fetus's fingerprints are also tweaked by subtle factors like the pressure of the walls of the womb and even the sloshing of amniotic fluid.

That means that although the fingerprints of identical twins can be very similar there are enough differences to tell them apart. Known in the fingerprinting business as "minutiae", these differences include variations such as a ridge splitting into two in a slightly different place in each twin or a loop being wound slightly more tightly. The same goes for toe prints.

We can easily identify people we know by the way they walk

Forensics notwithstanding, no one really knows what fingerprints are for. One study showed that, contrary to popular belief, they don't help with grip because they reduce, rather than increase, friction. Other possibilities are that they protect the skin by making it more flexible, or that they improve our sense of touch by amplifying vibrations.

Whatever their purpose, they clearly aren't crucial to survival. Researchers have identified a mutation that has caused a handful of people in just five families to be born without fingerprints. All seem to get along fine, at least until they get to border control – the condition is also known as immigration delay disease.

FACE

Faces are our most obvious badge of identity and we find it easy to recognise people by face alone. But they are perhaps not as distinct as we like to think. Even leaving aside identical twins, there are plenty of doppelgängers around. One analysis of several thousand Norwegian faces found that 92 per cent of them had at least one lookalike that both humans and facial recognition software struggled to tell apart.

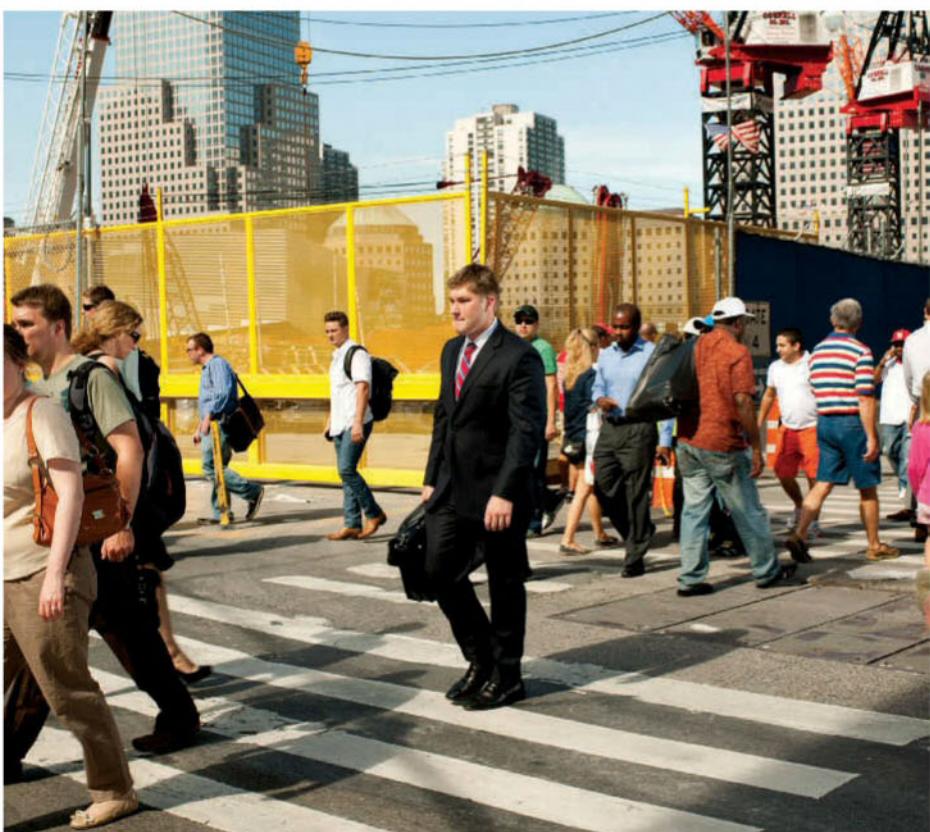
In another study, when asked whether two very similar photographs of faces came from the same person or not, neither human nor machine did any better than would be expected by chance. Humans got it right just 56 per cent of the time with unfamiliar faces and 66 per cent with familiar ones – surprisingly low considering how much of our identity is tied to our faces.

GAIT

Since our ancestors first became fully bipedal, at least 1.5 million years ago, humans have all walked in more or less the same way: one foot in front of the other, swinging from the hip and rolling from heel to toe. Remarkably, every one of us to walk the Earth since may have done so in a slightly different style.

While we can't be sure that everyone really does have a unique way of walking, studies as far back as the 1970s showed that gait differs enough for us to recognise people we know just from the way they walk at least 90 per cent of the time.

Gait changes during childhood but settles down when we stop growing. Then, differences in the length of our legs and



BRIAN FINKE/GALLERYSOCK LEFT: BRIAN SHURWAY/GALLERYSOCK

width of our hips, plus environmental factors such as the amount of muscle we build up through exercise combine to give us a characteristic walk.

It's something that is easy to spot but difficult to describe, says Mark Nixon, who researches gait at the University of Southampton, UK. "We don't have the words to describe the motions," he says.

Computers do it better, either by tracing the lines of the limbs and turning their movements into numbers, or by tracking the movement of various points such as hips, knees and feet and measuring their changing relationship as they move.

Another way to measure gait is to have someone walk over a pressure pad and record their unique footfall. This kind of system, developed by Todd Pataky's group at Shinshu University in Japan, could potentially be used to fast-track passengers through an airport.

Yet another idea, so far in its infancy, is to use the kind of motion sensors found in smartphones. Strapped to the leg, these could measure speed, acceleration and rotation. The technique could be used as a security feature for cellphones, so that they would only work when carried by their rightful owner.

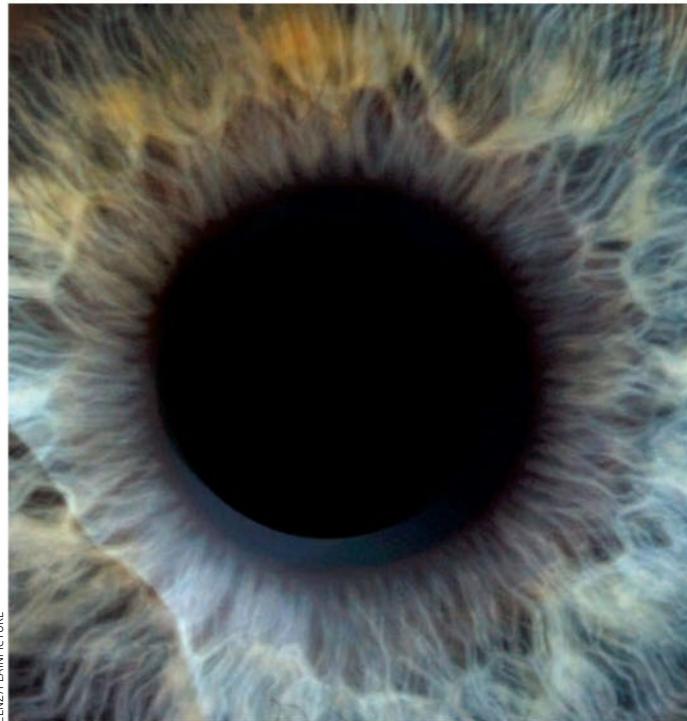
EARS

You probably haven't paid that much attention to the exact shape of your ears, but if you look in the mirror and pull them out you will see that one is very slightly different from the other. Not only that, but each of your ears is different from everyone else's.

This is because the human ear develops from six tiny bumps that appear on the side of the head around five weeks after conception, then gradually fuse. Although genes map out the general shape, the environment in the uterus, such as how the fetus lies, affects how ears turn out. Once formed, they hardly change shape as we (and they) grow and age.

Several researchers are working on ways to recognise people by the shape of their ears. An analysis found that ear identification is just as accurate as face recognition when identifying people from photographs.

In the US and the Netherlands people have even been convicted on the basis of an "ear print" left at the scene of a crime. The science of recognition by ear print is more controversial, however, because the shape of the print changes depending on the amount and direction of pressure put on the ear. At least one suspect in the US has been released on appeal after ear-print analysis was ruled unreliable.



LENZ/PLAINPICTURE

EYES

The iris of each eye is distinctive enough for several countries, including the UK, US and Canada, to accept an iris scan as proof of identity. But as anyone who has their daddy's eyes knows, the appearance of the iris runs in families. So how can eyes that are the spitting image of the rest of the family's be considered unique? The answer lies in the complexity of the iris's structure, a tangled mesh of muscles, ligaments, blood vessels and pigment cells that give it colour, depth, furrows, ridges and spots.

The colour and general texture of the iris is genetically determined, which accounts for family likenesses and for the fact that nearly everyone's left and right eyes look much the same. But iris-recognition systems used in airports ignore colour and texture and concentrate on the details of the ridges, furrows and freckles. These depend on the exact placement of the ligaments, muscles and pigment cells as the iris develops before birth, which happens randomly rather than being controlled by the genes. By this measure, each of your eyes is as different from the other as it is from anyone else's.

VOICE

When you speak, the sound that comes out is the sum of many parts: the noise that air makes as it vibrates through the larynx, the way it bounces around through the mouth and nose, and how it is shaped into words by the palate, tongue, lips and cheeks.

Since it is highly unlikely that two people will have a larynx, mouth, nose, teeth and

The exact shape and structure of a person's iris is largely random

muscles of exactly the same size and shape, voices end up being unique and easily recognisable (see "Voice almighty", page 44).

But unlike some features, such as fingerprints and iris, we can deliberately change our voice by altering how we use the muscles of our face and larynx to create volume, pitch and tone. According to Sophie Scott, a neuroscientist at University College London, that means most people are good at changing their voice when they want to, and even when they don't: our voices often change in response to social situations in ways we are unaware of.

Some people are clearly better at deliberately changing their voice. Scott is studying how impressionists can mimic others so convincingly. There are no clear answers yet, but she says that good impressionists seem to be highly musical, and adeptly imitate mannerisms as well as voice.

All of this means that there is no way of reliably identifying an individual voice by comparing waveforms or pitch and tone. There are a few voice signature systems on the market, but they tend to be backed up by an identity card or password, just in case a good impressionist turns bad.

SCENT

Dogs have always known it, and now science can prove it: no two people smell alike. But is there really enough variation for all 7 billion of us to have a unique odour? Definitely, says George Preti of the Monell Chemical Senses Center in Philadelphia, Pennsylvania. "Just think about what nature

"One aspect of your uniqueness isn't, strictly speaking, part of you at all. It comes from the 100 trillion bacteria that live on you and in you"



RANDY FARIS/CORBIS

does with only four bases in DNA. In the armpit alone there are at least a couple of dozen odorants, perhaps more, and you can have lots and lots of variation in relative amounts and concentration."

We don't have just one scent, of course, but several. Our various nooks and crannies have different types and quantities of secretions, and harbour different kinds of bacteria, which turn our mostly odourless secretions into scent.

An analysis of the volatile organic compounds in the sweat of 200 volunteers showed that out of the mix of nearly 5000 acids, alcohols, ketones and aldehydes, 44 of them varied enough to give an individual chemical profile that can be read like a fingerprint. Many of these compounds seem to have no other function than to make us smell. They may have a role in how we identify each other, Preti suggests.

No one has invented a way of capturing the total scent of a person and using it to identify them, although the US government is said to be interested in such a technology and Preti says he has been working on it too.

HEARTBEAT

Crooners would like to have you believe that two hearts can beat as one. In reality, no two heartbeats are the same. You wouldn't notice by putting your ear to somebody's chest, but it is possible to tell hearts apart by recording their electrical impulses.

An electrocardiogram (ECG) records three peaks: the P wave, which is the impulse that contracts the upper chambers; the QRS complex, the stronger contraction of the lower

chambers; and the much smaller T wave as the heart relaxes.

Each heart varies in size and shape, so the height, length and spacing of the peaks varies from person to person. And while the spacing of the peaks changes as the heart rate speeds up with exercise or stress, the individual signature can still be discerned.

Because heartbeat is subconsciously controlled it is almost impossible to fake, and a handful of biometrics companies are working on scanners that could be used to check identity. Apple, too, is working on using heartbeat as a password to protect private information. Where they lead, others will undoubtedly follow.

BRAINWAVES

What could be more individual than the way you think? It's something that seems obvious, but only recently has evidence started to emerge that measurable differences between people exist.

Although we are born with a huge number of neurons, our brains gradually prune out an astonishing 50 per cent of them during infancy and childhood. This process – which is driven largely by experience – leaves each of us with a unique brain that goes about tasks in a slightly different way from everyone else's. By listening in to the electrical activity of the brain with EEG, we can detect these subtle differences.

A 2001 study by Raman Paranjape at the University of Regina in Saskatchewan, Canada, found that a type of brain activity called alpha waves was different enough in 40 people to tell them apart. Another study found that the

No two people's heartbeats are exactly the same

strength of another kind of brainwave – gamma oscillations – also varied in 100 people while they were doing a standard test of object recognition.

Could brain differences explain why we all have different personalities? Possibly, though what isn't known yet is whether a person's brainwaves would be recognisable if they were measured days or even years later. Without that, there's no way of knowing if your brainwaves are like a fingerprint or just unique to one moment in time.

MICROBIOME

One aspect of your uniqueness isn't, strictly speaking, part of you at all. It comes from the 100 trillion bacteria that live both on and in you. They outnumber the body's cells 10 to 1 and in genetic terms they are even more dominant: microbes account for 3.3 million genes, compared with your measly 23,000. "You're 0.7 per cent human," says Jeremy Nicholson, a biochemist at Imperial College London.

Of the more than 1000 species that commonly live in and on the human body, each of us harbours only 150 or so, mostly in the gut. And everyone's bacterial population is made up of a different cast of characters.

Skin bacteria, too, vary from person to person though they are remarkably stable over time. One study found that a unique bacterial fingerprint is transferred from our fingers to the things we touch, such as a computer keyboard or mouse, and will hang around for up to two weeks. Even identical twins, who are difficult to distinguish on the basis of DNA, are easy to tell apart when you check out their bacterial companions.

Bacteria also contribute to uniqueness by modifying our metabolism. All humans share a basic biochemistry, but layered on top of this is a microbial biochemistry that is much more diverse. The metabolites that microbes produce affect a range of things, including cholesterol and steroid metabolism.

"There are a few thousand basic enzymatic reactions in the human body but there are tens of thousands of metabolites – because our metabolism interacts with microbial metabolism," says Nicholson. What this ultimately means is that without our non-human component, we wouldn't be ourselves at all. ■

Homo virtuous?

Humans are capable of incredible kindness and cruelty. What drove the evolution of our moral compass, asks Kate Douglas

A FEW years ago, I attended a conference on animal behaviour in Atlanta, Georgia. The end-of-meeting party included a trip to the zoo, and while we roamed freely between the caged beasts the conference organisers conducted a whimsical poll to discover which animals people thought were the “best” and “worst”. As you might expect the nominations were eclectic, but one name cropped up more frequently than any other – *Homo sapiens*. More striking still, humans were equally likely to end up in the “best” and “worst” categories. Some respondents even chose humans for both.

There is no getting away from it: *Homo sapiens* is both the basest of animals and the most noble. Ours is a species capable of horrific cruelty, genocide, war, corruption and greed. Yet we can also be caring, kind, fair and philanthropic – more so than any other creature. What lies behind this dual nature?

Our capacity for good and evil has exercised philosophers from Plato and Aristotle to Jean-Jacques Rousseau and Thomas Hobbes, but today some of the most exciting ideas are coming from an understanding of our evolution. In recent years, researchers have addressed such thorny questions as: why would altruism evolve, how did human conscience emerge, why does it feel good to be nice, and what causes us to give in to prejudice and hatred? The potential power of these insights is intriguing. By understanding the

kinds of environments that foster the saint rather than the sinner, we can try to create societies that promote our better nature. It’s not just a pipe dream. Some evolutionists are already putting their theories into practice.

The key to virtue is altruism. Anyone can do the right thing given enough incentive, but what distinguishes genuinely good deeds is their selfless nature – a rare phenomenon in the wild. Although colonial insects such as bees and ants can show an impressive level of self-sacrifice, the individuals are so closely related that helping others is tantamount to being selfish, at least in evolutionary terms, since it ensures the survival of their own genes. Relatedness can also explain why many birds, and some other animals, will help rear each other’s offspring.

It is far harder to find generosity extending outside the family. Even our closest evolutionary cousin, the chimpanzee, is basically selfish, although in one experiment chimps displayed a small amount of altruism similar to that found in young children, being just as likely to pass an object to an unfamiliar chimp even if some physical exertion was required. In a nice twist to our preconceptions, vampire bats offer one of the very few bona fide exceptions to the rule, sharing blood meals with their roost-mates.

Yet humans do appear to behave selflessly. Since the 1980s behavioural economists have used games to assess our altruistic tendencies.



First came the “ultimatum game”, wherein player A is given some money and told to split it with a second anonymous player B. If B accepts the split, both keep their share; if not, neither gets a cent. It is free money, so B should accept any amount no matter how small and A should offer as little as possible. But that is not what happens. Instead, in university labs around the world, the most common offer is 50 per cent, with an average of around 45 per cent. Even in a refined version of the experiment called the “dictator game”, where A can choose either to give half or 10 per cent and B has no option to reject, three-quarters of people make the more generous offer. It would appear that humans are very nice (and not very logical).

But are we really? Generosity may flourish in the sanitised environment of the lab, but experience suggests that people behave somewhat differently in the messy maul of the real world. And, sure enough, the evidence for virtue is less convincing out there. In one study, collectors of sports cards offered dealers a fixed amount of money in exchange for their best card at that price. John List from the University of Chicago found that when the transactions were done under his watchful eye, dealers played fair, coming up with a card that was worth what the collector had offered. But when dealers were not told they were taking part in an experiment, many ripped off their customers. Such cheating was particularly rife when they were off their home turf, away from their day-to-day customers.

Why be nice?

Anyone who considers humans to be the worst of animals will conclude that people behave well only if they think they are being watched, proving that there is no such thing as altruism. Another interpretation is that we simply need to redefine virtue in biological terms. After all, altruism cannot be without benefit for the do-gooder, otherwise it would not have evolved by natural selection in the first place. Working on this principle, evolutionary biologists have come up with a variety of explanations for human niceness.

The first possibility is rather disheartening. Traditional hunter-gatherer groups tend to consist of closely related individuals, with kin constituting around a quarter of the members. Individuals who helped their close relatives ended up passing on more genes, including those pushing us to help our own flesh and blood. So, like bees in a hive, we have ➤

"An individual's moral compass is not fixed. In a toxic culture almost everyone is capable of evil, from bullying and corruption to torture and terrorism"



MICHAEL HANSON/SYGMA

evolved strong nepotistic instincts and, by this argument, niceness to non-relatives is simply a case of overspill.

However, it takes time and energy to help others, so evolution would have favoured people who made fewer of these costly mistakes, unless the generosity provided benefits that outweighed the costs.

Reciprocity might be one such reason to do right by others. It can explain the altruistic behaviour of vampire bats, for example: they starve to death after a couple of nights without a blood meal, so sharing with a roost-mate that is likely to return the favour is an obvious strategy to help them pull through tough periods. Humans live in groups and are highly dependent on others, and we remember who owes us a favour, so we are perfectly placed to benefit from reciprocal altruism. Indeed, it might explain why List's sports-card dealers tended to play fairer on their home turf, where they are likely to bump into customers again.

It's not just our immediate acquaintances we have to worry about when considering the judgemental eyes of others. Humans are incredibly nosy: we like nothing better than to watch those around us and then gossip about our insights to others. This is how reputations are made and destroyed – and reputations matter. Virtues such as generosity, fairness and conscientiousness are universally valued and people who are seen to display them are rewarded – others like these individuals, want to do business with them and are more sexually attracted to them. So a good reputation can boost your chances of survival and reproduction. Taking this to its logical conclusion, Christopher Boehm from the University of Southern California, Los Angeles, argues that over the course of evolution rumour and hearsay may have forced us into becoming more altruistic – albeit in a biological self-serving sort of way.

Besides offering benefits for the individual, altruism would also have determined the way

groups competed over resources. Those that pulled together would have beaten groups whose individuals were more selfish, ensuring their survival. This "group selection" has been a controversial idea, but it is increasingly being accepted as an important driving force behind the evolution of altruism, says Edward O. Wilson at Harvard University.

So we have ended up nicer and more caring than chimps. Even so, our egoistic tendencies must still be far stronger than our altruistic ones – after all, natural selection helps those who help themselves. Indeed, by becoming more altruistic, we created an environment where the selfish can enjoy the benefits of cooperative living – be it a share of mammoth meat or an equitable banking system – without paying the costs. Of course, if everyone did this there would be no cooperative group to begin with. That's the dilemma our Jekyll-and-Hyde nature creates, but humans have evolved a few strategies to discourage free riders.

One is our seemingly innate desire to punish those who step out of line. People playing the ultimatum game will often reject mean offers from their partners just to see the Scrooges suffer, even if it means they both lose the prize. In another version of the game, people will even pay their own money to see selfish players punished for their stinginess. In the real world we commonly use gossip, censure and ostracism to punish minor misdemeanours, while the police, courts and prisons impose sentences to discourage more serious crimes. And although our prehistoric ancestors would have lacked institutions to enforce their rules, Boehm believes they used capital punishment as the ultimate sanction against free riders, based on his discovery that many modern hunter-gatherer societies have the death penalty. If he is correct, punishment has made our species a little bit less evil by removing the most antisocial genes from the human gene pool.

Fear of being punished is not the only thing that keeps our inner egoists in check. Often we are virtuous simply because it feels right. "You cooperate because it's a good thing to do," says Herb Gintis at the Santa Fe Institute in New Mexico. He calls this "strong reciprocity" because we end up doing things that are not personally beneficial but will be good for society if everyone does them – things like voting and giving money to people in need. Gintis believes this urge is behind all moral acts. What generates it?

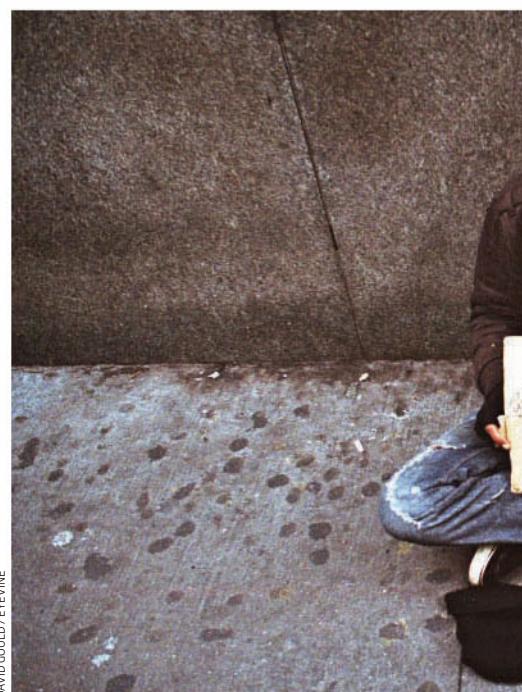
This is where conscience comes in – not the esoteric entity with religious connotations, but an evolved, subconscious risk calculator

that helps us weigh up the pros and cons of different moral options. It works like this. We learn the complex social rules of our particular culture and they become linked in our brains with emotions such as pride and honour, shame and guilt, giving them moral significance. These are the scales upon which moral judgements are weighed, and they tip the balance in favour of virtue; vice may be in your better interests, but it is associated with negative emotions, whereas virtue prompts positive ones.

The pleasure we get from performing a good deed is probably induced by a cocktail of neurochemicals, but one seems particularly important. Oxytocin is normally associated with feel-good activities such as sex and bonding, although as Paul Zak at Claremont Graduate University in California discovered, it is also linked to morality. His experiments reveal, among other things, that people with more oxytocin are more generous and caring, and that our oxytocin level increases when someone puts trust in us. Zak describes oxytocin as "the key to moral behaviour".

The mama-bear effect

So it would appear we have a neurobiological mechanism that tricks us into placing other people's interests above our own. This makes us less selfish but, perversely, is also behind some of our most heinous behaviour. That's



DAVID GOULD/EVINE

because the flip side of niceness to members of one's group is nastiness to outsiders. This xenophobia is underpinned by oxytocin, too, and is sometimes called the "mama-bear effect" because it mirrors a parent's urge to defend her offspring against a threat. As a result, the very system that keeps people working for the good of others can promote atrocities such as racism, genocide and war.

One consequence of this evolved conscience is that our concepts of "good" and "evil" are not universally shared, but rooted in the values of our culture. Take fairness. In modern Western cultures, we tend to equate it with equity – one for me and one for you – but other cultures have different ideas. When researchers took the ultimatum game to 15 traditional societies around the world, they found that the average offer of player A ranged from 15 per cent in one society to 58 per cent in another.

The fact that people adapt to the values of their culture makes morality a movable feast. What's more, we are all members of multiple cultures – from our closest family to the whole nation – so even an individual's moral compass is not fixed. Undoubtedly, some people are more predisposed to virtue than others, but in a dysfunctional culture almost everyone is capable of evil, from bullying and corruption to torture and terrorism. On the plus side, the converse is also true: the right cultural context brings out the good in us. That may not seem like a revolutionary

Morality is a movable feast depending on our society's culture and our circumstances

insight, but some people believe it could make the world a better place.

Perhaps the most prominent of them is David Sloan Wilson at Binghamton University in New York state. For the past few years he has been applying what we have learned about the evolution of morality to his home city. Like any city, Binghamton has neighbourhoods where antisocial behaviour is rife and others where people actively work to help each other. He has mapped these peaks and valleys of prosociality and found that when people move neighbourhoods they adapt their behaviour to fit the local culture. This is exactly what you would expect, given the factors that influence our moral behaviour. "People may want to be prosocial, but in an environment where others are not you lose out," says Wilson. His conclusion is radical.

"There's no point trying to make individuals more prosocial: you need to increase the prosociality of the entire neighbourhood."

That is exactly what Wilson is trying to do. One approach involves giving residents the opportunity to create parks on local wasteland. These serve both to improve the physical environment – which Wilson finds has a strong influence on moral behaviour – and to provide a common goal to build cooperative communities. Another project aims to make the classroom more cooperative and appealing to underperforming students by implementing Nobel-prizewinning economist Elinor Ostrom's principles of group cooperation. Wilson has also set up the world's first evolutionary think tank, the Evolution Institute, to bring these ideas to policy-makers worldwide.

Evolutionary insights underline the importance of other measures to promote virtuous cultures, too. One is to encourage transparency, since we know that being watched puts us on our best behaviour, if only to enhance our reputations. Also crucial is the rule of law, including swift and just punishment for non-compliance.

Less obvious, but highlighted by the study of 15 traditional societies, is economic development. "Modern market economies promote freedom, dignity, tolerance and democracy," says Gintis. Even globalisation presents an opportunity for good. People's wider social and information networks mean that the boundaries between groups are breaking down, reducing our xenophobic tendencies.

It will be interesting to see how far evolutionary theory in action can bring out the best in us. What is not in doubt is that our worst side will remain. Evolution has made us both altruistic and selfish – good and evil – and we cannot be otherwise. "It's impossible for us," says Edward O. Wilson. "If virtue was the only evolutionary force we would be angelic robots." ■



What might we discover about being human by giving a robot a sense of self? Tony Prescott is finding out

WHAT is the self? René Descartes encapsulated one idea of it in the 1600s when he wrote: “I think, therefore I am”. He saw his self as a constant, the essence of his being, on which his knowledge of everything else was built. Others have very different views. Writing a century later, David Hume argued that there was no “simple and continued” self, just the flow of experience. Hume’s proposal resonates with the Buddhist concept *anattā*, or non-self, which contends that the idea of an unchanging self is an illusion and also at the root of much of our unhappiness.

Today, a growing number of philosophers and psychologists hold that the self is an illusion. But even if the centuries-old idea of it as essential and unchanging is misleading, there is still much to explain, for example: how you distinguish your body from the rest of the world; why you experience the world from a specific perspective, typically somewhere in the middle of your head; how you remember yourself in the past or imagine yourself in the future; and how you are able to conceive of the world from another’s point of view. I believe that science is close to answering many of these questions.

A key insight is that the self should be considered not as an essence, but as a set of processes – a process being a virtual machine running inside a physical one, as when a program runs on a computer. Likewise, some patterns of brain activity constitute processes that generate the human self. This fits with Hume’s intuition that if you stop thinking, the self vanishes. For instance, when you fall asleep, “you” – the entity brought into being by a set of active brain processes – cease to exist. However, when you awake, those same processes pick up much where they left off, providing subjective continuity.

The idea that the self emerges from a set of processes has encouraged my colleagues and I to believe we can recreate it in a robot. By deconstructing it and then attempting

Me in the machine





DANIEL STOLLE

to build it up again piece by piece, we are learning more about what selfhood is. This is an on-going collaboration with researchers in several European institutes, and admittedly we still have a way to go. But I'm confident we can create an artificial self, or at least as much of one as would be wise. We believe our work will help resolve the mystery at the heart of self – that it feels compellingly real, yet, when examined closely, seems to dissolve away.

Meet iCub, the state-of-the-art humanoid robot in which we are creating this sense of self. This bot has vision, hearing, touch and a proprioceptive sense that allows it to coordinate its 53 joints. It can speak and interact with its world, and it improves its performance by learning. There are currently 30 such robots in research labs around the world. At Sheffield Robotics, our iCub has a control system modelled on the brain, so that it "thinks" in ways similar to you and me. For the past four years, we have been working to give this robot a sense of self.

We first had to consider exactly how we might deconstruct selfhood in order to build it in a machine. Philosophy, psychology and neuroscience give many insights into what constitutes the human self, and how to recognise and measure aspects of it in adults, infants and even animals. Our attempt begins with psychology, but can also be mapped on to a growing understanding of how the psychological self emerges from brain activity.

William James, a founder of modern

"WE CAN CREATE AN ARTIFICIAL SELF, OR AS MUCH OF ONE AS IS WISE"

psychology, suggested that the self can be divided into "I" and "me" – the former comprising the experience of being a self, the latter the set of ideas you have about your self. In the 1990s, psychologist Ulric Neisser, a pioneer of modern cognitive psychology, went further. He identified five key aspects of self: the ecological or physically situated self, the interpersonal self, the temporally extended self, the conceptual self and the private self (see "Aspects of self", page 22). Neisser's analysis is not the final word, but it is grounded in an understanding of human cognitive development, whereas classical philosophical views such as those of Hume and Descartes were not. It has also provided useful clues about what might be required to build up an artificial self, process-by-process.

How have we gone about creating these ➤

ASPECTS OF SELF

Psychologist Ulric Neisser's multifaceted description of the self provides useful targets for a robot to emulate

ECOLOGICAL SELF

Having a point of view; distinguishing yourself from others; having a feeling of body ownership

INTERPERSONAL SELF

Self-recognition (e.g. in a mirror); seeing others as agents like you; having empathy for others

TEMPORALLY EXTENDED SELF

Having awareness of your personal past and future

CONCEPTUAL SELF

Having an idea of who you are; having a life story, personal goals, motivations and values

PRIVATE SELF

Having a stream of consciousness; knowing you have an inner life

processes for our robot? We use an approach called neurorobotics, which means we incorporate knowledge about how real brains work into our programming. So our iCub's control system is designed to emulate key processes found in the mammalian brain. The interactions between these processes are governed by an architecture called distributed adaptive control, developed by my colleague Paul Verschure at the Catalan Institution for Research and Advanced Studies in Barcelona, Spain. This system is modelled on the cognitive architecture of the brain.

Peter Dominey and his group at the French Institute of Health and Medical Research in Lyon, have addressed this problem. They have encoded iCub's interactions with objects and people in a way that allows it to more clearly see their relevance to present situations. However, this model uses standard computing techniques, so we are working with them to create a neurorobotic version. It will directly emulate processing in brain areas, such as the hippocampus, that are known to play a role in creating human autobiographical memory.

Recent brain imaging studies have confirmed what we learned from N.N.'s experience: that the same brain systems underlie our ability to recall past events as well as imagine what the future might bring. Our hope is that a model of the temporal self will provide iCub with contextual information from the past that will help it to better understand its current experience. This, in turn, should improve its ability to predict what could happen next.

Thinking about self as a set of processes, it becomes clear that some of these are connected. For example, a key aspect of the interpersonal self is empathy, which derives from a general ability to imagine oneself in another's shoes. One way humans might do this is to internally simulate what they perceive to be another's situation, using the model that underlies their own ecological self. So the interpersonal self could grow out of the ecological self. But what more is needed? We consider an important building block to be the capacity to learn by imitation.

Your ability to interpret another person's actions using your own body schema is partly down to mirror neurons – cells in your brain

"SOMETIMES ICUB GIVES THE SURPRISING IMPRESSION THAT 'SOMEONE IS HOME'"

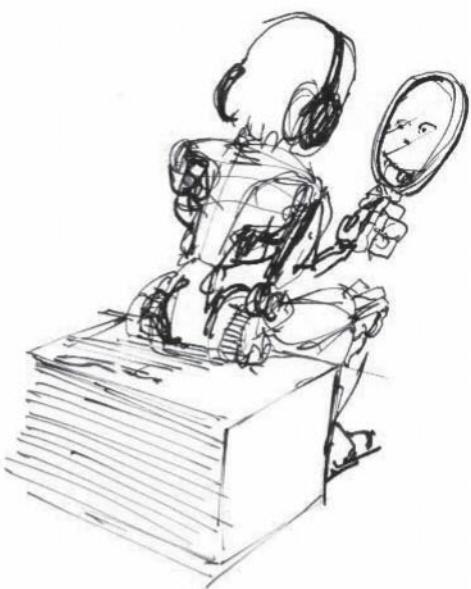
Using this approach, Giorgio Metta and colleagues at the Italian Institute of Technology in Genoa, Italy, are training our iCub to distinguish self from other, a fundamental aspect of the ecological self. The motor-babbling program also allows the robot to learn how to achieve a specific target pose. Combining this body model with knowledge of objects and surfaces nearby enables iCub to move around without colliding with things.

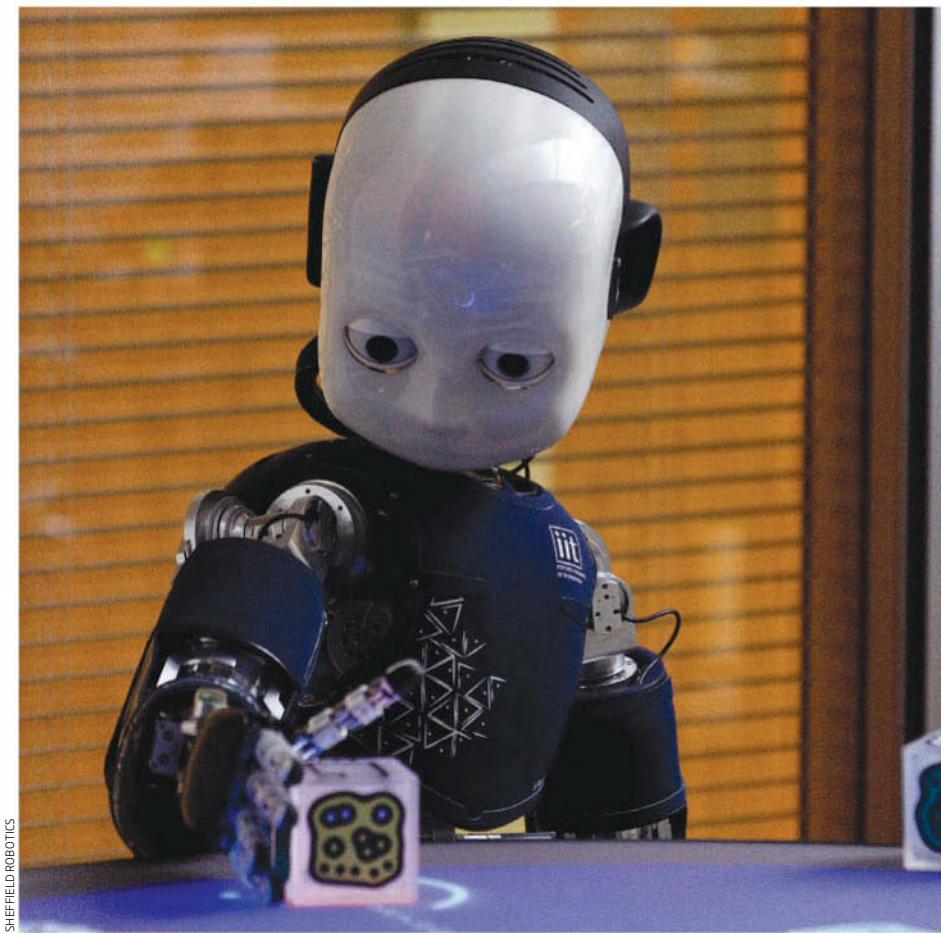
Then there's the temporally extended self. Insights about this can be found in the case of a man we will call N.N., who lost the ability to form long-term memories after an accident in the 1980s. The damage to his brain also left him completely without foresight. He described trying to imagine his future as "like swimming in the middle of a lake. There is nothing there to hold you up or do anything with." In losing his past, N.N. had also lost his future. His ecological self remained intact, but it had become marooned in the present.

This concept of time also poses a problem for our robot. Although we can channel all its sensory input into a hard drive, iCub must also be able to decide how best to use the information to make sense of the present.

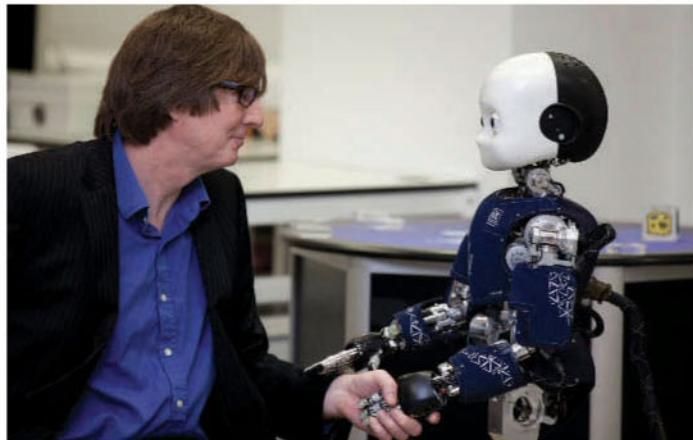
that fire when you perform a given movement and when you see someone else perform it. Using this insight, Yiannis Demiris at Imperial College London has extended iCub's motor-babbling program into an imitation learning system. As a result, iCub can rapidly acquire new hand gestures, and learn sequences of actions involved in playing games or solving puzzles, simply by watching people perform these tasks. The system will have to be extended further to achieve empathy, so that iCub recognises and mirrors a person's emotional state as well as their movement.

There is still plenty to do. Our models of the





SHEFFIELD ROBOTICS



ecological, interpersonal and temporal selves are undoubtedly crude in comparison to what goes on in human brains. And we have yet to tackle the conceptual and private selves that would provide iCub with knowledge of what – or who – it is, and an awareness that it has an internal world not shared by others.

When we meet the challenge of making iCub's self processes more realistic, there may be some aspects of the human version that we will not want to emulate. For example, the robot's motivations and goals are essentially those we design in, and it might be wise to leave things that way rather than allow

them to evolve as they do in people.

Something else holding us back is iCub's limited understanding of language. Although our robot can recognise speech, this is not the same as understanding meaning: that requires relating words to action and objects. Our colleagues in Lyon are working on a neurorobotic solution to this problem but, for the moment, iCub is only capable of two-way conversations on a few topics, such as the game it is currently playing with you.

That said, we can see the practical potential of robots of this kind. An ecological self makes our iCub safer to be around. The temporally

extended self allows it to remember the past and anticipate the future. The interpersonal self means it can conceive of, and anticipate, human needs and actions. Such a robot could work alongside people in fields from manufacturing and search-and-rescue to helping care for people with disabilities.

You might argue that our models have missed a crucial element: the "I" at the centre of James' notion of self – what we also call consciousness. But one possibility is that this arises when the other aspects of self are brought together. In other words, it may be an emergent property of a suitably configured set of self processes, rather than a distinct thing in itself. Returning to the Buddhist idea of the self as an illusion, when you strip away the different component processes, perhaps there will be nothing left.

But is it a person?

Our idea of the self is intimately tied up with our notion of what it means to be a person. Is it conceivable, then, that one day we might attribute personhood to a robot with an artificial sense of self? In the 17th century, philosopher John Locke defined a person as an entity with reason and language, possessing mental states such as beliefs, desires and intentions, capable of relationships and morally responsible for its actions. Modern philosopher Daniel Dennett at Tufts University in Boston largely agrees, but with an important addition. A person, he says, is someone who is treated as a person by others. So we grant personhood to one another.

Note that neither Locke nor Dennett specify that a person is made of biological stuff. Even so, at this stage, our iCub falls short of the criteria required. It can reason, use language, have beliefs and intentions, and enter into relationships of a kind. We might even be inclined to judge it for the appropriateness of its actions. However, it does not yet have the full set of processes associated with a human self, so we cannot be sure that its mental states are anything like ours. Neither is it a moral being – not as we commonly think of them – because it does not base its choices on values.

Be that as it may, our everyday attribution of personhood is grounded more in direct impressions than a philosophical checklist. As Dennett says, personhood is partly in the eyes of the beholder. And, when interacting with iCub, it can feel natural to behave towards this robot as though we are taking the first steps in creating a new kind of person. Sometimes it even leaves me with the surprising feeling that "someone is home". ■

The death of individuality

The idea that we are freethinking individuals is a linchpin of Western society. So what should we make of big-data studies of human behaviour that lead us to a radically different conclusion, asks **Alex Pentland**, pioneer of social physics

FOR most of Western history, truth and morality came from God and king, and free will was a theological question. This began to change in the 1700s, and the idea that humans were individuals with the freedom of rational choice soon wormed its way into the belief systems of the upper echelons of society. Over time, the concepts of rationality and individualism profoundly shaped the governments and culture of the West.

But to what extent are we freethinking individuals? The question matters because economics and much of cognitive science have, at their basis, the concept of an independent individual. Perhaps it is this assumption which has led to the difficulty these disciplines have had accounting for phenomena such as financial bubbles, political movements, mass panics and technology fads.

Recent research is beginning to uncover the degree to which we act as independent individuals. By combining big data from cellphones, credit cards, social media and other sources, we can now observe humans in the same way that biologists can observe animals in their natural habitats using cameras or sonar. From these observations of people, we can derive mathematical rules of behaviour – a “social physics” that provides a reliable understanding of how information and ideas flow from person to person. This social physics shows us how the flow of ideas shapes the culture, productivity and creative output of companies, cities and societies.

To develop this new science, my students and I have been studying living laboratories. By distributing smartphones with special software to all the residents of several small

communities, we could track their social interactions with their peers – both friends and acquaintances – and at the same time ask questions about their health, politics and spending behaviour. For instance, when we looked at weight gain, we found that people picked up new habits from exposure to the habits of peers, and not just through interactions with friends. This means that when everyone else in the office takes a doughnut, you probably will too. In fact, this type of exposure turned out to be more important than all the other factors combined, highlighting the overarching importance of automatic social learning in shaping our lives. We found that this same pattern held true for voting and consumer consumption.

The largest single factor driving adoption of new behaviours was the behaviour of peers. Put another way, the effects of this implicit social learning were roughly the same size as the influence of your genes on your behaviour, or your IQ on your academic performance.

The logic behind this is straightforward. If somebody else has invested the effort to learn some useful behaviour, then it is easier to copy them than to learn it from scratch by yourself. If you have to use a new computer system, why read the manual if you can watch someone else who has already learned to use the system? People overwhelmingly rely on social learning and are more efficient because of it. Experiments

“How important are individual choices compared with shared habits?”

We can use “living laboratories” to discover the mathematical rules of human behaviour



such as those from my research group show us that, over time, we develop a shared set of habits for how to act and respond in many different situations, and these largely automatic habits of action account for the vast majority of our daily behaviour.

In light of this, perhaps we should ask how important individual choices are compared with shared habits. Here again the power of sharing ideas, as opposed to individual thinking, is clear. When we study decision-making in small groups, we find that the pattern of communication – who talked to whom and how much they talked – is far more important than the characteristics of the individuals. In studies of workplaces ranging



kin". Derived from old English and old German words for knowledge, kith refers to a more-or-less cohesive group with common beliefs and customs. These are also the roots for "couth", which means possessing a high degree of sophistication, though its opposite, "uncouth", may be more familiar. Thus, our kith is the circle of peers – not just friends – from whom we learn the "correct" habits of action.

Our culture and the habits of our society are social contracts, and both depend primarily upon social learning. As a result, most of our public beliefs and habits are learned by observing the attitudes, actions and outcomes of peers, rather than by logic or argument. Learning and reinforcing this social contract is what enables a group of people to coordinate their actions effectively.

Social fabric

It is time that we dropped the fiction of individuals as the unit of rationality, and recognised that our rationality is largely determined by the surrounding social fabric. Instead of being actors in markets, we are collaborators in determining the public good. Indeed, our research has demonstrated that people are much more influenced by their social networks than by individual incentives. For instance, in one experiment aimed at promoting more healthy behaviour we compared the strategy of giving participants cash when they improved their behaviour with the strategy of giving cash to their buddies. We found giving buddies the reward was more than four times as effective as giving rewards directly to the participants. Similar social network incentives have yielded even more dramatic results when used to encourage energy savings and voting.

This power of the social fabric on individual decision-making is, in fact, the real reason that privacy is so important. As Stanley Milgram's work on social conformity demonstrated many years ago, the power of social influence can lead people to both good and terrible behaviours, and can transform our behaviour to an extent that is scarcely believable.

Without privacy, the power of corporations or government to manipulate our behaviour becomes virtually unlimited. The answer to the privacy problem is to use trust networks – the sort of computer interfaces that banks use to securely transfer money without revealing unnecessary information. Such networks allow you to control information that is about you and consequently limit the ability of others to manipulate you. But that is another story. ■

from call centres to drug-discovery groups, communication patterns are usually the single most important factor in both productivity and creative output. And in our study of 300 cities in the US and Europe, variations in the pattern of communication accounted for almost all of the differences in average earnings – much more important than variations in education or class structure. Importantly, income per person grows exponentially larger as more people share ideas, so it is the sharing that causes the growth, not just having more individuals contributing.

Instead of individual rationality, our society appears to be governed by a collective

intelligence that comes from the surrounding flow of ideas and examples; we learn from others in our environment, and they learn from us. A community with members who actively engage with each other creates a group with shared, integrated habits and beliefs. What social physics shows is that, when the flow of ideas incorporates a constant stream of outside ideas as well, the individuals in the community make better decisions than they could by reasoning things out on their own.

This idea of a collective intelligence that develops within communities is an old one. Indeed, it is embedded in the English language. Consider the word "kith" – familiar to modern English speakers from the phrase "kith and

CHAPTER THREE

THE BODY

THE



What makes humans so special? The obvious answer is our amazing brains. The body barely gets a mention.

Yet it should. Our bodies are extraordinary: hairless, upright and with many peculiar features related to intelligence, including an oversized head. And that is just the start.

From unruly urges to our neglected nooks and crannies, we reveal the body as you've never seen it before

Super humans

We may be feeble, but we give most species a run - and a throw - for their money, says **Graham Lawton**

HUMANS are remarkable in many ways, but in terms of physical attributes, we generally get outmuscled by other animals. Pound for pound, a chimp is about four times as strong as a human. Our jumping and gymnastic abilities are similarly weak, and we are sluggish sprinters. If there were an Animal Olympics, we would finish, feebly, near the bottom of the medals table.

But let's not be so quick to write ourselves off. It turns out that there are two events in which we would challenge for gold. Both require talents that reveal our body to be a remarkable piece of machinery. What's more, without these physical abilities we might never have acquired the mental dexterity we prize so highly.

At first glance the idea that we excel at running sounds unlikely. Usain Bolt can briefly hit a maximum velocity of about 45 kilometres per hour. Cheetahs can easily double that; greyhounds, horses and even chimps can beat it too. Mo Farah won the 2012 Olympic 10,000 metres in just over 27-and-a-half minutes. A racehorse could run the same distance in less than 20 minutes.

Beyond 10 kilometres, though, the playing field starts to level out. At marathon distances and beyond humans are up there with the best. A well-conditioned athlete can run at 20 kilometres per hour for several hours, which is comparable to nature's endurance specialists, including wild dogs, zebras, antelopes and wildebeest.

This ability depends on anatomical adaptations to the feet, legs, hips, spine and even ribcage that appeared in our lineage about 2 million years ago. In 2004, two biologists proposed that the

human body is specialised for long-distance running, perhaps as an adaptation for hunting (by running prey to exhaustion) or scavenging (allowing us to compete with dogs and hyenas for widely dispersed carcasses). Either way, endurance running could have supplied early humans with a rich source of protein that supported the flowering of our extraordinary brains.

If the marathon glory is a possibility, the javelin gold is a certainty. Other primates can fling objects with force, but underarm and with a poor aim. Only humans can launch a projectile such as a spear or a rock from over the shoulder with power and precision. This ability depends on several unique anatomical features. The shoulder is more forward-facing than in other apes and capable of freer rotation. The wrist, too, seems to be uniquely adapted for a throwing action.

Evolutionary biologist Paul Bingham of Stony Brook University in New York argues that our "accurate overarm throw" was a key force in human evolution. As well as allowing hunting and scavenging for all-important protein, it has been credited with driving brain changes involved in fine motor control, which underpin the evolution of language and technology. Most important, being able to kill at a distance led to a social revolution. No longer could powerful individuals browbeat their way to dominance. Cooperation became crucial, leading to the unique social arrangements that make civilisation possible.

So give your amazing physique the credit it deserves. Human achievement is not the product of brains alone. ■

Illustrated by the following works by sculptor Matteo Pugliese (www.matteopugliese.com)

La Promessa, 2010, Bronze
Pensiero Notturno, silver edition, 2010, Bronze
Pensiero Notturno, 2009, Bronze
Tra due mondi, 2009, Bronze
Angelo, 2008, Bronze
Ombra, 2008, Bronze
Prigione, 2007, Bronze



It's only natural

Your curious bodily behaviours say a lot more than you might think, says neuroscientist **Robert R. Provine**

IT'S your body, and you like to think you've got it under control. But underneath the calm exterior lurk unruly instincts and urges that are struggling to escape, putting you at risk of embarrassment or ridicule. These disreputable behaviours – the likes of the fart, hiccup, itch and yawn – are familiar to us all, yet they are also decidedly curious. Although they have been the source of folklore and puzzlement since antiquity, they have largely been overlooked by scientists. After all, where is the scientific grandeur in such ignoble acts? I take a different view. Where others see forbidden areas, I find unexplored territory and new frontiers of research. So I have made a point of studying our curious behaviours. What I have found sheds new light on our body, our mind and our evolution as a social animal.

Yawning

Whatever the purpose of a spontaneous yawn – and this remains hotly contested – the most extraordinary property of human yawning is its contagiousness. When we see someone yawn, our body is hijacked by a primal neurological process that is hard to resist. Imagine a yawning person with mouth stretched wide open, eyes squinting, taking a long inhalation followed by a shorter outward breath. Are you yawning yet?

Yawns are so catching that almost anything associated with them can stimulate more yawns, including seeing, hearing, reading about, or even thinking about yawning. My colleagues and I have found that silent videos of yawning people trigger contagious yawns in about 55 per cent of observers within five minutes, and almost everyone reports being at least



tempted to yawn. Surprisingly, given that a gaping mouth is the most conspicuous element of yawning, videos that had the mouth edited out were just as effective at making viewers yawn. In fact, videos showing just a yawning mouth evoked no more yawns than one of a smiling face. That may be because an open mouth is not exclusively associated with yawning and could be doing something else such as singing or yelling. We respond to the overall configuration of the yawning face, including the squinting eyes.

From the evolutionary perspective, spontaneous yawns are ancient – occurring in most vertebrates – whereas contagious ones are relatively modern, being confined to social mammals including chimpanzees and perhaps dogs. In humans, spontaneous yawning develops while we are still in the womb, but the contagious variety does not appear until a child is 4 or 5. This is also roughly when children start being able to attribute mental states to themselves and others, strengthening the idea that contagious yawning is linked with sociality. Although the neurobiology of this curious behaviour is little understood, it is clear that when it occurs we become mindless beasts of the herd. As a yawn propagates through a group, it drives a ripple of physiological and emotional connection, transforming individuals into a superorganism.

Itching

Itching is an exquisite torment that earned a place in Dante's *Inferno*, but it has its virtues. The skin is our body's first line of defence against invasion and we are neurologically primed to maintain its integrity. So, when threatened by insect pests, toxic flora or other irritants, an itch guides us to the problem area and motivates us to scratch, in an attempt to dislodge the invader and quell the discomfort. Only the skin, not internal organs, gets itchy. We also respond to tactile false alarms when we itch in response to skin conditions such as eczema, athlete's foot and psoriasis and, even more mysteriously, as a result of thyroid disease, diabetes and some

MANY VERSIONS OF YOU

From the top of your head to the soles of your feet, you have an amazing ability to regenerate, finds Jessica Hamzelou

HOW OLD IS YOUR HAIR?

6-7
years old

- ▶ The hair on your head could be anything up to 6 to 7 years old
- ▶ Each day your head hairs grow 0.5mm
- ▶ Body hair grows more slowly, about 0.27mm per day
- ▶ Your eyebrows renew themselves every 64 days

YOUR ONLY BRAIN



Cells in the brain's cortex are not renewed and are as old as you are, although there is evidence for continuous regeneration in the hippocampus

neuropathologies. Itching is inhibited by pain, but while vigorous, tissue-damaging scratching can offer blessed relief in the short term, it can produce even more itching, locking us into a self-perpetuating itch-scratch cycle.

Like yawning, itching is contagious. You can "catch" an itch from observing someone scratching, attending a lecture about itching, or viewing slides of itch-producing pests such as lice. Even reading this may make you itchy. Contagious itching makes evolutionary sense: your neighbour's pesky flea may jump from its host to you but won't get far if you are already scratching.

Hiccupping

Hiccupping starts with a sudden inhalation produced by a downward jerk of the diaphragm and contraction of the muscles between the ribs, and ends almost immediately by glottal closing to produce the "hic" sound. Although of unknown purpose, this enigmatic act is one of the most common prenatal behaviours, suggesting a developmental role. Hiccupping starts at around 8 weeks of gestation, peaking between 10 and 13 weeks, then declines through the remainder of life. For an unfortunate few, however, hiccups return with a vengeance in later life in the form of persistent bouts lasting 48 hours or longer. Men are nine times more likely to suffer this than women. The record for chronic hiccupping is held by Iowa farmer Charlie Osborne who hiccupped for over 67 years. Fortunately, hiccups usually stop during sleep.

A "hiccup generator" in the brainstem choreographs the widely distributed neurological and muscular components of a hiccup when it receives certain cues. These causes can range from distension of the stomach and irritation of the oesophagus to various thoracic and nervous disorders. Remedies are even more diverse. In his *Symposium*, Plato listed breath holding, gargling and sneezing. Other purported cures include eating sugar, drinking water upside down, being frightened and putting your fingers in your ears. During the course of my research I have discovered another. The audio recorder cure simply entails

my standing expectantly, microphone in hand, next to the hiccupper. It is particularly effective on children and shows the power of social inhibition over an ancient, instinctive act.

Vomiting

If you ingest a toxic substance, your body uses an effective and violent response to try to eject it: vomiting. However, you are also prone to retch at the mere sight, smell or sound of someone else doing it. Why? I became fascinated by this phenomenon as a child on a particularly nauseating family road trip when my cousin Karen was sick in the car, causing the other passengers to vomit. Decades later I got a chance to investigate contagious (or hysterical) vomiting. I found that girls of middle-school and high-school age are especially prone. Bouts usually occur during a group event that provokes anxiety. They tend to involve reports of vague smells such as vehicle exhaust fumes or sewer gas, or odd tasting or smelling food or drink. Symptoms are likely to be vague and the illness will resolve quickly and have no adverse effects.

Although contagious vomiting seems like a prime example of a bodily malfunction, in evolutionary terms it is adaptive, permitting everybody in a group to benefit vicariously from the reaction of the person who takes the first taste of something toxic. Messy false alarms are a small price to pay for a potentially life-saving gut reaction. Indeed, some Central and South American peoples intentionally induce communal vomiting by drinking the ritual emetic ayahuasca, in their quest for purification and bonding. Cheers!

Tickling

Tickling is exceptional in its philosophical, neurological, psychological and practical significance – impressive credentials for a behaviour that is often relegated to a footnote.

Everything starts with the observation that we cannot tickle ourselves. This is fortunate, otherwise we would go through life in a giant

"Standing next to a hiccuper with a microphone is usually enough to cure them"

chain reaction of goodness, confused about whether we touched something or it touched us. The neurological process that inhibits our response to self-touching also computes our discrimination of self and other. Who would have thought that the lowly tickle could offer a solution to the ancient and thorny philosophical problem of personhood (see "Me in the machine", page 20)?

This amazing insight even has a practical application. If computer scientists could create an algorithm to differentiate touching from being touched, they would increase the fine motor control of robots and be on the way to producing a machine with personhood.

The fact that we cannot tickle ourselves makes tickling inherently social. It is an important means of tactile communication and bonding, and, I would argue, the basis of a baby's earliest preverbal conversations with carers. Although self-professed tickle-haters abound, my surveys

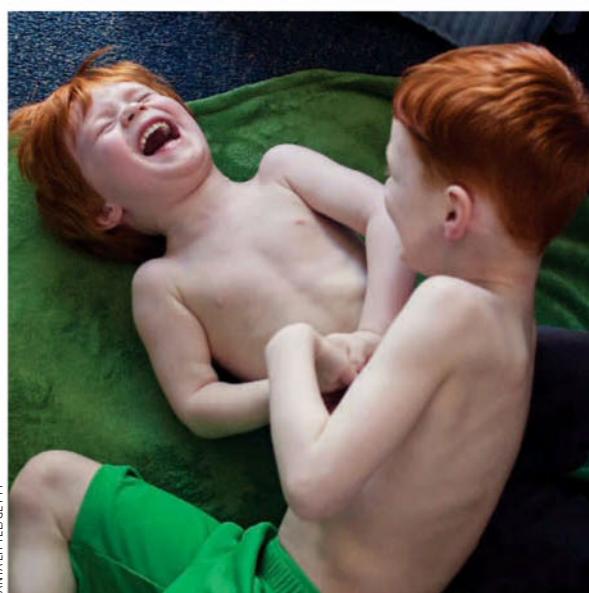
indicate that we usually tickle and are tickled by friends, family and lovers, with the motive of showing affection and getting attention. The capacity for mutual tickling enables the neurologically programmed choreography of tickle battles, physical play and sex play. The laboured breathing this produces is the origin of laughter, with the ancestral "pant-pant" – still produced by chimpanzees when tickled – evolving into the modern human "ha-ha". I will further suggest that feigned tickle, the basis of the "I'm going to get you" game, is the most ancient joke.

Farting

No investigation of our quirky bodily behaviours would be complete without considering flatulence. This uncouth act has attracted interest from scholars and the general public alike since antiquity. A growing appreciation of the importance of our gut microfauna has brought farting to the attention of gastroenterologists. My interest in the subject is more esoteric: given the rich variety of sounds entailed, I wondered why we speak through our mouth rather than our butt.

This is not as frivolous as it first seems, given that no part of the human body evolved specifically for speech. We speak through the same orifice through which we breathe, eat, drink and vomit, and the vocal cords are two flaps of tissue that act as a seal to keep food and drink out of the airway when we swallow. So why did evolution not take the alternative option of using the abdomen and lower bowel as bellows – some people do have such control – and the anal sphincter as the vibrating seal?

Well, a major weakness of this idea is that while the oral vocal tract has the mouth, tongue, teeth and throat to shape sounds, the anus lacks such features. That hasn't stopped herring using farts to communicate, but the fish are an exception, and even then it causes problems. Flatulent herring attract the attention of hungry killer whales that home in on the sound of their breaking wind. Alas, buttspeak turns out to be a weak contender in the speech evolution sweepstakes. ■



TANYA LITTLE/GETTY

THE EYES HAVE IT



The surface of the cornea is covered in a thin layer of cells that is continually renewed. Complete turnover is every 7 to 10 days

Cells in the retina do not regenerate, which is why vision problems arise with age. However, stem cell treatments are beginning to target degenerating retinas

Researchers have managed to regenerate rods, the photoreceptors that capture dim light. But only in a Petri dish, so far

SKIN DEEP



The surface of the skin is replaced every couple of weeks

Skin cells regenerate four times faster after a gentle injury, like ripping the top layer with sticky tape



It takes all sorts

Each person's body is unique and we're still evolving, finds **Caroline Williams**

IT DOESN'T take a scientist to spot that human bodies are all a variation on a theme: one head and for the most part the same number of limbs and organs in the same places. But we clearly come in all shapes and sizes. What's more, the template for our bodies has changed over the course of our evolution and is still changing today. So how variable are modern humans and why? What aspects of an individual's body are unique? And what will future humans look like?

None of our physical attributes differs more obviously than stature. There is almost half a metre between the height of the average man in the shortest population in the world, the Mbuti tribe in the Democratic Republic of the Congo, and the tallest, the Dutch (1.78 metres and 1.84 metres respectively). Between them lies everybody else. For people of European

descent, the average woman is 1.65-metres tall and the average man is 1.78-metres tall.

Differences in height stem from a complex mix of our genetic heritage, overlaid with the effects of nutrition and health in early childhood. The genetic influence can be traced way back. Our ancestors living on the plains of Africa 1.9 million years ago were tall – around 1.83 metres – with long legs and narrow bodies, adaptations that may have helped them keep cool while travelling long distances in search of food. As humans migrated towards the poles, however, they evolved shorter and stockier bodies with broad ribs and pelvises – perhaps to reduce the surface area from which heat could be lost. In the tropics they evolved the smallest bodies of all, possibly to reduce heat production in the first place.

TOP RIGHT: JEROME SESSUM/MAGNUM; TOP LEFT: MIKKEL OSTERGAARD/PLANPICTURE; BOTTOM: GETTY

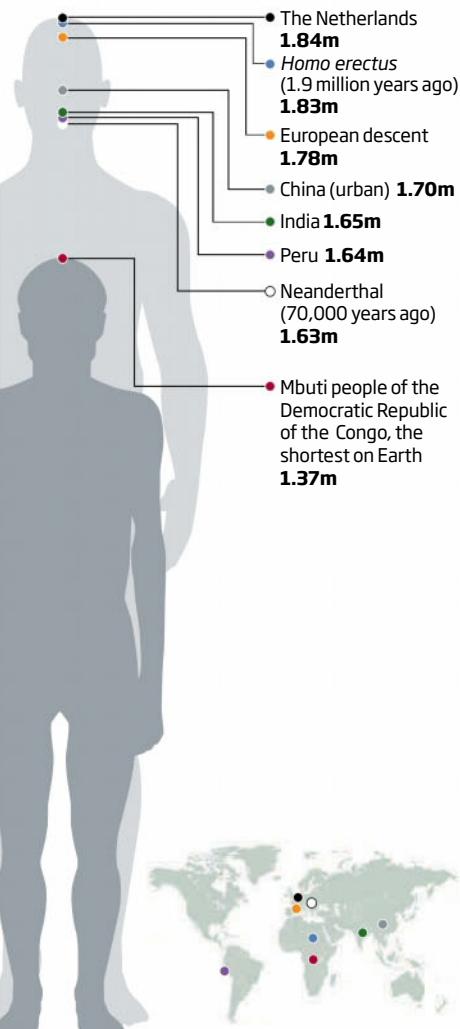
"The average Dutchman was 16 centimetres taller in 1990 than in 1860"

ELLIOTT ERWITT/MAGNUM PHOTOS



The long and the short of you

The height of an average man in a population depends partly on the geographic origins of his ancestors, and has varied over human evolution



Although these general patterns still hold, a much better predictor of your height comes from looking at your immediate family. Genetics accounts for 80 per cent of the variation, with over 50 gene variants that link to height found so far. The other 20 per cent is down to nutrition – particularly in the first two years of life – and whether the body had to divert energy to fight disease when it should have been growing. This 20 per cent largely explains why the species as a whole is getting taller. The average Dutchman, for example, was 16 centimetres taller in 1990 than in 1860 thanks to improvements in nutrition and healthcare. Still, the rate of growth in healthy, well-nourished Westerners has been slowing for decades, which suggests that there is a limit to how tall our genes will allow us to be under

Children are getting fatter yet punier

SAME BUT DIFFERENT

We all spent the first 30 hours of our lives as a single cell.

Babies born with teeth are rare – only 1 in 1000 by the highest estimates.

Some 6 per cent of people have an extra nipple. They tend to occur on the left side of the body and are more common in men.

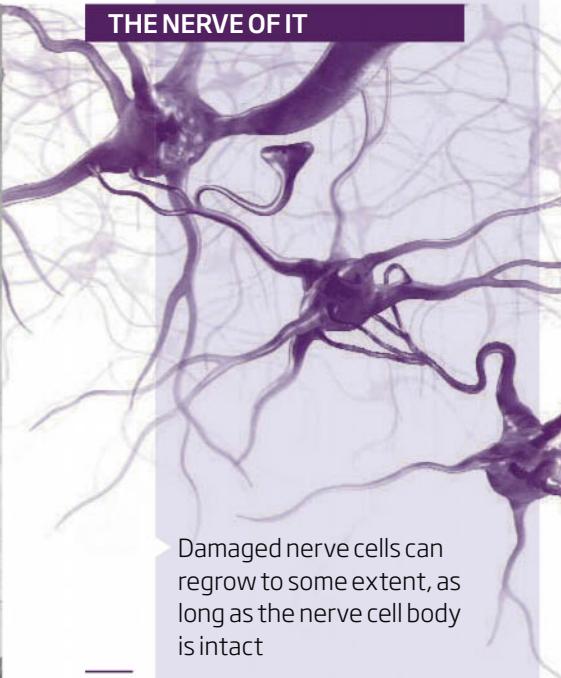
Each day your blood travels a total of 19,000 kilometres – half the circumference of Earth.

Messages travel along the fastest neurons at 400 kilometres per hour – faster than a Formula 1 racing car.

A handful of people go through life with no fingerprints, thanks to a rare gene variant, a condition dubbed immigration delay disease.



THE NERVE OF IT

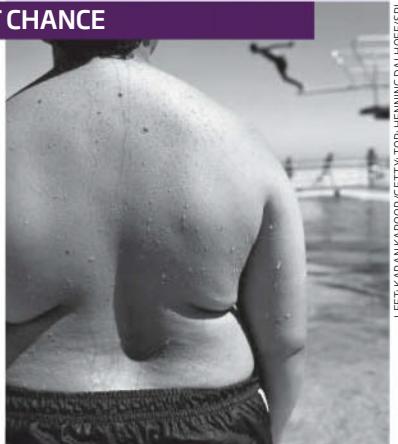


Damaged nerve cells can regrow to some extent, as long as the nerve cell body is intact

The rate of nerve regeneration after injury is thought to be around 2 to 3mm per day

2-3mm
per day

FAT CHANCE



LEFT: KARANKAPOOR/GETTY; TOP: HENNING DALHOFF/SPL

► The average age of a fat cell is 10 years

Each year 10 per cent of your fat cells are replaced

perfect growing conditions.

If height is variable then weight and body shape are even more so. According to one estimate, weight varies around the world by as much as 50 per cent, even if you leave the shortest pygmy populations out of the equation. Wherever you go, though, the trend is moving towards the same shape, and not a particularly healthy one. Belly sizes are increasing worldwide. Even in some of the poorest countries, including Bangladesh, Guatemala and India, there has been an increase in average body mass index. Most of the growth comes from wealthier people getting fatter more quickly rather than poorer people getting less thin.

Measures of BMI may actually underestimate our expanding waistline. A 2002 study found that

while children were about the same weight for their height in the 1990s as in the 1970s, they actually had 23 per cent more fat. This was offset by a reduction in muscle mass of 3.2 per cent, indicating that we are also getting punier. The only good news is that figures from the US, UK, Spain, Sweden and Switzerland suggest that rates of obesity may have started to level off. An ever more wobbly human race may not be a foregone conclusion after all.

Whatever the future holds for our species, it is comforting to know that there are still myriad ways in which each of our bodies is unique (see "One and only you", page 12). Studies of twins have found that even when two people begin with the same genes, they start to differ almost immediately. Not only do their genomes diverge along their own path because of random mutations, copying mistakes and epigenetic changes, but a twin's unique environment in its part of the mother's womb can alter the way its tissues grow and develop. Add to that the fact that many body parts owe their shape to randomness as much as genetics and the potential for variation is huge.

Take your iris. The complex mesh of muscles, ligaments and blood vessels in the eye is unique thanks to the random way in which each eye develops. As a result, your two eyes differ from each other as much as they differ from everyone else's. The likelihood of one eye being mistaken for another is around 1 in 200 billion, making iris recognition one of the most trusted forms of biometrics.

In fact, most of the research on variations in the human body has so far concentrated on complex features that can be used for biometrics. As well as iris patterns, these include the dimensions of the face, shape of the ears and, of course, fingerprints. But chances are that your individuality extends to everything from the shape and size of your belly button to the position of the organs inside your body and the placement of your nipples on the outside.

As a species, we may have become taller, wobblier and weaker, but at least each of us can take solace in the fact that, individually, we are as unique as ever. ■

Handy accessories

You have to hand it to them – nothing else so defines us as individuals and as a species, says Julia Brown

REMBRANDT instinctively understood it. In many of his portraits, he painted the hands with as much care as the face. Hands speak volumes about the sitter's status, age and lifestyle, be they the gnarled, wrinkled hands of a poor woman or the smooth, confidently folded ones of a nobleman. Now science is catching up, and it is clear that your hands say all sorts about you. They hold clues to your development, personality, health and fitness – if you just know where to look.

Hands define us as a species, too. "People think language makes us human, but it's the hand," says surgeon Simon Kay, who, in 2012, led the UK's first hand transplant operation at St James's University Hospital in Leeds. Hand gestures may have been the forerunner of language, and they remain central to communication even if we do not always notice them. Some cultures have made gesticulation an art form: Sicilian people, for example, have a huge range of hand signals, and the traditional dances of India and Bali are characterised by precise gestures, each with a specific meaning. Above all, the fiendish design of our hands allows us to interact with the world like no other animal. From writing, drawing and making music to building nuclear power stations, almost everything we do with them is peculiarly human.

The "forceful precision grip" is what separates our abilities from those of other primates, says Mary Marzke, an evolutionary biologist at Arizona State University in Tempe. After we split from our last common ancestor with

chimps, our palms became shorter, broader and more bendy, while thumbs got longer relative to the fingers. This allowed cupping of the thumb, index and middle fingers for holding objects of various shapes, and enabled us to grip firmly and precisely. We also developed flattened tips to our finger bones. These support fleshy finger pads, providing a greater sensing area and making our grip more stable.

Like many, Marzke believes these features evolved in tandem with our ability to manipulate tools. The most ancient tools found so far are 3.3 million years old, and our distinctive hand shape was apparent some 3 million years ago in *Australopithecus*. This suggests, she says, that early hominins developed skills such as cutting, scraping and digging over a long period. But that may not be the whole story. David Carrier of the University of Utah in Salt Lake City argues that the ability to form a fist, with shorter fingers curling into the palm, buttressed by a longer thumb, would have given an advantage to our male ancestors when competing for mates. The shape of our hands is a trade-off between dexterity and fighting, and in general women are more dexterous than men, he suggests.

Whatever evolutionary forces shaped the human hand, we are not born dexterous. Children only gradually learn to manipulate objects. Aged around 1, they go from grasping with their whole hand to using their thumb and index finger; fine coordination takes at least 10 years to develop fully.



"Whatever forces shaped the human hand, we are not born dexterous"

Handedness is mostly down to genetics but children can learn to exploit their less-preferred hand if necessary. And we are always learning. Until recently, people were used to typewriter-sized keyboards, says Lynette Jones, who studies tactile interfaces at the Massachusetts Institute of Technology, but we have quickly adapted to the tiny keypads on smartphones.

Still, there are some things our hands just cannot do. "You can't really move one finger at a time," says neuroscientist Marc Schieber at University of Rochester Medical Center in New York. You think you can, he adds, but you only have to look at your hands as you type to realise that is not the case. The reason is that our fingers



ALDO SPERBER/PICTURETAKEN RIGHT TOP: SPL; BOTTOM: SPL

finger, whereas in women they are more equal. A study in 2003 by John Manning, now at Northumbria University in Newcastle upon Tyne, UK, found that the ratio of these two fingers' lengths reflects the level of testosterone a fetus was exposed to in the womb. More recent research questions this conclusion but hundreds of studies reveal that the ratio is linked with a variety of characteristics, including sexuality. More "masculine" ratios correlate with traits ranging from risk-taking and financial acumen to athleticism and autism.

One very personal feature of your hands is definitely laid down in the womb: your fingerprints, which take shape between weeks 10 to 16 of gestation. Although genes influence their general patterns – the whorls, loops and arches – the details are affected by factors such as the position of a fetus and its hands. As a result, even the fingerprints of identical twins are different.

Why we have fingerprints at all is another matter. They may increase touch sensitivity, protect the fingertips by allowing the skin to stretch, or help with drainage in wet conditions. Perhaps surprisingly, the idea that they increase friction and so improve grip does not stand up.

Although fingerprints are unchanging, the appearance of your nails reflects health and nutrition. Changes in their colour, smoothness and shape, and whether they develop any ridges, are not usually the first sign of disease but can indicate a host of problems ranging from vitamin deficiency to heart disease and cancer. For example, yellow nails may signify diabetes, while half-white, half-dark ones suggest liver and kidney disease. Deep, horizontal ridges are nothing to worry about, though: they are usually a natural consequence of ageing.

It is no wonder that we identify so strongly with our hands. They are both highly personal yet always on display. Whether you adorn them with rings, watches and nail paint or simply embrace their lines and wrinkles, there is no other body part more familiar. You might even say you know them... like the back of your hand. ■

are linked to each other by neural circuits and physical ties. For example, the ring and little fingers share a tendon, making it very difficult to move them independently.

With around 17,000 receptors of various types, each hand has a sensory capacity similar to that of the eye. The ability to discern tactile sensations varies, though. Touch sensitivity is highly heritable and appears to have genes in common with hearing. It tends to be less acute in people with poor hearing, perhaps because hearing and touch both involve mechanosensory receptors. By contrast, blind people are often able to recognise an extraordinary variety of different sensations, Kay says. In addition, women generally have greater sensitivity than men, by virtue of their smaller fingers.

Male and female hands differ in another way, too. In men the index finger tends to be shorter than the ring

A LIVER ISN'T FOR LIFE



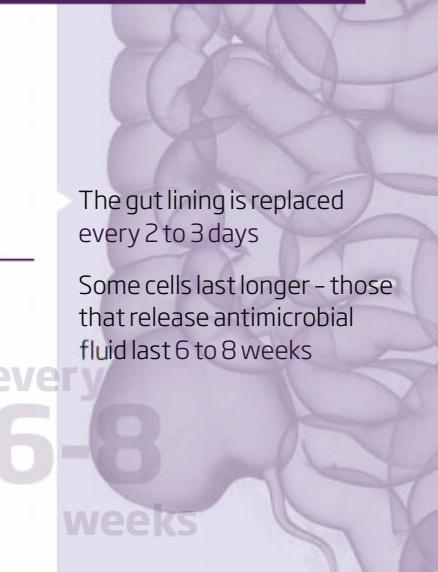
300
to 500
days

Liver cells turn over every 300 to 500 days

The human liver has an amazing capacity to regenerate itself. Remove up to 70 per cent of the organ and it will grow back to its normal healthy size in as little as a couple of months

Surgeons have even removed as much as 90 per cent of the liver, although recovery is incomplete

IT TAKES GUTS



The gut lining is replaced every 2 to 3 days

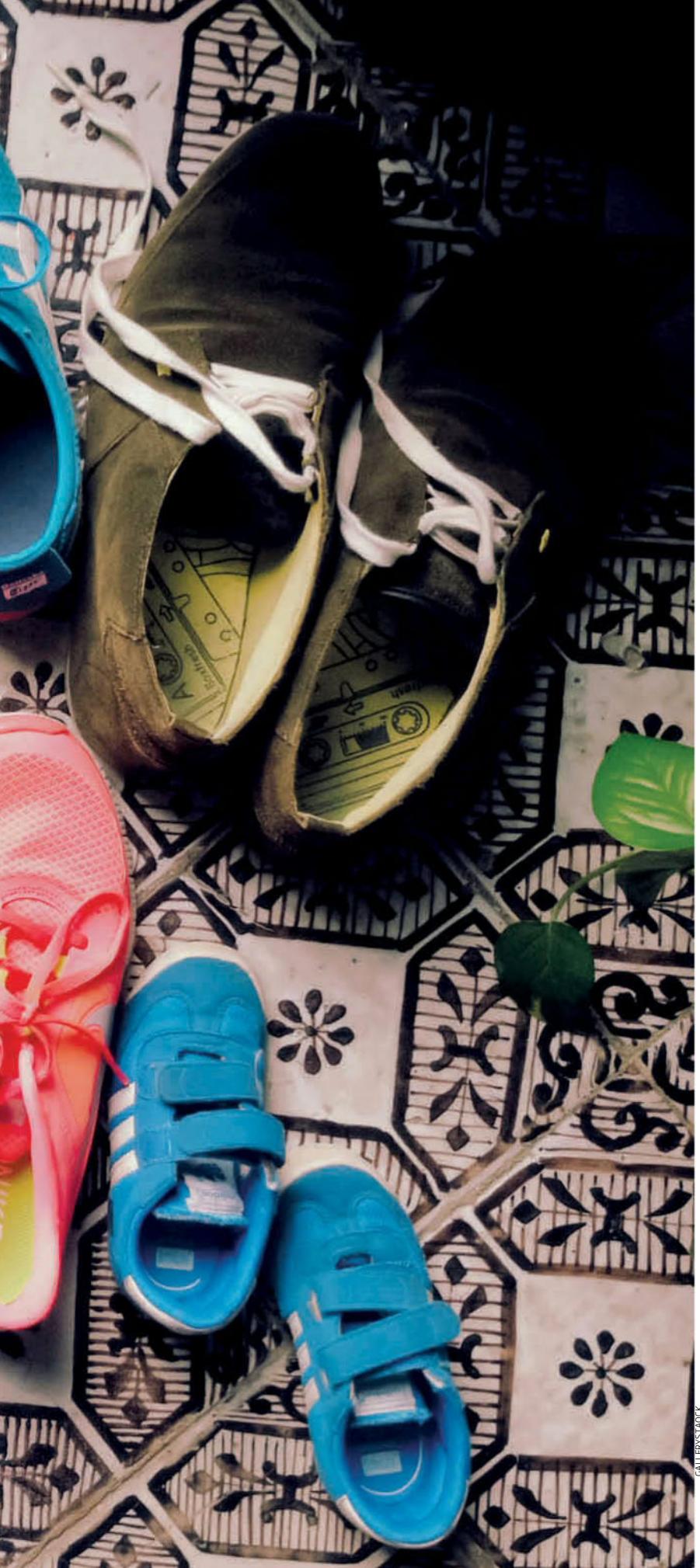
Some cells last longer – those that release antimicrobial fluid last 6 to 8 weeks

every
6-8
weeks



FUNNY FEET

Human feet are far more varied than we thought and - no offence - yours are weird, says Laura Spinney



MY RUNNING shoes have a thick sole and cushioned heel. I bought them five years ago, before the “barefoot” craze for minimalist shoes that would allow people to better emulate how our ancestors ran. Soon after that, reports began appearing of injuries sustained by runners who had adopted these shoes, and lawsuits were filed against some manufacturers. Now the maximally cushioned or “fat” shoe is back in vogue, and suddenly my old shoes look high-tech again.

Is all this simply a matter of fashion, I wonder, or is it telling us something more profound? Surprisingly, we are only beginning to discover what a normal human foot looks like, how it should move, and the role that shoes play. Recent research, sparked in part by the fallout from barefoot running, reveals enormous diversity in healthy feet. What’s more, the average Western foot turns out to be an outlier, deformed with respect to our ancestors’ feet and those of our barefoot contemporaries.

Much of this is down to shoes, which have taken over some of the work our feet had to do to allow us to become bipedal. “We assume that the people around us are normal, but from an evolutionary perspective, they’re not,” says evolutionary biologist Daniel Lieberman at Harvard University.

The anatomy of the human foot is no mystery. It is a complex structure, containing 26 bones and over 100 muscles, tendons and ligaments. It is also malleable, as will be obvious to anyone who has seen photos of young women’s feet bound according to a gruesome old Chinese custom, ostensibly to make them dainty. Some victims wound up with feet that looked as if they had inbuilt high heels.

Foot shape is the product of gene-environment interactions, but how do they play out? Until recently, the few studies there were had focused almost exclusively on Westerners – which, in practice, meant people who had worn shoes since they could walk. Lieberman and his colleagues were among the first to cast their net more widely. In a study published in 2010, they found that Kenyan endurance runners who had grown up without shoes landed more often on their toes than on their heels as 80 per cent of shoe-wearing distance runners do. The work helped to trigger the barefoot running craze, but Lieberman points out that the sample size was small and that the results didn’t support many of the claims later made for barefoot running, such as the idea that it reduces the risk of injury. However, the hint that wearing shoes could have such a big impact on how we use ➤



CINDERELLA'S LEGACY

"Things started to go wrong in the 16th century," says Marquita Volken, a shoe archaeologist who runs the Shoe Museum in Lausanne, Switzerland. It was then that European streets began to be paved and the soles of shoes began to get thicker to cushion urban feet. Influenced by the vagaries of fashion, heels rose and both men and women were soon tottering on platforms up to half a metre high. These were the peacock's tail of footwear, a showy badge of social superiority, says Kristiaan d'Août of the University of Liverpool in the UK – since there was no way the wearer could work in them.

The French Revolution brought everyone back down to earth, and when heels started rising again the trend only affected women's shoes – probably, d'Août suggests, because they exaggerated the female aspects of gait. A recent study hints this could have benefits. It showed that men's (but not women's) helpfulness towards a woman was correlated with the height of her heels.

High heels are not good for feet, however, especially when shoes also constrict the toes. Studies of premodern European skeletons suggest that hallux valgus – the condition commonly known as the bunion – started to become prevalent in the 16th century, and has never been more common in women than it is now. A 1993 survey of American women showed that 88 per cent wore shoes that were too small for them, 80 per cent reported pain, and 76 per cent had some sort of foot deformity, bunions being the most common. "Shoe design is cyclical," says Volken, whose new book *Archaeological Footwear* chronicles the development of shoes from prehistory to the 1600s. "We're currently in an unhealthy phase."

"Three-quarters of women reported having some sort of foot deformity"

our feet was intriguing, and Lieberman and others have pursued its implications.

A team led by biological anthropologist Kristiaan d'Août, then at the University of Antwerp, Belgium, also did pioneering work in this area. In 2009, they measured the feet of 70 Indians who didn't wear shoes and compared them with those of 137 Indian and 48 Belgian shoe-wearers. They also asked all three groups to walk on a pressure-sensing treadmill, which generated dynamic pressure maps of the foot as it hit the ground.

The barefoot walkers tended to have relatively wide feet, with pressure fairly evenly distributed over the parts touching the ground when walking. The shoe-using Indians had narrower feet and a less even pressure distribution. But the Belgians, who wore more constricting shoes, more often than the shoe-wearing Indians, had very different feet: relatively short and slender, with pressure hotspots at the heel, big toe and midfoot region of the metatarsals (see diagram, right).

Floppy feet

The researchers concluded that shoe-wearing is one of the most powerful environmental factors influencing the shape of our feet. It can also have a big impact on the way we walk, as anthropologist Jeremy DeSilva and gait expert Simone Gill, both at Boston University, discovered. They persuaded nearly 400 adult visitors to the Boston Museum of Science to walk barefoot over a 6-metre-long "gait carpet", which measured speed and stride length as well as building pressure maps. This revealed something remarkable. Around 1 in 13 people were extraordinarily flat-footed: they had a pressure hotspot resulting from their midfoot moulding to the ground as they walked. "Their feet were as flexible as chimps," says DeSilva.

As humans evolved to be bipedal, our feet developed longitudinal and transverse arches. These created rigidity in the central part of the outside of the foot, to help propel us forward when we lift our heel and push down on the ball of the foot. In other words, a rigid midfoot is a signature of bipedality. Chimps lack this rigidity, their feet being floppier in the middle to allow them to grip a branch. In technical terms, they have a "midtarsal break", and it's this that DeSilva and Gill observed in some museum visitors. Since publishing their finding in 2013, they have ruled out the possibility that the midtarsal break runs in families. In other words, it isn't strongly heritable, although a predisposition to it could be. Instead, DeSilva suspects that it is

"Around 1 in 13 people were extraordinarily flat-footed. Their feet were as flexible as chimps"

mainly a result of wearing shoes. "The shoe provides the rigidity, in a way, so the foot doesn't have to," he says.

Two studies published by Lieberman and colleagues last year seem to back this conclusion. In one, they looked at the feet of Tarahumara Native Americans in Mexico – famed endurance runners whose traditional sandals inspired minimalist running shoes – and found that those who ran in sandals had stiffer arches than those who ran in conventional shoes. The other study showed just how quickly feet can adapt. After 12 weeks of regular running in minimalist shoes, Western runners developed significantly stiffer arches.

What goes on within our feet as we walk is still a bit of a mystery. The pressure map method can only give an indirect measure of the mechanics involved. But a novel technique pioneered by Paul Lundgren at the Karolinska Institute in Stockholm, Sweden, and colleagues, takes things a step further. They surgically implanted metal pins into nine bones in the feet of six volunteers, and capped the protruding ends with reflective markers that could be tracked using motion-capture cameras. The technique revealed that all the joints in the foot and ankle contribute to the way we walk, the movement of each joint being dependent on the others. It also showed great diversity among individuals in the range of movement of each joint – especially in the midfoot.

A team at the University of Liverpool, UK, led by Karl Bates, has replicated that finding in a group of 45 volunteers, using pressure maps. Their study also included bonobos and orangutans, revealing the pressure of human footfalls to be as diverse as those measured in these most arboreal of apes. "What the bone-pin study showed is that everybody is different," says Bates. "For some people the foot is stiff, but for others there is actually a surprising amount of movement."

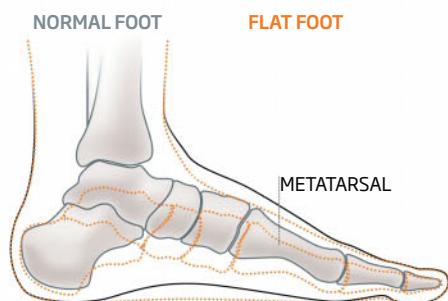
This natural variation raises important questions. First, if "normal" covers such a wide range, what is an abnormal foot? In the past, foot disorders have been defined as much by social concerns as by medical ones. For example, flat feet were regarded as a sign of moral flabbiness in the American character, according to medical historian Beth Linker of the University of Pennsylvania, Philadelphia. During the first world war, a soldier could be invalidated out of the US army for flat feet – but not for shell shock – and flat-foot camps, designed to rehabilitate the afflicted, spread across the country.

Doctors also have misconceived ideas about feet. "The human foot is supposed to be very stiff, and if it's not then often a clinical problem is diagnosed," says Bates. But he and others have shown that flat-footedness isn't necessarily associated with pain or any radical

Born to run: do stiffer arches give Tarahumara runners the edge in ultramarathons?

Shaped by our shoes

Wearing shoes could be making our feet narrower and bendier, especially in the midfoot and around the metatarsals – making some people more prone to developing flat feet



restriction of function. None of the flexi-footed visitors to the Boston Museum of Science complained of pain. And although DeSilva suspects that people with mobile midfeet may not figure among the fastest runners, because they have less elastic recoil when they push off the ground, they pay no obvious price in terms of health.

Bates believes the new findings should also change the way we interpret hominin fossils, because the bones of one individual may tell us little about how its foot worked, let alone how other members of the species walked. Take Lucy, the famous 3.2 million-year-old australopithecine unearthed in Ethiopia, who carries all the hallmarks of bipedalism. When DeSilva compared her ankle bones with X-rays of modern human feet, he concluded that she was probably flat-footed in a non-pathological way. It's hard to say how typical of her kind she was, though. "There would have been variation in her species as in ours, but perhaps around a different norm," he says.

We still have much to discover about what normal means when it comes to feet but one thing is clear. Although going barefoot was normal for most of human evolution, our relatively short period of footwear use – about 40,000 years, according to the archaeological record – has left its mark. That's largely because the human foot turns out to be so plastic. This finding, in turn, holds hope for anyone wanting to turn back the clock. We may be able to run more like our ancestors if we take it gradually, realising that in donning minimalist shoes we load our bodies differently, and that the surfaces we run on are quite different to what they coped with. Nevertheless, the jury is still out as to whether barefoot shoes bring better performance or fewer injuries. Until it delivers its verdict, I'll be hanging on to my old running shoes. ■



Lost in translation

We all think we can interpret body language, but there's more to our movements and poses than meets the eye, says **Caroline Williams**

WHEN Tom Cruise and Katie Holmes announced their divorce a few years ago, tabloid journalists fell over themselves to point out that they had seen it coming. "Just look at their body language!" the headlines screamed, above shots of Holmes frowning while holding Cruise at arm's length. "Awkward!" Around the same time, Barack Obama lost a US presidential debate to Republican nominee Mitt Romney, and some commentators blamed it on his "low-energy" body language and tendency to look down and purse his lips, which made him come across as "lethargic and unprepared".

Popular culture is full of such insights. After all, it is fun to speculate on the inner lives of the great and the good. But anyone with a sceptical or logical disposition cannot fail to notice the thumping great elephant in the room – the assumption that we can read a person's thoughts and emotions by watching how they move their body. With so many myths surrounding the subject, it is easy to think we understand the coded messages that others convey, but what does science have to say about body language? Is there anything more in it than entertainment value? If so, which movements and gestures speak volumes and which are red herrings? And, knowing this, can we actually alter our own body language to manipulate how others perceive us?

A good place to start looking for answers is the oft-quoted statistic that 93 per cent of our communication is non-verbal, with only 7 per

cent based on what we are actually saying. This figure came from research in the late 1960s by Albert Mehrabian, a social psychologist at the University of California, Los Angeles. He found that when the emotional message conveyed by tone of voice and facial expression differed from the word being spoken (for example, saying the word "brute" in a positive tone and with a smile), people tended to believe the non-verbal cues over the word itself. From these experiments Mehrabian calculated that perhaps only 7 per cent of the emotional message comes from the words we use, with 38 per cent coming from tone and the other 55 per cent from non-verbal cues.

Mehrabian has spent much of the past four-and-a-half decades pointing out that he never meant this formula to be taken as some kind of gospel, and that it only applies to very specific circumstances – when someone is talking about their likes and dislikes. He now says that "unless a communicator is talking about their feelings or attitudes, these equations are not applicable" and that he cringes every time he hears his theory applied to communication in general.

So the oldest stat in the body language book isn't quite what it seems, and the man who came up with the formula would like everyone to please stop going on about it. After all, if we really could understand 93 per cent of what people are saying without recourse to words, we wouldn't need to learn foreign languages and no one would ever get away with a lie.

Clearly, people can lie successfully. And,

generally, though it is useful to lie occasionally, we would rather that others could not. Which is why a lot of the interest in body language concerns detecting lies. Legend has it that liars give themselves away with physical "tells", such as looking to the right, fidgeting, holding their own hands or scratching their nose. How much of this stacks up?

The first item is easy to dispatch. A study published in 2012, the first to scientifically test the "liars look right" assertion, found no



TRENT PARKE/MAGNUM



evidence to back it up. It was carried out by a team led by psychologist Richard Wiseman of the University of Hertfordshire in Hatfield, UK, who observed the eye movements of volunteers telling lies in lab-based experiments. They also studied footage of people at police press conferences for missing persons, where some of the emotional pleas for information came from individuals who turned out to be involved in the disappearance. In neither case did the liars look to the right

any more than in other directions.

As for other tells, a meta-analysis of more than 100 studies found that the only bodily signs found in liars significantly more often than in truth-tellers were dilated pupils and certain kinds of fidgeting – fiddling with objects and scratching, but not rubbing their face or playing with their hair. The best way to spot a liar, the study found, was not to watch a person's body language but to listen to what they were saying. Liars tended to talk with a

higher-pitched voice, gave fewer details in their accounts of events, were more negative and tended to repeat words.

Overall, the researchers concluded, subjective measures – or a gut feeling – might be more effective for lie detection than any available scientific measure. The problem with relying on body language is that while liars may be slightly more likely to exhibit a few behaviours, people who are telling the truth do the same things. In fact, the signals ➤



Sure signs? Defeated, hostile, playful and sexy – or perhaps not

you might think of as red flags for lying, like fidgeting and avoiding eye contact, tend to be signs of emotional discomfort in general, and a non-liar is more likely to express them under the pressure of questioning. This is perhaps why, despite having a vested interest in spotting liars, we are generally pretty bad at it. In fact, US psychologist Paul Ekman has found that most people perform no better than would be expected by chance. And the success rate of judges, police, forensic psychiatrists and FBI agents is only marginally higher.

So it might be best not to go around accusing people of lying based on their body language. And there are lots of other examples in which our preconceptions of non-verbal communication are off beam or even totally misleading. Take crossed arms. Most people believe that when someone folds their arms they are being defensive or trying to fend off another individual or their opinions. This may be true. "But the same arm-cross can mean the opposite if the torso is super-erect, bent back somewhat – then it conveys invulnerability," says David McNeill, who studies gestures at the University of Chicago. Besides, an arm crosser might simply be cold, trying to get comfortable, or just lacking pockets.

McNeill is also not convinced by claims trotted out by public-speaking consultants about the importance of hand gestures. It is often said, for example, that "steepling" your fingers makes you look authoritative and an open hand signals honesty. He says that these are examples of metaphorical gestures that have the meanings that people in management perceive, but they are not limited to these meanings. In other words, these well-known "rules" of body language are arbitrary. An open hand, for example might be a metaphor for trustworthiness, but it could just as easily signal holding the weight of something. The gesture is ambiguous without context and cues from spoken language.

So far, our scientific approach has provided little support for those who claim to speak fluent body-ese, but it turns out there are some gestures everyone understands. At the 2008 Olympic and Paralympic Games, athletes from all cultures made the same postures when they won: arms up in a high V, with the chin raised. The same was true for athletes who had been blind from birth, suggesting that the victory pose is innate, not learned by observation. Defeat postures seemed to be universal too. Almost everyone hunches over with slumped shoulders when they lose.

In fact, if you are hunting for signs of victory or defeat, the body may be a better place to

look than the face. In 2012, Hillel Aviezer, then at Princeton University, and colleagues revealed that the facial expressions of professional tennis players when they won or lost an important point were so similar that people struggled to tell them apart. However, the body language was easy to read even when the face was blanked out.

Other recent studies indicate that we can glean important clues about people from the

"Power posing actually changes your physiology, so it really can make you more powerful!"

way they move. Men judge a woman's walk and dance as significantly sexier when she is in the most fertile part of her menstrual cycle, suggesting that a woman's body language sends out the message that she is ready to mate, whether or not she – or the men around her – realise it. Meanwhile, women and heterosexual men rate the dances of stronger men more highly than those of weaker men, which might be an adaptation for women to spot good mates and men to assess potential opponents.

Using body language to assess sexual attraction can be risky, though. Karl Grammer at the University of Vienna in Austria found support for the popular notion that women signal interest in a man by flipping their hair, tidying their clothes, nodding and making eye contact. But he also discovered that they make the same number of encouraging signals in the first minute of meeting a man whether they fancy him or not. Such flirting is only a sign of real interest if it keeps going after the first 4 minutes or so. Grammer interprets this as women using body language to keep a man talking until they can work out whether he is worth getting to know.

Even when there is general agreement about how to interpret body language, we can be wrong, as has been revealed in research on gait. Psychologist John Thoresen, then at the University of Durham, UK, filmed people walking and converted the images to point-light displays to highlight the moving limbs while removing distracting information about body shape. He found that almost everyone judged a swaggering walk to signal an adventurous, extroverted, warm and trustworthy person. A slow, loose and relaxed walk, on the other hand, was associated with a calm, unflappable personality. However, when the researchers compared the actual



Not in so many words

Some behaviours and gestures are worth paying attention to, but which?

Posture	Perceived meaning	The science says...
Arms crossed	Defensive	Maybe. But could also signal feeling invulnerable, self-comforting or being cold
Hands on hips, wide stance	Power, confidence	True. Adopting this stance influences hormone levels, making you more assertive
Scratching nose	Lying	No more common in liars than truth-tellers
Looking up and to the right	Lying	No supporting evidence
Swaggering walk	Confidence	Not necessarily. Can be a red herring and is easily faked
Averting gaze	Lying	False. A misconception in many cultures. But it does signal embarrassment
Fidgeting	Embarrassed	True
Raised arms, chin up	Triumph, pride	True in all cultures and even among people blind from birth
Palms up when talking	Trustworthy	One interpretation of many. No corroborating evidence

personalities of the walkers to the assumptions other people made about them, they found no correlation.

Arguably, it doesn't really matter what your body language actually reveals about you. What matters is what other people think it is telling them. So can it be faked?

Fake it to make it

Thoresen says that it should certainly be possible to fake a confident walk. "I have no data to back this up," he says, "but I do believe people can be trained to change perceived personality." There are other corporeal tricks that may help in impression management, too. For example, people in job interviews who sit still, hold eye contact, smile and nod along with the conversation are more likely to be offered a job. Those whose gaze wanders or who avoid eye contact, keep their head still and don't change their expression much are more likely to be rejected. If it doesn't come

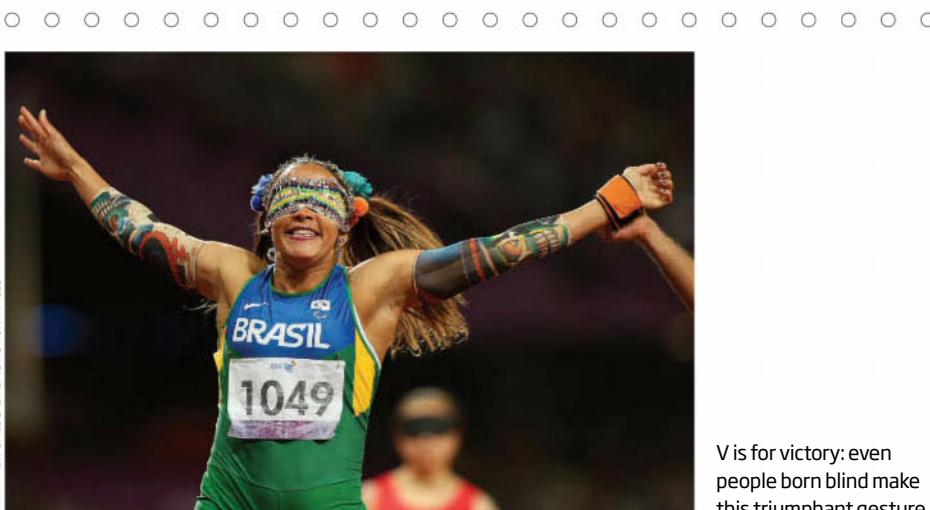
naturally, consciously adopting a confident strut, a smile and nod and some extra eye contact probably won't hurt – unless you overdo it and come across as a bit scary.

Faking calmness and confidence may change the way others perceive us, but psychologist Dana Carney at the University of California, Berkeley, believes it can do far more than that. She says we can use our body language to change ourselves. Carney and her colleagues asked volunteers to hold either a "high power" or "low power" pose for 2 minutes. The former were expansive, including sitting with legs on a desk and hands behind the head and standing with legs apart and hands on hips, while the latter involved hunching and taking up little space. Afterwards, they played a gambling game where the odds of winning were 50:50, and the researchers took saliva samples to test the levels of testosterone and cortisol – the "power" and stress hormones, respectively – in their bodies. Those who had held high-power poses were significantly more likely to

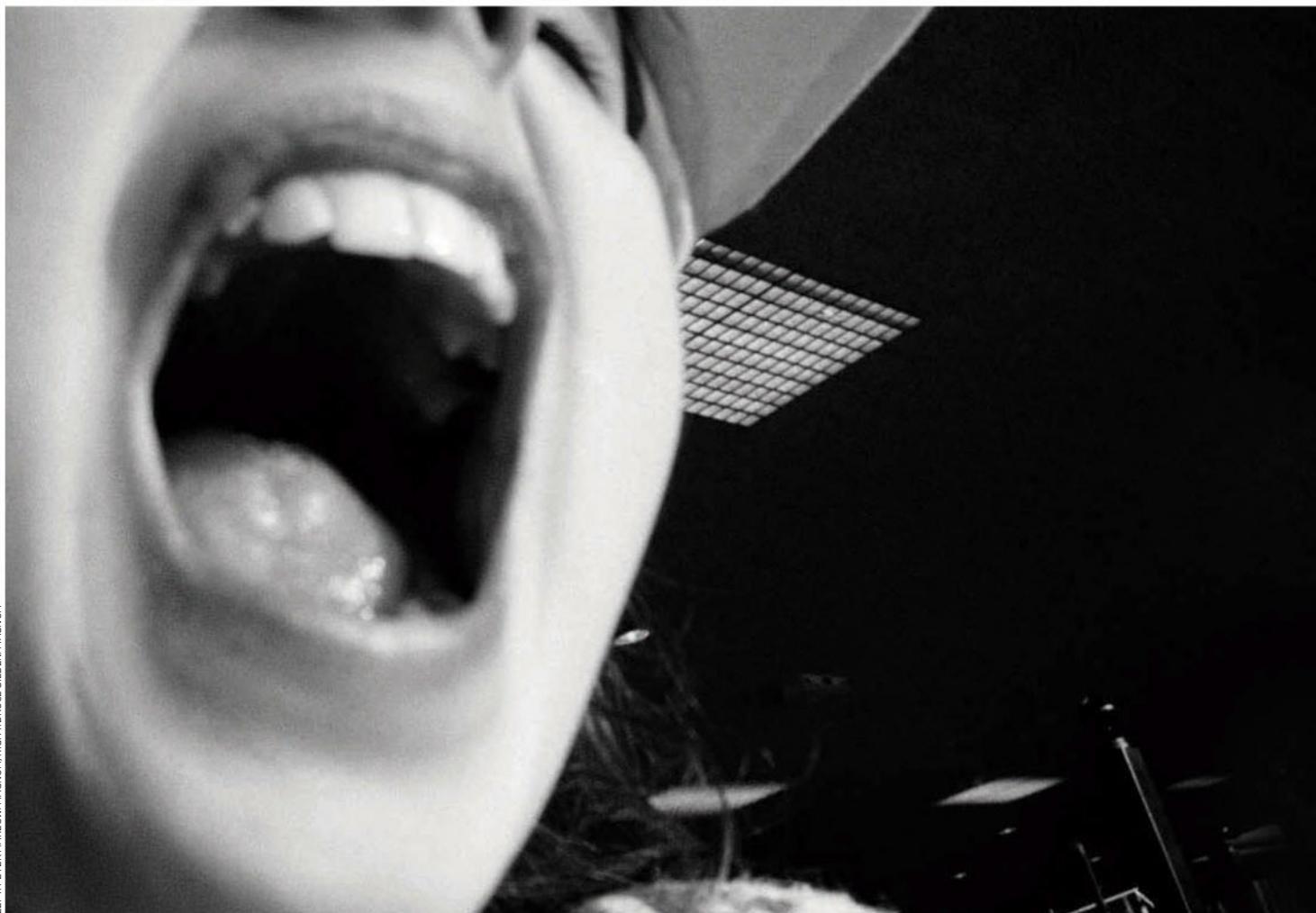
gamble than those who held low-power poses (86 per cent compared with 60 per cent). Not only that, willingness to gamble was linked to physiological changes. High-power posers had a 20 per cent increase in testosterone and a 25 per cent decrease in cortisol, while low-power posers showed a 10 per cent decrease in testosterone and a 15 per cent increase in cortisol.

"We showed that you can actually change your physiology," says Carney. "This goes beyond just emotion – there is something deeper happening here." The feeling of power is not just psychological: increased testosterone has been linked with increased pain tolerance, so power posing really can make us more powerful. And this is not the only way body language can influence how you feel. Carney points to studies showing that sitting up straight leads to positive emotions, while sitting with hunched shoulders leads to feeling down. There is also plenty of evidence that faking a smile makes you feel happier, while frowning has the opposite effect. In fact, there is evidence that people who have Botox injections that prevent them from frowning feel generally happier.

Despite these results, if science has shown us anything it is that we should always question our preconceptions about body language. Even when people from diverse cultures are in agreement about the meaning of a particular movement or gesture, we may all be wrong. As the evidence accumulates, there could come a time when we can tailor our body language to skilfully manipulate the messages we send out about ourselves. For now, at least our popular conceptions can be modified with a little evidence-based insight. Or as Madonna almost put it: "Don't just stand there, let's get to it, strike a pose. There's something to it."



V is for victory: even people born blind make this triumphant gesture



Voice almighty

Your dulcet tones affect everything from your sex appeal to your bank balance. But they can also wildly misrepresent you, finds Tiffany O'Callaghan



THE YEAR was 1927. The BBC had only passed its fifth birthday and radio broadcasting was still a novelty. With radio plays wafting through the airwaves into almost every living room, British psychologist Tom Hatherley Pear wanted “to discover what actually goes on in the minds of different listeners” as they tuned in to programmes “presenting the voice and nothing besides”.

So he recruited 9 people – ranging from his 11-year-old daughter to a judge and a minister – to read on air a passage from *The Pickwick Papers*, in which Dickens describes a comically unsuccessful outing on ice skates. The readings were broadcast on BBC stations across the UK on three consecutive nights in January, and listeners were asked to cut out a form from the *Radio Times*, fill it out describing their impressions of the speakers, and send it in to Pear’s team.

The experiment captured the public’s imagination: nearly 5000 people responded, some with highly detailed descriptions of the people they had heard. Whether they were right or wrong, what was striking was the strength of impressions they had formed.

Many participants happily provided full backstories for the voices in question. Of the minister who read on air, one listener wrote: “I should say he has suffered considerably and is very sympathetic... I would imagine him as being tall and cadaverous, round-shouldered with a long neck and protruding chin.”

Pear had identified something that we perhaps all know instinctively, that the voice can be powerfully suggestive. Whether you are eavesdropping from another room or taking a phone call at work, the way someone speaks can paint a clear picture of a person, their personality and even provide a sense of their history. But often, you won’t be aware of this, nor of the way these impressions are influencing your behaviour.

“There’s so much going on with voice, and we don’t think about it,” says Jody Kreiman, co-director of the Voice Perception Laboratory at the University of California, Los Angeles. “Your voice is your auditory face.” Kreiman is among a number of researchers who are lending an ear to the secrets of voice. It turns out that some of the most subtle effects are also the most potent; they can influence your

We can feel that someone’s whole personality is reflected in their voice. But how much of it is real?

sexual allure, your political credentials – even your salary.

Much of the recent work has built on Pear’s original findings to pin down the cues that shape our mental pictures of other people’s physical characteristics. Consider the way we form an impression of someone’s gender from the way they speak. As you might expect, the most obvious clue is pitch – an association with a long evolutionary history. The males of many species tend to have longer vocal tracts than the females, giving a deeper sound that makes them seem bigger to potential rivals and mates. That is probably the result of “sexual selection” – with females’ preference for more imposing-sounding mates driving the evolution of the male’s vocal tracts.

In humans, these gender differences can be striking. Men’s vocal tracts are up to 20 per cent longer than women’s, and men also have larger vocal cords – or vocal folds – causing them to speak about an octave lower, on average. Supporting the idea that this is due ➤

to sexual selection, studies show that women tend to find men with lower voices more attractive, while men prefer higher voices in women. Indeed, one team recorded women's voices at different stages of the menstrual cycle and found that the pitch rises slightly, and it takes on a subtle kind of shimmer, in the two days before ovulation – possibly enhancing a woman's sex appeal.

Yet we are so accustomed to linking pitch with gender that it can be easy to overlook subtler cues that may also be important. For instance, a study of men undergoing gender reassignment found that two voices speaking at exactly the same frequency can sound either masculine or feminine simply by the way they pronounced the sibilant "s" sound at the end of the word "centuries". As well as variations in pitch, such differences may explain why actors can rarely switch gender convincingly – often to comedic effect (think Julie Andrews in *Victor Victoria* or Robin Williams in *Mrs Doubtfire*).

After gender, the next easiest characteristic to read from a voice may be the speaker's age. As we get older, we tend to speak more slowly, and eventually decreasing muscle tone can mean we produce weaker, breathier sounds when speaking. We hardly have pinpoint precision, though. Kreiman has found listeners in her lab were typically able to estimate a speaker's age to within about 10 years. There were some notable exceptions, though. One 3-year-old was identified by some listeners as the youngest speaker and by others as the oldest. "It's actually my niece and she had just had her tonsils out, so she had all the hallmarks of an elderly voice," Kreiman explains. "She had imprecise articulation because she's 3, she's very hoarse, she's breathy, and she's talking slowly."

The sound of a hairstyle

What about reading more specific aspects of someone's appearance from the way they speak? As Pear's volunteers showed, our impressions can be surprisingly detailed. Based on the voice alone, one listener described a police detective as "a big, stoutish man, with medium-coloured, rather unruly hair". Lest you wonder what he meant by this, he continued: "By unruly, I don't mean a curly, tousled mop, but hair that won't go the right way and is unaccustomed to brilliantine."

When forming these pictures, we may be tuning into the way the voice's sound is transmitted through the body because the shape of the lips, jaw, nose and chest influence where the sound waves resonate and amplify.



And to a certain extent, it works. We can approximate height based on voice alone, but our best guesses are still off by about 10 centimetres, Kreiman says. And while we may think voices convey subtle hints about the contours of people's faces, it is very difficult to pair up photos of faces with the voices that go with them. During the study that found the biggest effect, participants were able to match voices to faces (from a selection of people of the same gender) only slightly better than chance.

Things get even murkier when we try to read the same cues for psychological, rather than physical traits. Despite our confidence in our judgements, they are often based on crude biases. And as with other types of bias, the consequences can be troubling.

One of the more telling examples again concerns the pitch of the voice. Besides its

People of note

A study of CEOs in the US found that those with slightly deeper voices tend to work for bigger companies and enjoy bigger pay packets

Pitch 125 Hz	~B		\$3.7 million
Pitch 102 Hz	~A ^b		\$3.88 million

role in sexual attraction, pitch can also send out signals of other qualities. For both sexes, a deeper voice has come to be associated with greater competence and leadership ability. That can be a boon for men with a Barry White growl: an examination of nearly 800 male CEOs of US companies found that other things being equal, those with deeper voices tended to be in charge of larger firms and accrue around \$190,000 more in annual earnings, compared with men with higher voices (see diagram, below).

But the situation is more complicated for women. As with men, speaking in a deeper voice makes women seem more powerful and assertive, but that may be at the expense of their perceived attractiveness. Casey Klofstad, a political scientist at the University of Miami in Florida, was particularly intrigued by the way this could influence elections: "Is it going to be perceptions of competence and strength that drive our vote choices, or perceptions of attractiveness?" His experiments suggest it is the former. After listening to recordings of female candidates soliciting votes, subjects consistently preferred – and said they would vote for – the women with the deeper voices.

The power of a deep voice was no secret to Margaret Thatcher's advisers, who helped the once higher-pitched British politician develop a more stately tone. "Thatcher had a completely manufactured voice," says Barbara

As the movie *The King's Speech* portrayed, the way you talk can make or break your image

Berkery, a voice coach who has worked with actors on films such as *The King's Speech*. Honing a speaking voice may be particularly problematic for female politicians in the US, says Klofstad. "On average, Americans are politically disengaged and we choose leaders based on impressionistic judgments," he says – so factors like the pitch of someone's voice matter. Hillary Clinton may want to take note, he adds.

Cultural cues

Such implicit associations might even be driving large-scale changes in the way we speak. For example, a 1995 study that compared the pitch of women in Japan and the Netherlands found that Japanese women had consistently higher voices. This reflected cultural values, the researchers concluded, noting that traditional gender roles – with an emphasis on the man as the breadwinner and protector – were very highly valued in Japanese culture at the time, but less so in Dutch culture. Studies in Sweden, the US, Australia and Canada have also shown that women's voices have grown deeper in those countries since the 1950s – by more than 20 hertz, roughly the equivalent of moving between the "middle" C and B on a piano.

Perhaps nothing shapes our voice-based judgements of a person the way accents can – even if our assumptions can lead us wildly astray. During Pear's study, for instance, half of the people who responded were convinced that the police detective reading the Dickens extract was a farmer – presumably because he spoke with a more rural accent.

Our reliance on accents as cues probably had some evolutionary benefit: according to one view, linguistic differences emerge to help us define our cultural identity, so that we can tell our in-group from out-groups. Some evolutionary anthropologists suggest that distinctive vocalisations may have helped early humans to distinguish their kin before they even started to use a spoken language.

It seems that we absorb these associations at a very young age. University of Chicago psychologist Katherine Kinzler presented white 5-year-olds with photos of other children of the same age. She found that, when no one was speaking, they tended to prefer those who shared the same skin colour as "friends". But when the children were given recorded voices of native English speakers or kids who spoke with foreign accents

Margaret Thatcher's voice was "completely manufactured"

alongside the photos, they chose those who sounded most like them, regardless of ethnicity. The preference tends to shift towards skin colour as children age but, as Kinzler says, it nevertheless illustrates "the power of the voice as a really important feature of identity".

The connotations of a particular accent are complex and can influence perceptions of prestige, attractiveness and intelligence. Often, we seem to be more indulgent of these biases, compared with other kinds of prejudice. "If a parent in my lab hears his or her child express race-based attitudes, they become very uncomfortable," Kinzler says. "But when kids say they like someone who speaks in the same accent as they do, parents don't have the same kind of negative response."

Yet like other stereotypes, biases based on accent can unfairly swing important decisions in places such as the courtroom. In one study, based on a voice recording, people were more likely to judge a suspect as guilty if he spoke in a regional Birmingham accent rather than a more standard English accent. (People who had "Brummie" accents themselves were excluded from the study.) Also, when people have thick accents that may make them harder to understand, we are less likely to trust what they have to say. Researchers asked native speakers of English, and non-native speakers who spoke English with either a mild or heavy accent, to record themselves reading statements of trivia. When listening to these recordings, people consistently thought the statements read by those with heavy accents were less likely to be true – even when they

were told that all of the trivia was provided by the researchers, not the speakers.

It may seem surprising, but one way to overcome these prejudices may be to try imitating another voice. To some extent, we may already do this naturally. According to one theory, we understand others by going through the motions of their speech ourselves: our brain's motor cortices kick into action, showing the same kind of activity as if we were actually saying the words.

Simply tuning in to unfamiliar accents may not only help us to decode the new sounds, but also lose our assumptions about the speakers. Patti Adank, now at University College London, and colleagues asked people who had never lived in Scotland, and were not often exposed to Scottish accents, to mimic speakers from Glasgow. Before and after, participants rated the attractiveness of the

"Women's voices have grown deeper in Sweden, the US, Australia and Canada since the 1950s"

Glaswegian accent. Assessments of power and competence remained the same, but after mimicking the accent, participants consistently found it more attractive. "After we asked people to imitate people from Glasgow, they liked them a bit more," Adank says. She suggests this reflects an in-group/out-group effect. "If you're being put in an out-group's perspective, that works as a levelling factor."

While prejudices remain, many people turn to elocution lessons – and not just to remove traces of a regional accent. Voice training can help transgender individuals, for instance, learn the subtle differences in enunciation between men and women. Others are turning to "voice-lift" therapy to remove the breathy or gravelly tones that can signal age.

Whatever your reason, perfecting a new voice takes time, says Berkery, who worked with the actor Renée Zellweger for two months to help her prepare her English accent for *Bridget Jones's Diary*. "For Renée it was a 24/7 occupation," Berkery says. Put in the time, however, and you will find that your voice is more flexible than you might imagine. "There are physiological limits, but they're pretty broad," says Kreiman.

Perhaps the biggest hurdle will be psychological. Our voice has grown with us since we first learned to talk. As Kreiman points out, it is as much a part of our identity as our face. In some small way, changing it means becoming a whole new person. ■



WILLIAM LOVELACE/GETTY

CHAPTER FOUR

THE MIND



Daydream believers

Our endless capacity for imaginative thought could be the surprise factor that gave rise to civilisation, finds Catherine Brahic



IT WAS during the Abix-Rontu war for control of the solar system that the planets Rorkak and Slockland were formed. The war had erupted when two 6-year-old boys living in the US could not agree on whose cat should rule their shared imaginary world. It was resolved diplomatically when they decided to split it in two. Kevin walked away with Abixia, an island nation on planet Rorkak inhabited by the cat-human Abixians who worship the horse god Aht. Simon got Rontuia, a constitutional monarchy on planet Slockland inhabited by lynx-like Slocks with advanced technological prowess.

The imaginary worlds of Kevin and Simon (not their real names), documented by child psychologist Marjorie Taylor of the University of Oregon in Eugene, seem very elaborate to the adult observer: Kevin has minted coins and written a gospel for the Abixian religion, while Simon has made sculptures and designed buildings. But this complexity is far

GOOD WIVES AND WARRIORS

from exceptional. Psychologists who research pretend play say 12 per cent of US college students remember having imaginary worlds (psychologists call them paracosms). Two-thirds of children under the age of 7 have or remember having imaginary friends.

A short post on my Facebook page asking for my friends' own examples elicited accounts of Fred who lived inside the shaggy lounge rug and didn't have much luck with girlfriends; Loula and Loulac who were responsible for any naughty behaviour; elaborate fairy worlds at the bottom of gardens; and skating worlds beneath beds.

And the phenomenon isn't just the preserve of childhood. While many of us leave our imaginary worlds and companions behind as we grow up, some adults continue to interact with them. Agatha Christie reportedly still spoke to her imaginary companion at the age of 70, and Kurt Cobain addressed his suicide note to his childhood imaginary friend Boddah. More frequently, adults indulge their imaginations with novels, movies and video games, not to mention daydreaming, fantasy and hypothetical thinking.

Central role in thought

So why do we spend an inordinate amount of time immersed in worlds that exist only in our heads? Neuroscientists and psychologists used to regard our propensity to conjure up and then flesh out fictional scenarios, people and objects as mere mental fluff. Now imagination is recognised as playing a central role in human thought, from planning and creativity to memory and problem-solving. It protects our mental health and may even be the fragile foundation on which human society is built.

When I found out that nobody knows how much time people typically spend immersed in figments of imagination, I set out to keep track of my own imaginings. My aim was to do it over the course of a month, but I gave up after a few hours, overwhelmed by the scale of the task. I may be prone to daydreaming, but even so imagination seems like an almost continuous feature of inner life. Even on an ordinary day we exercise it all the time: what to have for lunch, how to prioritise today's workload, how to structure the next sentence.

If imagination is the ability to transcend our current circumstances and use our minds to travel through time and space and beyond, then that includes everything from daydreaming of unicorns to visualising an event from last weekend and figuring out, ➤

at two in the afternoon, how best to get to a social occasion across town that evening. If you go with that definition, then we are constantly using our imagination, says Taylor, who runs the Imagination Research Lab at the University of Oregon.

Alison Gopnik, a psychologist and philosopher at the University of California, Berkeley, uses a slightly narrower definition to rule out any confusion with memory. She sees imagination as our ability to consider possibilities that we know aren't true in the here and now – a definition that includes unicorns and future events but excludes memories and visualisations of things that really happened. Even this more narrow definition encompasses a large proportion of human thought.

Decisions, decisions

Gopnik is particularly interested in counterfactual thinking, a kind of imagination that treads a fine line between the real and the unreal. Take the following scenario: you were interviewed for a new job, but just heard that you didn't get it. You mull over all the things that happened in the interview and how they might have played out differently. Why didn't you see that question coming? How could you have forgotten to mention the brilliant idea you had prepared ahead of time? In other words, you think about a reality that didn't happen – but only just. This is how we learn from our mistakes and adjust our behaviour, and is seen as being one of the prime functions of imagination.

Similarly, every day we play out various scenarios in our minds to enable us to select the best one. Is it better to carry on working tonight, or quit now and finish off early tomorrow? Would a glass of wine help? Should I call my sister to tell her my news? What if I sent her an email instead? Sometimes these spill over into pure fantasy, from daydreams about future holidays to visualisations of what a new romantic relationship might be like.

This kind of mental flight of fancy is an important part of how we make decisions. It allows us to explore our emotional reactions to various outcomes without having to actually experience them. Imagination also plays a role in designing and innovation. Taylor points out that every human-made object in your line of vision was imagined before it became real.

It's nigh on impossible to say how much time the average adult spends immersed in mental time travel, daydreaming, planning,

counterfactual thinking, creativity and fantasy. "But one thing pretty much everyone agrees on," says Gopnik, "is that however much we as adults imagine, we don't do it nearly as much as children." Pretend play starts when we are about 2 years old, and young children can spend most of their days immersed in it, making them ideal subjects in the study of imagination.

Gopnik wants to know why children spend so much time immersed in pretend play. "They have so much to learn about the real world, so why are they spending so much time off in these crazy imaginary worlds?" To answer the question, her colleague Daphna Buchsbaum, now at the University of Toronto

"I would love to know if chimpanzees can entertain the notion of a unicorn"

in Canada, introduced a group of 3 and 4-year-olds to a stuffed toy monkey and told them it was his birthday. She also showed the children a musical machine that would play *Happy Birthday* to the monkey if it was fed an object called a zando, but wouldn't play if it was fed a different object that was not a zando.

The imagination part came when a person

walked into the room and took away the birthday machine, the zandos and the non-zandos. Buchsbaum grabbed a box and two blocks and said they could just pretend that the box was the birthday machine and that one of the blocks was a zando.

The children were later asked various questions that required counterfactual thinking, such as "what if we said this zando was a non-zando – now what happens if I put it in the birthday machine?"

Buchsbaum found that the children who had spent time in pretend play with the box and blocks were better at answering the counterfactual questions. "If they can pretend that they are playing with the machine then they can also do more counterfactual thinking about it," says Gopnik. She sees this as evidence that pretend play is serious business, allowing children to explore causal relationships in the world around them.

So when a child tells another "let's pretend that's a tiger cage and I'm the zookeeper and you're the tiger," she isn't just messing about. She is exploring all the possible scenarios in that set-up, and their consequences. If the tiger is locked in the cage then it can't eat the other children, but if the zookeeper leaves the cage open, the tiger can escape, and then what happens?



Flights of fancy

Do other animals have the power of imagination?

HUMANS are probably uniquely imaginative. But some researchers who study apes and other clever tool-making animals such as crows and scrub jays see powers of imagination in their subjects: they plan ahead when making complex tools and solve problems they have never encountered before without resorting to trial and error.

Nicky Clayton of the University of Cambridge says the explanation is that the crows are imagining what might happen if they do X or Y and picking the right option according to the imagined outcomes.

But Josep Call of the Max Planck Institute for Evolutionary Anthropology in Leipzig, Germany,

isn't convinced. Can chimpanzees and other animals conceive of something that isn't present, or think of something that happened yesterday? Yes, absolutely, Call says. We see this in the way they cache food and later go back to find it. But he maintains that there is simply no convincing evidence that they can do any more than this.

"I would love to know if chimpanzees can entertain the notion of a unicorn, but we have no idea," he says. "As far as I can tell, we don't even know whether they can entertain two possible scenarios to solve a problem." In Call's view, it is impossible to say whether the animals that solve problems without trial and error are consciously imagining different solutions, or subconsciously integrating information to come up with the correct solution. "I'm not saying animals can't imagine two different scenarios," he says. "I just

don't see the evidence for it."

He does, however, agree that animals probably have rich mental lives. In experiments carried out around a decade ago, captive chimpanzees were taught artificial codes to allow them to communicate. Suddenly, the animals began to express desires and other emotions – proof, says Call, that there is more going on inside their heads than meets the eye.

"Very often people will say the mental lives of animals must be impoverished because they don't have language," says Call. "I think the mental lives of chimpanzees are very rich."

We may never know if our great ape cousins can muse about unicorns, or dream up imaginary friends or worlds, but one thing just about everyone agrees on is that even if they do, they are no match for humans in terms of the sheer amount of time spent immersed in make-believe.



GRAVITY GIANT PRODUCTIONS/GETTY

Another form of make-believe that reveals a lot about childhood imagination is having an imaginary friend. Once thought to be the refuge of loner kids who had trouble establishing relationships or interacting with the real world, it is now clear that they are a common element of a normal childhood.

Taylor has spent decades interviewing children about imaginary friends and says most are very aware of their fictional nature. "We take notes very seriously while they are talking to us and at some point, they will say 'you know, this is just pretend'. Or we will ask them where they met their friend and they say, 'Well, I just made her up'." In a study of 83 children with imaginary friends, a third spontaneously offered this kind of clarification and only two children showed any signs of being confused about the nature of their friends.

So what's the point? "Imaginary friends are pretty multipurpose individuals," says Taylor. "They are the most unbelievably diverse group that you could think of." Over the years, Taylor has been introduced to Epsy Welsy, a tie-dyed veterinarian; a shark that lived inside a child's throat; Charlie Ravioli, who was always too busy to play with the little girl who had made him up; and hundreds more.

"It used to drive me crazy," she says. "I would wonder 'what's the typical imaginary

friend?' Then I realised the finding is that there is no typical imaginary friend." Their diversity, she says, reflects their range of uses, from plain old fun to being vehicles to express fears, explore emotions and run "experiments" on the mysterious adult world.

Division of labour

In this way, childhood imagination can be seen both as a way to safely explore the real world and as a dress rehearsal for adult imagination. Gopnik talks about a division of labour between childhood and adulthood. She compares the former to a sort of research and development division, where we can experiment with the world and develop our creative minds unencumbered by worries about survival. The skills we acquire during this period prepare us for adulthood – the production and marketing division.

Imaginary friends may also help children cope with real-life difficulties. Taylor and her colleagues interviewed 152 12-year-olds whose teachers said they were problematic. They were from poor families, had poor grades, got into trouble a lot and didn't interact well with their peers. Thirteen said they had imaginary friends. Six years later, 11 of these children reported back, and eight of them were doing well – they had no mental illness, were not

using illegal drugs, hadn't been arrested and had graduated high school. By contrast, only a quarter of the kids who hadn't reported imaginary friends also ticked all of these boxes.

The result is far from conclusive – the numbers are very small and the outcome could reflect correlation not causation. But it is backed by interviews that Taylor has done with children in the US foster care system. Those who had imaginary friends often used phrases like: "She was there when I needed her"; or "whenever I got sad or mad or I wanted to throw something and break, it was like what a mom would do, try to calm someone down". Taylor says that in difficult situations, imaginary friends can offer the same kind of support as real friends and family.

Whether children's imaginary worlds predict something about their future is an open question. One study, led by Michele Root-Bernstein of Michigan State University in East Lansing, found that adults who had received awards for creativity were more likely to have had paracosms as children. But Taylor says there simply haven't been any long-term studies following individuals over decades to show whether kids who engage in more pretend play make more creative adults.

Some studies also suggest that children with imaginary friends have stronger ➤

SEVEN STEPS TO IMAGINATION

According to Steven Mithen, an anthropologist at the University of Reading, UK, who specialises in the evolution of the mind, seven key changes were needed to allow the emergence of human imagination as we know it. Each happened for other purposes; the first three were in our distant ancestors, the final four exclusive to *Homo sapiens*

1 Theory of mind

What is it? The knowledge that others have beliefs and thoughts that are different from one's own. Probably evolved in response to larger social groups
How does it support imagination? Allows "thought experiments" about thoughts and behaviours of others

2 Human life history

What is it? A long period of infant helplessness plus an extended childhood and adolescence. May have evolved to resolve the conflict between bipedalism – which narrows the pelvis – and large brain size
How does it support imagination? Enables an extended period with no adult responsibilities, giving the opportunity for imaginative play

3 Specialised intelligence

What is it? The evolution of dedicated mental modules to deal with specific types of thought or behaviour
How does it support imagination? Allows the combination of different types of knowledge or ways of thinking to create new ideas

4 Language

What is it? Strictly speaking, a system of words and grammatical rules. Mithen argues that only *Homo sapiens* evolved true language
How does it support imagination? Enables the creation, sharing and elaboration of ideas that couldn't have been conceived in a single human mind

5 Cognitive fluidity

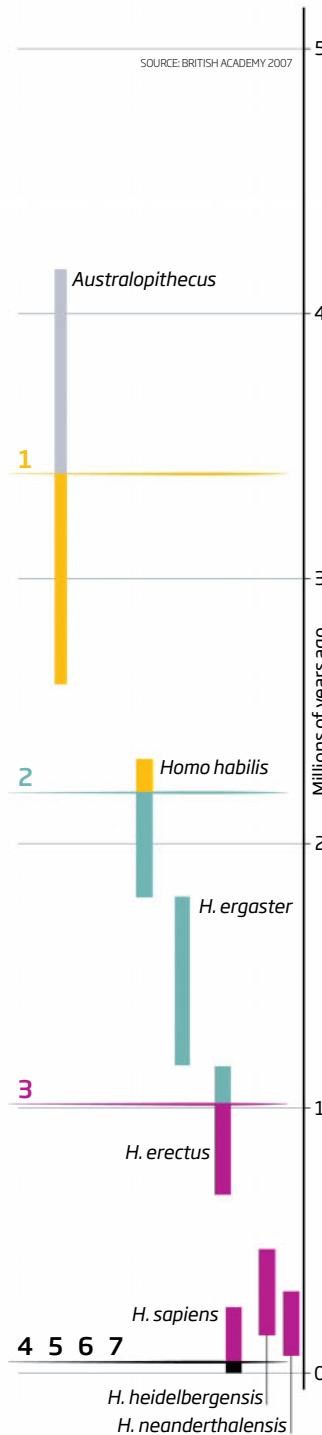
What is it? Using language to more efficiently combine specialist knowledge across cognitive domains
How does it support imagination? Allows the creation of novel thoughts and ideas including metaphors and symbols

6 The extended mind

What is it? The use of technologies such as writing and computer chips to store and share ideas
How does it support imagination? Allows existing ideas to be built on and improved

7 Sedentary lifestyle

What is it? The transition from nomadic hunter-gathering to settled farming lifestyles
How does it support imagination? Through a massive expansion of the shared, extended mind and also the creation of food surpluses so individuals could spend time on creative pursuits



theory of mind – meaning they are better able to understand and relate to the mental states of other people (see "Inside job", page 54).

Steven Mithen, an archaeologist and anthropologist at the University of Reading, UK, suggests that the evolution of theory of mind in our early ancestors was the first step in acquiring our unique skills of imagination.

Mithen, who specialises in the evolution of the human mind, has outlined seven key milestones in the gradual evolution of our imagination (see "Seven steps to imagination", left). He argues that every one of these milestones was selected for other reasons. "The modern human creative imagination was largely an accident of evolutionary history," he says.

One milestone was becoming bipedal, which required a narrow pelvis. This in turn means infants must be born with flexible skulls and small brains, which grow to full size during childhood. So standing up on two feet laid the foundation for long childhoods when our brains develop under cultural influences.

For Maurice Bloch, an anthropologist at the London School of Economics, the moment our imaginations became unique was around 10,000 years ago, and is inextricably linked to world domination.

For tens of thousands of years after first appearing in Africa, *Homo sapiens* lived in small, isolated groups of hunter-gatherers.



Around 60,000 years ago, some left Africa for Asia, Europe and the Americas.

Then, about 30,000 years ago, a revolution took hold. Suddenly, there was a flowering of cultural expressions. Cave paintings appeared, tools became more complex and evidence of symbolic thought through sculptures and representations of the dead became frequent. Global domination was cemented 10,000 years ago with the emergence of large civilisations built around sedentary societies.

Anthropologists have suggested all sorts of explanations for what archaeologist Colin Renfrew of the University of Cambridge calls the “sapient paradox” – the mystery of why it took tens of thousands of years for our ancestors to make this leap. Language is thought to have played an important role. And climate change offers a popular explanation: the end of the last ice age would have allowed people to start farming, living in villages built around or near religious temples.

But many, including Renfrew, believe that something may have also been stirring deep inside the human brain 10,000 years ago. For Bloch, at least part of that has got to do with imagination.

Made-up world

Large societies and the glue that holds them together are completely made up, says Bloch. Nations, tribes, religion, marriage, money and the law-enforcing powers of a judge are arbitrary products of our creative thought. So to create them, our ancestors must have had fantastic powers of imagination.

“If people belong to a clan,” says Bloch, “they might say we are members of this clan, we came to this land 200 years ago and will be there 200 years from now. But that idea can only exist in imagination.” Without these imaginary structures, interactions within



social groups are limited to being physical transactions between animals that exchange favours. “If you want to have large-scale societies you have to move to a transcendental level of social cognition,” says Bloch.

So, according to Bloch, the thing that was stirring in our brains 10,000 years ago and that triggered the sudden world domination of our species was a significant upgrade in human imagination to a level that can conceive of the existence of abstract concepts like laws, nationality or religion. Since then, he says, humans have been using their remarkable imaginations to dream up and then create social structures and institutions, including religion, money,

laws, nation states, science and much more. That is an amazing feat that may explain why we alone among the creatures on Earth have developed technological civilisations.

But Bloch suspects there is a subtle downside. The imaginary fabric of human society makes it inherently fragile, he says. “This is only a hunch for now, but I think there are moments when suddenly the arbitrariness of the system appears.” Legalising gay marriage may be one such momentous issue for some people, he suggests.

“I’m fascinated by the people who have been demonstrating against gay marriage in France,” says Bloch. Talking to them, he found that “what really worried them was this notion that if gay marriage is possible then everything will collapse. What I think is going on is suddenly an awareness of the imaginary nature of the institutions that we live in.”

There is, of course, a very real distinction between imagination and the real world. Nobody protested when Rorkak and Slockland decided to go their separate ways; nobody died in the Abix-Rontu war. But the fact that Kevin and Simon were able to dream them up at all tells us a great deal about what it means to be human, and the world we have conjured out of mere thought. ■



Inside job

Humans have an impressive ability to get into other people's heads, discovers Kirsten Weir. So why are some of us better at it than others?

PICTURE two friends, Sally and Anne, having a drink in a bar. While Sally is in the bathroom, Anne decides to buy another round, but she notices that Sally has left her phone on the table. So no one can steal it, Anne puts the phone into her friend's bag before heading to the bar. When Sally returns, where will she expect to see her phone?

If you said she would look at the table where she left it, congratulations! You have a theory of mind – the ability to understand that another person may have knowledge, ideas and beliefs that differ from your own, or from reality.

If that sounds like nothing out of the ordinary, perhaps it's because we usually take it for granted. Yet it involves doing something no other animal can do to the same extent: temporarily setting aside our own ideas and beliefs about the world – that the phone is in the bag, in this case – in order to take on an alternative world view.

This process, also known as "mentalising",



KEITH NEGLEY

not only lets us see that someone else can believe something that isn't true, but also lets us predict other people's behaviour, tell lies, and spot deceit by others. Theory of mind is a necessary ingredient in the arts and religion – after all, a belief in the spirit world requires us to conceive of minds that aren't present – and it may even determine the number of friends we have.

Yet our understanding of this crucial aspect of our social intelligence is in flux. New ways of investigating and analysing it are challenging some long-held beliefs. As the dust settles, we are getting glimpses of how this ability develops, and why some of us are better at it than others. Theory of mind has "enormous cultural implications", says Robin Dunbar, an evolutionary anthropologist at the University of Oxford. "It allows you to look beyond the world as we physically see it, and imagine how it might be different."

The first ideas about theory of mind emerged in the 1970s, when it was discovered

that at around the age of 4, children make a dramatic cognitive leap. The standard way to test a child's theory of mind is called the Sally-Anne test, and it involves acting out the chain of events described earlier, only with puppets and a missing ball (see diagram, page 56).

When asked, "When Sally returns, where will she look for the ball?", most 3-year-olds say with confidence that she'll look in the new spot, where Anne has placed it. The child knows the ball's location, so they cannot conceive that Sally would think it was anywhere else.

Baby change

But around the age of 4, that changes. Most 4 and 5-year olds realise that Sally will expect the ball to be just where she left it.

For over two decades that was the dogma, but more recently those ideas have been shaken. The first challenge came in 2005, when it was reported that theory of mind seemed to be present in babies just 15 months old.

Such young children cannot answer questions about where they expect Sally to look for the ball, but you can tell what they're thinking by having Sally look in different places and noting how long they stare: babies look for longer at things they find surprising.

When Sally searched for a toy in a place she should not have expected to find it, the babies did stare for longer. In other words, babies barely past their first birthdays seemed to understand that people can have false beliefs. More remarkable still, similar findings were reported in 2010 for 7-month-old infants.

Some say that since theory of mind seems to be present in infants, it must be present in young children as well. Something about the design of the classic Sally-Anne test, these critics argue, must be confusing 3-year-olds.

Yet there's another possibility: perhaps we gain theory of mind twice. From a very young age we possess a basic, or implicit, form of mentalising, so this theory goes, and then around age 4, we develop a more

➤



sophisticated version. The implicit system is automatic but limited in its scope; the explicit system, which allows for a more refined understanding of other people's mental states, is what you need to pass the Sally-Anne test.

If you think that explanation sounds complicated, you're not alone. "The key problem is explaining why you would bother acquiring the same concept twice," says Rebecca Saxe, a cognitive scientist at Massachusetts Institute of Technology.

Yet there are other mental skills that develop twice. Take number theory. Long before they can count, infants have an ability to gauge rough quantities; they can distinguish, for instance, between a general sense of "threeness" and "fourness". Eventually, though, they do learn to count and multiply and so on, although the innate system still hums beneath the surface. Our decision-making ability, too, may develop twice. We seem to have an automatic and intuitive system for making gut decisions, and a second system that is slower and more explicit.

Double-think

So perhaps we also have a dual system for thinking about thoughts, says Ian Apperly, a cognitive scientist at the University of Birmingham, UK. "There might be two kinds of processes, on the one hand for speed and efficiency, and on the other hand for flexibility," he argues.

Apperly has found evidence that we still possess the fast implicit system as adults. People were asked to study pictures showing a man looking at dots on a wall; sometimes the man could see all the dots, sometimes not. When asked how many dots there were, volunteers were slower and less accurate if the man could see fewer dots than they could. Even when trying not to take the man's perspective into account, they couldn't help but do so, says Apperly. "That's a strong indication of an automatic process," he says – in other words, an implicit system working at an unconscious level.

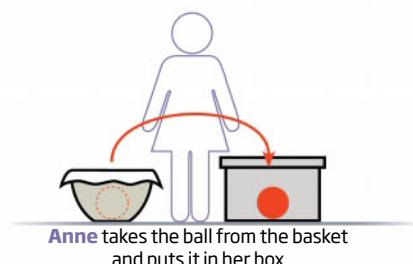
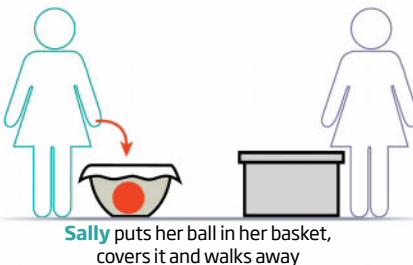
If this theory is true, it suggests we should pay attention to our gut feelings about people's state of mind, says Apperly. Imagine surprising an intruder in your home. The implicit system might help you make fast decisions about what they see and know, while the explicit system could help you to make more calculated judgments about their motives. "Which system is better depends on whether you have time to make the more sophisticated judgement," says Apperly.

The idea that we have a two-tier theory of mind is gaining ground. Further support comes from a study of people with autism, a group known to have difficulty with social skills, who are often said to lack theory of

Mind reading

Understanding that other people can have knowledge or beliefs that differ from our own is a crucial part of our social intelligence

The standard way to see if young children have acquired this ability is the **Sally-Anne test**



Most 3-year-olds think that Sally will look in the box. Around the age of 4 or 5, children understand that although they know the ball has been moved, Sally does not

We need more difficult tests for adults Some objects are screened from Sally's view, so you must take this into account when following her instructions



Depending on how the test is presented 20-50% of adults would incorrectly move the topmost ball

mind. In fact, tests on a group of high-functioning people with Asperger's syndrome, a form of autism, showed they had the explicit system, yet they failed at non-verbal tests of the kind that reveal implicit theory of mind in babies. So people with autism can learn explicit mentalising skills, even without the implicit system, although the process remains "a little bit cumbersome" says Uta Frith, a cognitive scientist at University College London, who led the work. The finding suggests that the capacity to understand others should not be so easily written off in those with autism. "They can handle it when they have time to think about it," says Frith.

If theory of mind is not an all-or-nothing quality, does that help explain why some of us seem to be better than others at putting ourselves into other people's shoes? "Clearly people vary," points out Apperly. "If you think of all your colleagues and friends, some are socially more or less capable."

Unfortunately, that is not reflected in the Sally-Anne test, the mainstay of theory of mind research for the past four decades. Nearly everyone over the age of 5 can pass it standing on their head.

To get the measure of the variation in people's abilities, different approaches are needed. One is called the director task; based on a similar idea to Apperly's dot pictures, this involves people moving objects around on a grid while taking into account the viewpoint of an observer. This test reveals how children and adolescents improve progressively as they mature, only reaching a plateau in their 20s.

"We may have a two-tier theory of mind - one process for speed, the other for flexibility"

How does that timing square with the fact that the implicit system – which the director test hinges on – is supposed to emerge in early infancy? Sarah-Jayne Blakemore, a cognitive neuroscientist at University College London who works with Apperly, has an answer. What improves, she reckons, is not theory of mind per se but how we apply it in social situations using cognitive skills such as planning, attention and problem-solving, which keep developing during adolescence. "It's the way we use that information when we make decisions," she says.

So teenagers can blame their reputation for being self-centred on the fact they are still developing their theory of mind. The good news for parents is that most adolescents will learn how to put themselves in others' shoes eventually. "You improve your skills by experiencing social scenarios," says Frith.

It is also possible to test people's explicit mentalising abilities by asking them



convoluted “who-thought-what-about-whom” questions. After all, we can do better than realising that our friend mistakenly thinks her phone will be on the table. If such a construct represents “second-order” theory of mind, most of us can understand a fourth-order sentence like: “John said that Michael thinks that Anne knows that Sally thinks her phone will be on the table.”

In fact Dunbar’s team has shown that such a concept would be the limit of about 20 per cent of the general population. Sixty per cent of us can manage fifth-order theory of mind and the top 20 per cent can reach the heights of sixth order.

As well as letting us keep track of our complex social lives, this kind of mentalising is crucial for our appreciation of works of fiction. Shakespeare’s genius, according to Dunbar, was to make his audience work at the edge of their ability, tracking multiple mind states. In Othello, for instance, the audience

has to understand that Iago wants jealous Othello to mistakenly think that his wife Desdemona loves Cassio. “He’s able to lift the audience to his limits,” says Dunbar.

So why do some of us operate at the Bard’s level while others are less socially capable? Dunbar argues it’s all down to the size of our brains.

According to one theory, during human evolution the prime driver of our expanding brains was the growing size of our social groups, with the resulting need to keep track of all those relatives, rivals and allies. Dunbar’s team has shown that among monkeys and apes, those living in bigger groups have a larger prefrontal cortex. This is the outermost section of the brain covering roughly the front third of our heads, where a lot of higher thought processes go on.

In 2012, Dunbar applied that theory to a single primate species: us. His team got 40 people to fill in a questionnaire about the

number of friends they had, and then imaged their brains in an MRI scanner. Those with the biggest social networks had a larger region of the prefrontal cortex tucked behind the eye sockets. They also scored better on theory of mind tests. “The size of the bits of prefrontal cortex involved in mentalising determine your mentalising competencies,” says Dunbar. “And your mentalising competencies then determine the number of friends you have.” It’s a bold claim (see “The bright stuff”, page 77), and one that has not convinced everyone in the field. After all, correlation does not prove causation. Perhaps having lots of friends makes this part of the brain grow bigger, rather than the other way round, or perhaps a large social network is a sign of more general intelligence.

Lying robots

What’s more, there seem to be several parts of the brain involved in mentalising – perhaps unsurprisingly for such a complex ability. In fact, so many brain areas have been implicated that scientists now talk about the theory of mind “network” rather than a single region.

A type of imaging called fMRI scanning, which can reveal which parts of the brain “light up” for specific mental functions, strongly implicates a region called the right temporoparietal junction, located towards the rear of the brain, as being crucial for theory of mind. In addition, people with damage to this region tend to fail the Sally-Anne test.

Other evidence has emerged for the involvement of the right temporoparietal junction. When Rebecca Saxe temporarily disabled that part of the brain in healthy volunteers, by holding a magnet above the skull, they did worse at tests that involved considering others’ beliefs while making moral judgments.

Despite the explosion of research in this area in recent years, there is still lots to learn about this nifty piece of mental machinery. As our understanding grows, it is not just our own skills that stand to improve. If we can figure out how to give mentalising powers to computers and robots, they could become a lot more sophisticated. “Part of the process of socialising robots might draw upon things we’re learning from how people think about people,” Aupperly says.

For instance, programmers at the Georgia Institute of Technology in Atlanta have developed robots that can deceive each other and leave behind false clues in a high-tech game of hide-and-seek. Such projects may ultimately lead to robots that can figure out the thoughts and intentions of people.

For now, though, the remarkable ability to thoroughly worm our way into someone else’s head exists only in the greatest computer of all – the human brain. ■



DAVID HOLLOWBACH

HAVE you ever, against your better judgement, nurtured a belief in the paranormal? Or do you believe that gifted rock singers are more likely to die at the age of 27? Maybe you just have the sneaking suspicion that you are smarter, funnier and more attractive than the next person.

If you buy into any of these beliefs, you are probably suffering from confirmation bias – the mind's tendency to pick and choose information to support our preconceptions, while ignoring a wealth of evidence to the contrary. Consider the idea that rock stars die at 27 – a fallacy that crops up time and again in the media. Once you have heard of the “27 club”, it is easy to cite a handful of examples that fit the bill – Janis Joplin, Kurt Cobain, Amy Winehouse – while forgetting the countless other musicians who survived their excesses past the age of 30.

The confirmation bias is just one of a truckload of flaws in our thinking that psychologists have steadily documented over the past few decades. Indeed, everything from your choice of cellphone to your political agenda is probably clouded by several kinds of fuzzy logic that sway the way you weigh up evidence and come to a decision.

Why did we evolve such an apparently flawed instrument? Our irrational nature is very difficult to explain if you maintain that human intelligence evolved to solve complex problems, where clear, logical thought should offer the advantage. As such, it has remained something of a puzzle.

But an elegant explanation has been proposed. Hugo Mercier at the University of Neuchâtel, Switzerland, and Dan Sperber at the Central European University in Budapest, Hungary, believe that human reasoning

evolved to help us to argue. An ability to argue convincingly would have been in our ancestors' interest as they evolved more advanced forms of communication, the researchers propose. Since the most persuasive lines of reasoning are not always the most logical, our brains' apparent foibles may result from this need to justify our actions and convince others to see our point of view – whether it is right or wrong. “You end up making decisions that look rational, rather than making genuinely rational decisions,” says Mercier.

The flip side, of course, is that we also face the risk of being duped by others, so we developed a healthy scepticism and an ability to see the flaws in others' reasoning. This ability to argue back and forth may have been crucial to humanity's success – allowing us to come to extraordinary solutions as a group that we could never reach alone.

Mercier and Sperber are by no means the first to suggest that the human mind evolved to help us manage a complex social life. It has long been recognised that group living is fraught with mental challenges that could drive the evolution of the brain. Primates living in a large group have to form and maintain alliances, track who owes what to whom, and keep alert to being misled by others in the group. Sure enough, there is a very clear correlation between the number of individuals in a primate group, and the species' average brain size, providing support for the “social brain” – or “Machiavellian intelligence” – hypothesis.

The evolution of language a few hundred thousand years ago would have changed the rules of the game. The benefits are clear – by enabling the exchange of ideas, complex ➤

The argumentative ape

Forget rationality and right or wrong. Your brain evolved to persuade, finds Dan Jones

"Whether we are debating a friend's infidelity or the 'war on terror', we are simply justifying our gut reactions rather than looking for a fair conclusion"

communication would have fostered innovation and invention, leading to better tools, new ways to hunt and trap animals, and more comfortable homes. But the gift of the gab would also have presented a series of challenges. In particular, our ancestors had to discern who to trust. Signs of expertise and examples of past benevolence would offer reasons to listen to some people, but our ancestors would have also needed to evaluate the ideas of people they may not have known well enough to trust implicitly.

A powerful way to overcome this challenge would have been to judge the quality of their arguments before accepting or rejecting what they had to say, helping the group arrive at the best strategies for hunting and gathering, for instance. "Providing and evaluating reasons is fundamental to the success of human communication," says Sperber, who has spent years considering the ways an argumentative mind might ease our way through the "bottleneck of distrust", as he calls it.

On the one hand, a healthy scepticism

would have been essential, leading us to more critical thought. Equally beneficial, however, would have been an ability to persuade others and justify our point of view with the most convincing arguments. It was Mercier who began to wonder whether this need to sway other people's opinions might explain some of our biases, which might skew our logic but which may nevertheless give us the edge when arguing our opinions. So the pair set about reviewing an enormous body of psychological studies of human reasoning.

Consider the confirmation bias. It is surprisingly pervasive, playing a large part in the way we consider the behaviour of different politicians, for instance, so that we will rack up evidence in favour of our chosen candidate while ignoring their competitor's virtues. Yet people rarely have any awareness that they are not being objective. Such a bias looks like a definite bug if we evolved to solve problems: you are not going to get the best solution by considering evidence in such a partisan way.

But if we evolved to be argumentative apes,

then the confirmation bias takes on a much more functional role. "You won't waste time searching out evidence that doesn't support your case, and you'll home in on evidence that does," says Mercier.

Mercier and Sperber offer a similar explanation for the "attraction effect" – when faced with a choice between different options, irrelevant alternatives can sway our judgement from the logical choice. It is perhaps best illustrated by considering a range of smartphone contracts: people who would tend to choose the cheapest option can be persuaded to opt for a slightly upmarket model if an even more expensive, supposedly luxury model is added to the mix (see "Decisions, decisions", below left).

According to Mercier and Sperber's argumentative theory, the luxury option might sway our decision by offering an easy justification for our decision to go with the middle option – we can use it to claim that we have landed a bargain. Notably, the attraction effect is strongest when people are told that they will have to defend publicly whatever choice they make. "In these kinds of situations, reasoning plays its argumentative role and drives you towards decisions that you can easily justify rather than the best decision for you," says Mercier.

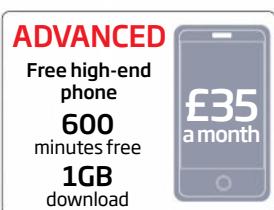
Framing effect

The duo found further evidence from the framing effect, first identified 30 years ago by psychologists Daniel Kahneman of Princeton University and Amos Tversky. In a series of studies, they found that people treat identical options very differently depending on how the options are presented, or framed. One classic experiment asks people to imagine an outbreak of disease threatening a small town of 600 people. The subjects are offered two forms of treatment: Plan A, which will definitely save exactly 200 people, and Plan B, which has a 1-in-3 chance of saving everyone and a 2-in-3 chance of saving no one.

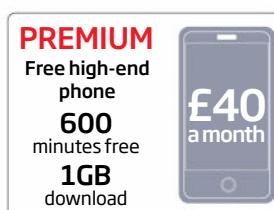
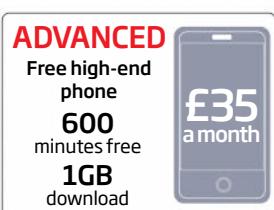
Most people choose Plan A. But they tend to change their mind when exactly the same plans are rephrased with a different emphasis. The subjects are now told that if Plan A is selected, 400 people, but no more, will definitely die. Plan B stays the same: there's a 1-in-3 chance no one will die, and a 2-in-3 chance that everyone will die. In this case, most people opt for Plan B – the choice they had previously shunned. Kahneman and Tversky explained this inconsistency in terms of "loss aversion": in the second set-up, the

Decisions, decisions

The "attraction effect" is a prime example of human irrationality. To see how it works, imagine you are weighing up two smartphone contracts. Which one would you choose?



Let's say you picked the cheaper contract because it was adequate for your needs. Now, what would you have done if there had been a third option?



People who previously chose the **Basic** option are now more likely to choose the **Advanced** contract, because it looks like a better deal than **Premium**, even though the **Basic** option best matched their needs



loss of life seems especially salient, so people avoid it. But the argumentative theory offers a new twist, suggesting that participants in these experiments choose the response that will be easiest to justify if challenged. In the first scenario, there is a direct argument for their choice – it will definitely save 200 lives whereas in the second scenario, they can instead argue that their decision might save 400 people from certain death.

Once again, experiments have shown that people are more susceptible to the bias when they are told that they will have to defend their decision, just as you would expect if we evolved to convince others of our actions. The effect may weigh heavily on the way we weigh up the benefits and risks of certain lifestyle choices – it is the reason that “90 per cent fat-free” food sounds healthy, when a product advertised with “10 per cent fat content” would seem less attractive.

Drawing together all the difference strands of evidence, Mercier and Sperber published a paper outlining their theory. In addition to confirmation bias and the framing and attraction effects, they cited many other seemingly irrational biases that might be explained by our argumentative past, including the sunk-cost fallacy – our reluctance to cut our losses and abandon a project even when it would be more rational to move on – and feature creep, which includes

our tendency to buy goods with more features than we would ever actually use.

The paper has caused quite a stir since it was published. Jonathan Haidt, a moral psychologist at New York University, believes the theory is so important that “the abstract of their paper should be posted above the photocopy machine in every psychology department”. Mercier and Sperber’s ideas dovetail neatly with Haidt’s influential view that our moral judgements stem from our gut reactions to moral transgressions, and not from rational reflection. In one example, Haidt and Thalia Wheatley of Dartmouth College in Hanover, New Hampshire, showed that hypnotically inducing the feeling of disgust leads people to make harsher moral judgments, even in cases when no one has done anything wrong – supporting the idea that emotion rather than logical reasoning drives morality. We still spend masses of time arguing about the morality of certain

situations – whether we are considering a friend’s infidelity or debating the “war on terror” – but according to Haidt’s research, we are simply trying to justify our gut reactions and persuade others to believe our judgments, rather than attempting to come to the most just conclusion. “Moral argumentation is not a search for moral truth, but a tool for moral persuasion,” says Haidt.

The idea that we evolved to argue and persuade, sometimes at the expense of the truth, may seem to offer a pessimistic view of human reasoning. But there may also be a very definite benefit to our argumentative minds – one that has proved essential to our species’ success. Crucial to Sperber and Mercier’s idea is the fact that we are not only good at producing convincing arguments, but we are also adept at puncturing other people’s faulty reasoning. This means that when people get together to debate and argue against each other, they can counterbalance the biased reasoning that each individual brings to the table.

As a result, group thinking can produce some surprisingly smart results, surpassing the efforts of the irrational individuals. In one convincing study, psychologists David Moshman and Molly Geil at the University of Nebraska-Lincoln looked at performance in the Wason selection test – a simple card game based on logical deduction. When thinking

“Hypnotically inducing the feeling of disgust leads people to make harsher moral judgements”

about this task on their own, less than 10 per cent of people got the right answer. When groups of 5 or 6 people tackled it, however, 75 per cent of the groups eventually succeeded. Crucially for the argumentative theory, this was not simply down to smart people imposing the correct answer on the rest of the group: even groups whose members had all previously failed the test were able to come to the correct solution by formulating ideas and revising them in light of criticism. There is also good evidence that groups are more creative than individual lone thinkers.

Collective intelligence

Given that the skills of the individual members do not seem to predict a group's overall performance, what other factors determine whether it sinks or swims? Anita Williams Woolley of Carnegie Mellon University in Pittsburgh, Pennsylvania, helped to answer this question with a series of studies designed to measure a group's "collective intelligence", in much the same way an individual's general intelligence can be measured by IQ tests. The tasks ranged from solving visual puzzles and brainstorming ideas to negotiating how to distribute scarce resources.

She concluded that a group's performance bears little relation to the average or maximum intelligence of the individuals in the group. Instead, collective intelligence is determined by the way the group argues – those who scored best on her tests allowed each person to play a part in the conversations. The best groups also tended to include members who were more sensitive to the moods and feelings of other people. Groups with more women, in particular, outperformed the others – perhaps because women tend to be more sensitive to social cues.

Such results are exactly what you might expect from a species that evolved not to think individually, but to argue in groups. Mercier and Sperber do not believe this was the primary benefit of our argumentative minds, though. "We think that argumentation evolved to improve communication between individuals, helping communicators to persuade a reticent audience, and helping listeners to see the merits of information offered by sources they might not trust," says Sperber. "As a side effect, you get better reasoning in a group context."

Others aren't so sure, believing instead that improved group reasoning drove the evolution of our ability to argue. "If reasoning works so much better in a group context, then why

"A group's performance bears little relation to the intelligence of its members. Instead, it is determined by the way they argue"

shouldn't it have evolved for collective reasoning, given that we are a social animal?" asks philosopher Keith Frankish of the University of Crete in Greece, who nevertheless remains undecided on the issue.

That is not to say that group thinking does not backfire occasionally. "The problem is that in many high-stakes situations, vested interests and emotions run high," says Robert Sternberg, a psychologist at Cornell University in Ithaca, New York. This is especially true when groups of like-minded individuals focus on emotionally charged topics. "In these situations, people egg each other on to more extreme positions, while more moderate thinkers are chased out," says Sternberg.

This can all too easily lead to dangerous "groupthink", in which dissent is stifled and alternative courses of action are ignored, often resulting in disastrous decisions. When Irving Janis developed the idea of groupthink in the 1970s, he used it to explain catastrophic group decisions such as the escalation of the

Vietnam war under US president Lyndon Johnson. The same perils can be seen in the decision to invade Saddam Hussein's Iraq despite the lack of compelling evidence for weapons of mass destruction.

Even though thinking things through in groups can go awry, some researchers believe it is high time to make better use of our argumentative brains for collective reasoning. Neil Mercer, an educational psychologist at the University of Cambridge, has developed an approach to teaching called "Thinking Together", which explores collaborative reasoning and learning in the classroom. His work shows that when children think together, they engage with tasks more effectively, and use better reasoning as they solve problems. The results are striking in science and mathematics problems; not only do groups often do better on these tasks, but individuals who participate in group reasoning also end up doing better in their exams in these subjects. Similar improvements can be seen in the kinds of non-verbal reasoning tasks used in IQ tests. "Kids can learn to see group reasoning as a kind of enlightened self-interest that benefits everyone," says Mercer.

His work suggests a few pointers to get the best results. Group reasoning was most productive when the children were asked to engage in "exploratory talk", he says, where ideas can be openly aired and criticised, and when they entered the task with the clear goal of seeking agreement, even if this goal remained elusive.

Although such collaborative forms of teaching have gained some measure of popularity in recent years, Sternberg believes educational systems are still too focused on developing individual knowledge and analytical reasoning – which, as the research shows, can encourage us to justify our biases and bolster our prejudices.

"We believe that our intelligence makes us wise when it actually makes us more susceptible to foolishness," says Sternberg. Puncture this belief, and we may be able to cash in on our argumentative nature while escaping its pitfalls. ■



Schools could help children reap the benefits of their argumentative minds

“...collaboration is the cornerstone of our strategy

'Brain cancer research is getting really collaborative. It's a cross and multidisciplinary team that's getting together to solve this complex problem.'

- Michelle Stewart, Head of Research
Cure Brain Cancer Foundation



Find out more about us
curebraincancer.org.au/research



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The background of the image is a collage of three photographs. The top-left photo shows shelves filled with colorful plastic toy vehicles like cars and trucks. The top-right photo is a dense collection of various toy guns, including AK-47s and semi-automatic models, some with camouflage patterns. The bottom photo shows a woman sitting on a stool in a shop, surrounded by a massive pile of colorful plastic toy cars and trucks.



BE

Humans are materialistic by nature, but we have an odd relationship with the things we own. Possessions enrich our lives but they also come at a cost, both environmental and psychological.

In this chapter, we take stock of our ambivalent relationship with material goods, size up the things that a modern human actually needs, consider the ways possessions define us and ponder the future of ownership. But first, we look back at the evolution of our instinct for stuff.

Hunters and gatherers

Our urge to accumulate has deep evolutionary roots. Alison George finds it hard to let go

WHEN I moved house recently, I was overwhelmed by the number of boxes containing my family's possessions. It made me feel quite sick.

Even so, I couldn't bring myself to throw any of it out. Possessions define us as a species; a life without them would be barely recognisable as human. Without clothes, a roof over my head, some means of cooking and a supply of clean water, I couldn't survive at all. I struggle to imagine living without a bed, a bath, towels, light bulbs and soap – let alone indulgences and luxuries, and all those objects with sentimental value.

Our closest living relatives make do with none of this. Chimps employ crude tools and build sleeping nests, but abandon them after one use. Most other animals also get by without possessions (see "Creature comforts", far right). And yet we can barely survive without belongings, and seem to have an instinct to accumulate more than we need.

How did we evolve from indigent ape to hoarding human? Answering this question is not easy. For one thing, drawing a line between "possessions" and "non-possessions" is not straightforward: do I own the soil in my garden, for example, or the water in my taps? And when I discard something, when does it cease to be mine? What's more, many objects our ancestors may have owned – animal pelts or wooden clubs – don't survive in the archaeological record.

Nonetheless, there are clues about humanity's first possessions. The earliest stone tools, made some 3.3 million years ago, are an obvious place to start. They were designed to do a job, and must have been held by an individual for a time. Yet they were simple and expendable, like chimpanzee tools. "I doubt there was much concept of ownership," says

archaeologist Sally McBrearty of the University of Connecticut in Storrs.

But as tools became more sophisticated, a sense of ownership must have started to evolve. Tools became "possessions" – items that were valued by their owner, carried for a length of time and worth fighting over. For McBrearty, the concept of ownership took off with the advent of spear and arrow heads, which first appeared in Africa at least 300,000 years ago. "They are made to specific designs that vary from group to group," she says. "The spears and arrows took time and effort to make, and were probably the property of a single hunter." Hunters would have retrieved them from kills, and used them again and again.

Another key early possession was probably fire. Some contemporary hunter-gatherer groups carry embers around with them, and so can be thought of as "possessing" fire. Our ancestors may have done the same thing. The earliest convincing evidence of controlled use of fire dates to around 800,000 years ago.

Clothing, too, made an early entrance.



TAO IMAGES/GETTY

Genetic evidence from body lice that have evolved to live in clothes suggests we started wrapping ourselves up about 70,000 years ago.

Once humans possessed fire, clothing and sophisticated tools, we presumably came to depend on them for survival – especially after colonising colder climates. Our belongings started to become part of our "extended phenotype", as crucial to survival as a dam to a beaver.

With time, there was another leap forward. Objects became valued not only for their utility but also as prestige goods to advertise the skill or social status of their owner. Eventually, certain objects became valued for these reasons alone – jewellery, for example. The earliest evidence of this is a small number of 100,000-year-old shell beads found in Israel and Algeria.

It is clear, then, that tens of thousands





Papooses were probably among our earliest possessions

of years ago the relationship between people and objects had already evolved beyond utility and survival value. Some archaeologists argue that objects had become part of our sense of self. "We developed sophisticated relationships with objects that we don't see in other animals," says Lambros Malafouris at the University of Oxford. "You use shell beads to decorate your body – at the same time that becomes part of your self-identity that others will see and recognise."

What's mine is mine

By the time modern humans reached Europe around 40,000 years ago there are clear signs of ownership. "You can see notches and marks on various items – the notion of ownership is there," says Steven Mithen of the University of Reading, UK.

But the amount of stuff that people

could accumulate was constrained by their nomadic lifestyle, leading some archaeologists to speculate that bags or papooses might have been among our earliest possessions. This changed with the switch to a settled lifestyle. Once people chose to live in one place, their possessions began to accumulate. This lifestyle also heralded a new form of society and economy. Groups became larger and hierarchies developed, with the status of important individuals bolstered by prestige items such as fine clothes and jewellery. In fact, some archaeologists such as Ian Hodder of Stanford University in California argue that societies could not have become complex and hierarchical without an associated "material culture".

This switch to sedentariness drove materialism in another way. Gary Feinman at the University of Illinois



CREATURE COMFORTS

A few weeks ago a small and bedraggled cuddly toy appeared in my house, looking like something the cat dragged in. When another bedraggled toy appeared a few days later, it became clear that it *was* something the cat dragged in. She now has four cuddly toys. I think of them as hers – but does she?

In 1776, philosopher Adam Smith noted a curious fact about animals: they don't appear to own things. "Nobody ever saw a dog make a fair and deliberate exchange of one bone for another with another dog," he wrote in *The Wealth of Nations*.

In many respects Smith was right. Only humans have a complex system of property and property rights. But some animals do have rudimentary notions of "yours" and "mine". Primates, for example, often show respect for possession. If an individual is holding an object, others, even those more dominant in the group, generally let them keep it.

Captive chimps can also be taught a more complex understanding of possession. They are willing to work for tokens that can be accumulated and exchanged for food, and understand the difference between their stash and that of other chimps. But behaviour like that has never been seen in the wild.

Some wild animals arguably do have possessions: birds' nests, beavers' dams, spiders' webs and so on. Squirrels and scrub jays cache food and will often move items to keep them safe. Magpies and bowerbirds collect shiny and colourful objects to attract mates. And many animals defend a territory.

But none of these behaviours come close to the sophistication of human ownership. The reason is simple: language. Without words, mutually understood rules and institutions to enforce them cannot exist. So whatever I think of my cat's toys, it is unlikely that she agrees.

Graham Lawton



KONRAD WOETHE/MINDEN

"Our belongings started to become as crucial to our survival as a dam to a beaver"

in Chicago argues that our urge to accumulate stuff is based on a desire to minimise risk. "When people settled down, they became more susceptible to environmental disaster," he says. A way to insure against this was to store surplus food – a process that created the need for possessions to gather and hoard, as well as the domestication of animals. Another insurance policy was to develop relationships with neighbouring groups. "Exchange of non-necessary goods could grease those reciprocal relationships," says Feinman.

Eventually, when societies became even larger and more complex, material goods became a store of wealth. Trade in such goods eventually led to the development of money.

Of course, there are a number of groups in the world today who don't live in large, complex societies, and who have very few possessions. The hunter-gatherer Hadza people of Tanzania, for example, have few material goods and a culture of enforced sharing. But the vast majority of people don't live like this and, as a consequence, are surrounded by stuff.

So what are the chances of breaking the human habit of owning too much? When you consider our reliance on things to survive and signal social status, it doesn't seem likely. Aimee Plourde, an expert in prestige goods formerly at the University of Sheffield, UK, says: "Today we talk of the psychology of bling, of conspicuous consumption, but this taps into a psychology that predates even the formation of wealth. It goes far back." ■

12
The number
of homes
most Western people will
live in across an entire lifetime

MIGRATION EXPECTANCY DATA, US CENSUS BUREAU



MY BLANKIE!

A raggedy blanket, a tatty teddy bear: the dog-eared appearance of many childhood possessions is testament to how dearly they are held. But when and how does this sense of ownership begin?

Even a newborn regards their mother as "special", and will seek out her face and smell over those of other women. By 2 months, babies begin to understand that they have ownership of their own bodies, while at 8 months they start to grasp the concept of loss. By 12 months they start to form attachments to comfort-objects like blankets. Psychologists suggest these provide a temporary substitute for their caregiver.

Also around one year, children start to say their first words, usually nouns like "bath" and "duck". By 21 months or so a word surfaces that will provide a soundtrack for the coming years: "mine".

Not for nothing are they called the terrible twos: the constant squabbles over possessions are combined with an underdeveloped sense of empathy and a propensity to tantrum. Two-year-olds fight harder for toys when they actually own them, indicating they can distinguish temporary possession from longer-term ownership, says Susan Gelman, who studies conceptual development in children at the University of Michigan in Ann Arbor. "By 3 years of age they even

protest if someone tries to take or throw away someone else's toy, which shows that they understand ownership even when it doesn't involve their own self-interest."

Children's concept of ownership continues to change as they grow older. Gelman's team recently ran an experiment in which 2 and 3-year-olds were shown three objects: one they were told was "theirs", one which belonged to the researcher and one simply placed beside the others. When the items looked different, 2-year-olds had no problem identifying which was theirs, but if they were identical, or their object was less desirable, they would become confused. In contrast, 3-year-olds kept track – even when their object was far less desirable than the other two.

This may help to explain why the replacement of a lost "blankie" or teddy bear with a newer model never goes down well: ownership overrides appearance. Indeed, when Bruce Hood from the University of Bristol, UK, showed 3 to 6-year-olds a "magic copying machine" that could replicate their favourite toy, most children demanded the original back, and a quarter refused to have it copied at all. Ownership seems to bestow a magical quality that can't be faked – even in young children.

Linda Geddes

The bare necessities

What is the smallest set of things that we need in a modern consumer society? Evolutionary psychologist **Geoffrey Miller** delves for insights

ON SOCIAL media site Instagram, thousands of people in the US post photos with the hashtag #edc, meaning “everyday carry”. These show the tools, weapons and accoutrements that they haul around day in, day out. Men also show off the contents of their pockets through #pocketdump, whereas women tend to favour #whatsinmybag.

The core stuff is remarkably similar for both groups. Those possessions we keep

closest on a daily basis have a special practicality, concreteness, intimacy and symbolic importance. As the tool-making species, we are what we carry. And what we carry might offer a guide to what we really need, stripped of the clutter of overconsumption.

For an evolutionary psychologist like me it is natural to wonder if we can link our everyday stuff to that of our distant ancestors, for whom raw survival

dictated most of their possessions.

Sadly, we don't have any prehistoric #pocketdump or #whatsinmybag images, but we do have some useful clues from Ötzi, a man who lived about 5300 years ago, and whose ice-preserved body was found in the Italian Alps in 1991. Since then, we have learned a lot about him, from his genome and the proteins expressed in his brain to the make-up of his gut microbes and his lethal arrow wound. His possessions were also well-preserved: a diverse set of clothes, tools, weapons, fire-makers, supplies and foul-weather gear suitable for his mixed roles of soldier, hunter, camper and explorer.

Much of his gear looks primitive to modern eyes. But Ötzi wasn't a distant ancestor: he had an anatomically modern brain in an anatomically modern body. In terms of timescale, we are no further from Socrates than Socrates was from Ötzi. So we should be able to find similarities between what he carried and our essentials.

The things we carry

Many are obvious. Ötzi's tinder fungus and flint for making fires is analogous to a lighter. His lumps of birch polypore fungus had antibiotic and anti-parasitic properties, as well as the ability to stop bleeding, like modern amoxycillin, deworming tablets and adhesive bandages.

Likewise, Ötzi's clothing and luggage make sense to us as everyday essentials. His well-worn, often-repaired goat-hide leggings are akin to a favourite pair of jeans. His deerskin shoes with bearskin soles are like rugged boots. His leather backpack is today's bag to haul our essentials around.

But it is Ötzi's weapons that really get to the heart of the search for our essential possessions – namely, the ability to acquire food. His longbow was an important possession. If he had lived long enough to finish making it, it would have been a formidable weapon, capable of killing animals up to 40 metres away. In the same vein, Ötzi's prize possession was probably his axe, with a blade of



Most of us carry our true essentials in our bags or pockets

NATHAN SCHRODER

175

The pairs
of jeans

that you
will love and leave before you die

UK DATA FROM KANTAR UK INSIGHTS AND UK NATIONAL STATISTICS

offered by vast systems of finance, medicine, security and governance. The contents of a high-status New Yorker's wallet or purse represent a small yet potent claim on the combined resources of Citibank, the Mount Sinai Medical Center, the New York Police Department and the US Navy.

Although not a carried possession, there is another aspect of Ötzi's life that informs today's needs. For thousands of years, his people lived in permanent settlements, usually on hilltops, for protection against raids. If Ötzi was high status, he would have lived in the equivalent of a McMansion in a gated community, with an active neighbourhood watch. Almost all #pocketdump or #whatsinmypurse images include house keys. This ubiquitous portable possession unlocks warmth, shelter, security and access to the rest of our things.

And while most of Ötzi's possessions look purely practical, it is clear that some had a bit more pizzazz. Take his stripy coat. It was made from strips of goat hide, alternating dark and light, and would

have presented a striking pattern. Today's urban hipster might wear a bomber jacket in distressed leather – wholly practical yet pretentiously stylish. And Ötzi's axe almost certainly carried prestige value; of his formally buried clan-mates, fewer than one in five were interred with similar axes. We start to see that even essentials can't escape that grey zone where needs and wants mingle. Just like Ötzi's axe, the stuff we carry can go beyond the practical to be highly symbolic – the iPhone, the BMW car keys, the "magnum-sized" condoms, the Clinique lipstick.

World in our hands

Finally, our most advanced essential – the smartphone – has no real analogue in Ötzi's kit. With it we can access any human knowledge, buy any good or service, and summon any form of help. We can talk with any of the 5 billion people who own a phone. We can find our location through GPS, food through Yelp, shelter through Airbnb and a mate through Match.com. If the copper axe was the most distinctive status symbol that Ötzi carried, the smartphone is ours.

Clearly, at the physical level, our technologies are better, lighter and more robust than Ötzi's. Our modern boots beat Ötzi's leaky shoes. Amoxycillin kills bacteria better than birch fungus.

Yet the real power of our handy essentials comes from the physical, social and informational ecosystems that they let us access. Car keys, house keys, debit cards, passports and smartphones aren't just hardware; they are the input-output devices that let our brains and bodies plug into modern civilisation. One car key can access 300 horsepower. One Oyster card can access all 400 kilometres of track on the London Underground. One iPhone can access trillions of dollars of telecoms, internet and GPS satellite infrastructure.

With them we can tap into vast networks of human cooperation, mutual accountability and symbolic status, on scales unimaginable to Ötzi and his peers.

So, what we need is pretty much what we carry. Next time you leave the house, grabbing your bag with your keys, phone and wallet, spare a thought for what you have with you – all the power, knowledge and vanity of an entire species compressed into a handful of objects. ■

BRIDGEMAN/GETTY

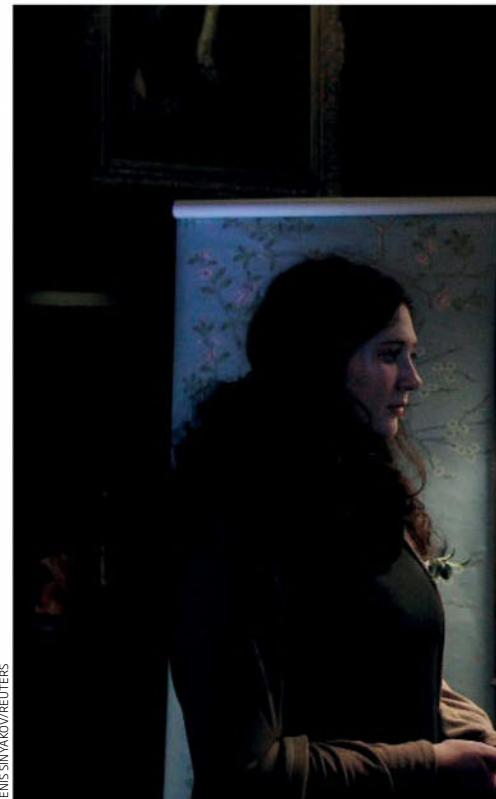
"If a copper axe was Ötzi's most distinctive status symbol, the smartphone is ours"



Ötzi offers
a glimpse of
material life
5300 years ago

My precious

Our belongings can have deep meaning, but do they make us happy, asks **Michael Bond**



DENIS SINYAKOV/REUTERS



Any possession can become invested with emotion

HAVE nothing in your houses that you do not know to be useful, or believe to be beautiful." This was a golden rule for those struggling to furnish or redecorate their homes, offered by William Morris, a 19th-century British textile designer.

Insightful as it sounds, Morris's advice turns out to be rather impractical. As we all know, our relationship to the things we own goes far beyond utility and aesthetics. Simply put, we love our stuff. Morris's contemporary, the psychologist William James, had a notion why. Our possessions, he argued, define who we are: "Between what a man calls me and what he simply calls mine the line is difficult to draw."

As well as being useful, our possessions represent our extended selves. They provide a sense of past and tell us "who we are, where we have come from and perhaps where we are going", says Russell Belk, who studies consumerism at York University in Toronto, Canada. Our things are "repositories of ourselves", says Catherine Roster at the University of New Mexico in Albuquerque. "It might be a sweater, a lamp, an umbrella – an object doesn't have to have material value to have emotional value."

Our ability to imbue things with rich meaning is a universal human trait that emerges early in life (see "My blankie!", page 68) and develops as we age. A 1977 survey of multiple generations of

13
The number
of cars

the average American will possess in their lifetime

BASED ON US DATA FROM IHS AUTOMOTIVE

1.3 million

The sheets
of toilet paper that
you'll flush before you fade away

US DATA FROM KIMBERLY CLARK/THE WALL STREET JOURNAL/CDC

families in Chicago revealed that older people tend to prize objects that spur memories and reflection, whereas younger people value things with multiple uses – like a kitchen table and chairs. That may be the case in the digital era as well. Sociologist Eugene Halton of the University of Notre Dame in Indiana, who conducted the survey, speculates that although younger people might prize their smartphone above all else, it is unlikely to stay special for long. "Not a lot of people collect their old computers and cellphones as meaningful possessions," he says.

The inclination to value things we own beyond what others think they are worth is known in psychology as the endowment effect. It explains why we are more likely to buy a coat once we have tried it on, or a car once we have test-driven it – just imagining that something is ours makes it seem more valuable.

Our ability to imagine the way new things will change our lives is what drives us to acquire them in the first place, says Marsha Richins at the University of Missouri in Columbia. She found that we have "transformation expectations" about new stuff: we expect things to make our lives better and enhance the way we are viewed by others. It's a tendency expertly exploited by advertisers, she says. Our culture of hyper-consumerism can make it difficult to determine where normal behaviour ends and compulsion begins.

Of course, we are all materialistic to some extent – some more than others – and we do get a boost of happiness from buying things. But it doesn't last. And because it is so fleeting, many people quickly feel the desire to top up with another purchase, and another – and are often willing to go into debt to do so.

Studies show that those who routinely

Hoarding can be an obsession that overwhelms all else

POSSESSED BY POSSESSIONS

When our instinct for ownership goes wrong

HOARDING

As many as 1 in 20 people struggle with an obsession with acquiring stuff and the inability to part with it – some to the point that their home becomes impassable. "This isn't just about clutter," says psychiatrist David Tolin at Yale University School of Medicine. "It becomes a disability."

This new diagnosis – it received its own category in the latest edition of psychiatry's diagnostic manual, *DSM-5* – may seem a fitting indictment of a modern society obsessed with stuff and status. But that idea is almost certainly wrong.

Hoarding isn't new. It was referred to in Dante's *Inferno* back in the 1300s. But it has only recently been distinguished from obsessive compulsive disorder (OCD). In a 2012 brain-imaging study, for example, Tolin and his colleagues asked volunteers to hold an object they owned and decide whether to throw it away. Unlike people with OCD, hoarders showed overactivity in the anterior cingulate and insular cortex – areas of the brain that help determine importance, relevance and salience.

This manifests as perfectionism – hardly the word summoned by reality TV shows with dead cats mouldering under mountains of unworn clothes. Yet it is the growing consensus: people with impaired decision-making worry so much about wrong decisions that they keep the item for later appraisal. "It's counter-intuitive," says Tolin, "but it makes perfect sense."

Hoarding also isn't limited to Western society. Cultural idiosyncrasies may

shape how it manifests, but "hoarding exists in virtually every culture", says psychologist Randy Frost at Smith College in Northampton, Massachusetts. We can all be reluctant to part with possessions. For hoarders, it becomes an "obsession with not losing a piece of your life".

COMPULSIVE SHOPPING

Unlike hoarding, "compulsive buying disorder" is not in the *DSM-5*, but recent numbers suggest it affects 6 per cent of the US population. Still, no one can agree whether it shares a basis with addiction, impulse control or OCD. There is also an increasingly thin line between normal shopping behaviour and compulsion – one happily blurred by advertisers.

There may be an intuitive link between hoarding and compulsive shopping, but the two disorders are certainly distinct. About 60 per cent of people with hoarding disorder are also compulsive shoppers, but the inverse is true for only 40 per cent of compulsive shoppers.

Also, hoarding exists across cultures, but shopping addiction can't exist without very specific societal conditions: a market-based economy, availability of a variety of goods, disposable income and free time. As Donald Black, professor of psychiatry at the University of Iowa, puts it: "If gambling opportunities do not exist, it is highly unlikely for gambling addiction to exist." So shopping addiction truly is a product of our material world. **Sally Adee**



"We get a boost of happiness from buying things, but it doesn't last"



LUCAS JACKSON/REUTERS

seek out material things to make them happy may be struggling to find fulfilment in other aspects of their lives, such as relationships. But, interestingly, the drive for stuff itself may not be the cause of this discontent: a study by Rik Pieters at Tilburg University in the Netherlands showed that loneliness tends to make people more materialistic, but the inverse isn't necessarily true.

Another reason to refrain from "retail therapy" is the sizeable toll consumerism has on the environment. In part to make way for new stuff, people in the US throw away an average of 30 kilograms of clothing and other textiles each year. Also, it turns out that the more you prize possessions, the more likely you are to dismiss environmental concerns.

Still, the solution isn't simply to reject our instinct for accumulating belongings. Our stuff has an important role in shoring up our sense of identity, one made most apparent when we are forced to let it go. This can be difficult, even traumatic, since it is akin to letting go of parts of ourselves. Institutions such as prisons and military camps strive for just this effect by removing clothes and other personal items from people and issuing them with standardised kit to diminish their individuality. They become like clay, primed for reshaping.

People who have lost their homes

and everything in them because of a natural disaster often report a profound confusion of identity. Following the huge wildfire in Oakland Hills, California, in 1991 that left more than 5000 people homeless, Shay Sayre at California State University in Fullerton recorded the feelings of survivors. One told her: "We became orphans without a past. Like we had amnesia, like we didn't exist before the fire." When people lose their possessions, reflected Sayre, questions of the self become critical, for if we are what we own, who are we when we own nothing?

Status update

Our sense of self isn't the only reason we accumulate stuff, or doggedly hang on to it. Possessions are also symbols of social standing and status. Several recent studies suggest that today's 20 to 35-year-olds are far more inclined than previous generations to try to acquire status or prestige by buying things like designer handbags or high-end fashion items. Part of that may be because they receive more disposable income from their parents or have more ready access to credit cards.

The availability of such "easy money" may explain another recent finding: investigating materialistic tendencies among older teenagers in the US,

➤

THESE ARE A FEW OF YOUR FAVOURITE THINGS

When we asked *New Scientist* readers what item you had purchased in the past decade that brought the most happiness - for the chance to win a set of beautifully bound popular science books from the Folio Society - nearly 2000 responded. Your answers inspired, amused and at times bewildered us, but above all they showed how deeply we connect to the things we own.

Unsurprisingly, there are many bibliophiles among you - some with cherished collections of paperbacks, others who praised e-readers for enabling you to tote around an entire library. Many of you loved a specific book: the text recommended by a professor that spurred a career; the "mouldy copy of a children's tale I'd borrowed from a dying library".

You also celebrated your pets, even if the notion of "buying" them didn't sit quite right. As Jared Cole told us: "I never think of my dog Grimm as property, but I did buy his freedom. I couldn't have better spent that cash."

Love was a common theme - from the purchases that launched a romance to the ones that signal enduring commitment. Many of you mentioned your wedding or engagement rings, but Sheree Jonker's was perhaps the most surprising: "My girlfriend hates jewellery. I proposed to her with a red ring pop... she said yes, then ate it."

You celebrated gifts given to others, favourite cars, cameras that captured your travels, the seeds with which you started a garden - and the "truckload of manure" to make it grow. There were the homes you bought, the university education that fulfilled you and the plane tickets and trips that took you around the world and returned you to friends and family.

We asked how much you paid for the thing that made you the happiest. There were some big-ticket items - a handful of you spent more than £6000 or even £60,000. But most of you paid less than £600 for that happy-making item, and for a third of you, it cost less than £60.

Whatever you spent, you showed us that psychologist Elizabeth Dunn at the University of British Columbia is on to something (see page 74): money can buy happiness, you just have to spend it right.

Tiffany O'Callaghan

researchers at San Diego State University in California found that, since the mid-1970s, there has been a growing discrepancy between young people's desire to own expensive things and their willingness to do the work to earn them – which they call the "fantasy gap".

Our materialistic desires are usually dictated not by what we need, but by what those around us have. Envy is a mover of markets. At a deep level, it is all about fairness and dignity, says Edward Fischer, an anthropologist at Vanderbilt University in Nashville, Tennessee.

"Is it fair that I have less than others? And what does this mean to my sense of self-worth?" This isn't just a feature of affluent societies, he adds. "It is also true among rural Maya farmers, Cairo's workers and around the world. The norms of those peer groups vary a lot, but the influence of relative standing in them is important everywhere."

How to spend it

We may not be able to shake our drive to acquire stuff, nor our tendency to compare ourselves with others. But we can change the amount of happiness we get out of the stuff we buy. It is well known that once you earn enough to maintain a comfortable lifestyle, additional money doesn't continue to improve your quality of life. But that may be because people are spending it wrong. Research by psychologist Elizabeth Dunn at the University of British Columbia in Vancouver, Canada, found that spending on experiences and other people offers a more enduring boon than splashing out on other things. Whether you buy your nephew the fanciest football boots you can find or a basic pair matters less than whether you go to the park with him to try them out, she says.

Another strategy is to think about how our purchases will affect how we go about our daily lives. Though we expect new things to bring change, in truth this is often a hazy notion, which, for its nebulous nature, evaporates all the more quickly once we have acquired that new thing. So before you break out the credit card, Dunn suggests you pause to consider what you will be able to do differently once you have your new thing, and whether it will truly affect the way you spend your time – the most precious commodity. ■

Things to come

We all love our belongings. But how can we enjoy them without so many drawbacks, asks **Chris Baraniuk**

EVERYBODY has prized possessions. We collect things obsessively and yet simultaneously worry about the rise of clutter and the global impact of wasted stuff. But can technology offer ways to ease this ambivalent relationship?

Extending the lifespan of objects could help us minimise the guilt of wasted devices. When Dutch designer Dave Hakkens's camera stopped working, he wanted to have it repaired. After all, it was just one part that had worn out – the lens motor. But the manufacturer said it could not be replaced. "Basically, they told me to just get a new camera," he says. "That's how it goes with electronics. We buy it and if one small part breaks we just throw away the entire thing."

It inspired Hakkens to develop "Phonebloks" – a cellphone with components that can be easily replaced or removed for repairs. Everything from the screen to the camera and processor was reimagined as an individual module.

When an online petition to gauge public interest in the design received support from hundreds of thousands of web users, Hakkens knew he was on

to something. Indeed, phone giant Motorola soon revealed that they had been developing a similar concept.

Another way to extend the lifespan of stuff is to use "self-healing" materials. Polymer coatings, such as that on the rear of LG's G Flex cellphone, can gradually repair minor surface scratches.

But it isn't only external nicks that can be put right. Chao Wang and colleagues at Stanford University in California have used self-healing polymers to increase the lifespan of rechargeable batteries. These have silicon anodes, but the silicon gradually degrades each time a battery is recharged. To hold the fragmented silicon together so it maintains electrical contact, and therefore charge, they coated it in a polymer that acts as a self-healing brace.

Self-healing materials could one day ensure the longevity of electronics embedded in our clothes and other everyday objects, says Wang.

On-demand 3D-printed objects also present a new kind of access to stuff and, like the modular smartphones, hold the promise of being able to make and fit replacement parts at home – extending the lifetimes of products and also cutting the environmental costs of shipping.

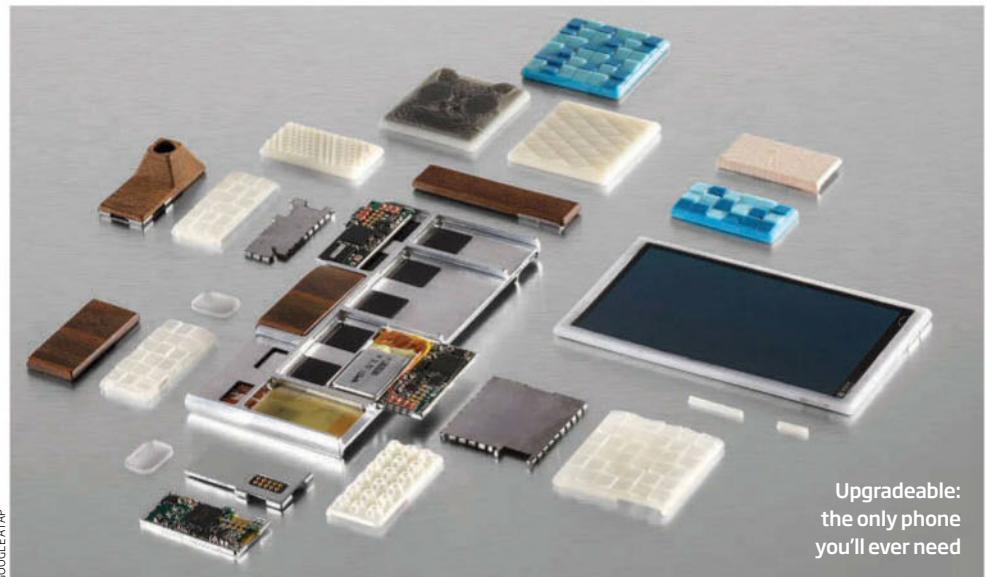
Of course, technology is changing our relationship with things in other ways, too. It's clear that the rise of digital media has caused a significant shift – in some cases making us more selective about the physical objects we bring into our homes.

In the era of iTunes it may be surprising to hear that vinyl sales are at their highest for two decades, according to the latest figures from the British Phonographic Industry. But digital music sales had been on the rise too. It seems that the two formats appeal to people precisely because they suit different contexts. You can listen to David Bowie on your iPod while out jogging and spin a record of his later work while relaxing at home.



PHILIPPE LOPEZ/REUTERS/FOLIO

"The digital world could allow us to move away from the physical incarnations of stuff entirely"



GOOGLE ATAP

When you buy the physical object, it is often with the experience of how you will listen to it in mind.

A similar phenomenon is occurring with books. Paperback sales may have slumped, but in 2013 the Association of American Publishers reported that hardback sales were up 10 per cent, double the increase seen in ebook sales. It seems the existence of both formats means that people can more carefully curate which bound books to put on the shelves at home.

There are some who believe the digital world offers an opportunity to take things a step further, to move away from the physical incarnations of stuff entirely. But even proponents of this movement point out that although digital possessions are easier to move around than physical ones, they still eat up their share of resources and require careful management and organisation.

In fact, the same type of preoccupation that people have with physical objects may soon extend to digital collections as well. "For now, hoarding is defined by physical clutter, but of course, it is possible to have chaotic digital files and to spend inordinate amounts of time collecting new items that are then lost in the 'pile,'" says Gail Steketee, who studies hoarding at Boston University.

End of ownership

One solution to this problem has already been spied by the music, film and video game industries: content streaming. In 2013 there was a 100 per cent increase in on-demand music streaming in the US. The sales of digital music files, in contrast, fell by 6 per cent.

The digital world is also providing opportunities to better manage our stuff in the physical world, in particular with the continued rise of the "sharing economy". In 2013, a report by The People Who Share advocacy group found that, thanks to a wide range of online services, 33 million Brits shared food, rides to work or bought and sold second-hand goods. What's more, cities like Amsterdam have refreshed legislation to encourage services that allow residents to rent out their homes to travellers. Airbnb, the most popular of these, has served more than 25 million people worldwide since it was founded just seven years ago.

But will sharing our stuff – or even

blueprints for 3D printing – erode some of the individual connection that we have with our possessions? Not according to Andy Hudson-Smith at University College London's Bartlett Centre for Advanced Spatial Analysis. He argues that overlaying the physical world with the digital one makes it possible to share an item and feel more emotionally connected to it at the same time.

In 2012, he and his team placed QR codes on objects in a branch of the second-hand charity shop Oxfam. When people scanned a code, they received information about the object's history. Not only did the project, called Shelflife, boost sales in the shop, it also meant that Hudson-Smith was moved to reconsider purchasing a "tacky lucky bear" once he realised that it had been a good luck charm for a girl who passed her school exams. "It was tacky and horrible," he remembers, "but I actually bought it because it gave me that strong emotional tie and I just couldn't put it back on the shelf. It now sits on my desk at work as a talking point." He believes that such technology could be of most immediate benefit to the sharing economy and second-hand goods trade.

For Daniel Miller, an anthropologist and expert in material culture at University College London, the digital world is simply making the ties to our objects more explicit. "It was always the case that objects spoke to connectivity, both socially and geographically. We prize them for that," he says. "The ornaments in our house often reveal, for example, the places we have visited as tourists or they signify people who have close relationships to us."

The difference now is that our connected belongings can be part of a "labour-saving" initiative to record our memories and personal ties for us, so we don't have to. But while objects with digital memories might make it easier for others to understand what our things mean to us, Miller suspects they will only tell part of the story. "We don't necessarily accept objects that offer to do emotional work because we benefit from the labour of doing it ourselves," he says. After all, the stuff we really care about is that with which we have an emotional connection. It's the immaterial side of decidedly material things which, curiously enough, ends up meaning the most. ■





FOREVER FRIENDS

Our urge to connect runs so deep that it has shaped our minds and physiology. Is the age of digital friendship changing us again?

CHAPTER SIX

FRIENDS AND FAMILY



The bright stuff

Only the smartest creatures have what it takes to make friends, says evolutionary psychologist Robin Dunbar

MOST animals have acquaintances but only a few species are capable of true friendship. This select group of mammals includes the higher primates, members of the horse family, elephants, cetaceans and camelids. It is no coincidence that all of these animals live in stable, bonded social groups. Group living has its benefits, but it can also be stressful and you cannot simply leave when the going gets tough – which is where friendship comes in. Friends form defensive coalitions that keep everyone else just far enough away, without driving them off completely.

Friendship gives social groups a very different structure from the amorphous herds of deer or antelope. From the point of view of each member, a bonded society is made up of layers, like an onion, with your best friends at the core and successive layers filled with individuals with whom you are decreasingly intimate. Whatever the species, the core tends to consist of some five intimates, with the next layer taking the group to around 15, and the widest circle encompassing around 50 friends. Each layer provides different benefits. So although intimates offer personal protection and help, you may rely on a larger friendship group for food, and the entire society for defence against predators.

It takes intelligence to live in a bonded, layered social system. Whereas a herd animal must simply know its neighbour, here you need to know the structure of the whole social network of the group. This is important because when you threaten me you risk upsetting my friends too, and they may come to my aid. In other words, you must be aware of the wider social consequences of your actions. The cognitive demands of this are reflected in the link between the size of a species' social group and the size of its brain – or, more specifically, the frontal lobes, since this is where calculations about social relationships seem to be made. This link is not straightforward, though. What matters is the complexity of individual relationships, not simply the number. So, smart monkeys, such as baboons and macaques, need bigger brains to manage groups of a given size than do less intelligent monkeys. Apes need bigger computers still.

This link between group size and brain size – sometimes referred to as the social brain hypothesis – turns out to apply not only to species but also to ➤

"A bonded society is made up of layers, like an onion, with best friends at the core"

individuals. Neuroimaging studies of both macaques and humans have shown that the number of friends an individual has is linked to the size of parts of their frontal lobes.

Many aspects of cognition are necessary for the complex social decisions that animals make, but one that seems to be especially important is "mentalising" – the ability to understand another's state of mind (see "Inside job", page 54). "I believe that you suppose that I wonder whether you think that I intend to..." represents five mind states, and is what human adults can typically manage. The size of key regions of your prefrontal cortex determines your mentalising skills, which in turn determine the number of friends you have.

Many species create and service their friendships by social grooming. Grooming – or light stroking in the case of humans – triggers the release of endorphins in the brain, which makes you feel relaxed and trusting. The bigger the group, the more time an animal devotes to grooming, but the fewer individuals it grooms. This is because

as group size increases and group living becomes more stressful it becomes increasingly necessary to ensure that your friends are reliable and will come to your aid when you need them. You do this by spending more of your available social time grooming core friends. Among female baboons, at least, this has demonstrable benefits – those with stronger friendships produce less of the stress hormone cortisol and produce more surviving offspring.

Since the quality of a relationship depends on how much time is invested in it, and there is only so much time available for grooming in a busy day, this sets an upper limit on the number of friends an animal can have, and hence the overall size of the social group. If you try to groom too many individuals, you end up spreading your time too thinly, the quality of your friendships is poorer and social groups are consequently less stable and keep breaking up. In monkeys and apes, this sets an upper limit on average social-group size of about 50, which is just what you find in baboons and chimps.

Laughter and language

But humans are different. Over the past two million years, there seems to have been increasing pressure to evolve ever-larger social groups. Based on the social brain hypothesis, I have calculated that our social group size should be around 150. This has come to be known as "Dunbar's number" and turns out to be both a common community size in human social organisations and the typical size of personal social networks. But how could humans and their immediate ancestors have sustained groups that greatly exceed the number that can be bonded by grooming?

It seems we have exploited three additional behaviours that are very good at triggering the release of endorphins but can be done in groups, allowing several individuals to be "groomed" at the same time. First came laughter, which we share with the great apes. Essentially a form of chorusing, laughter typically involves a group of three people, making it more efficient than grooming as a bonding mechanism. Next, perhaps 500,000 years ago, we added singing and dancing, which increased the grooming group still further. Finally, language gave greater control over both laughter – through jokes –

Grooming is time-consuming, meaning that chimps cannot sustain social groups of more than about 50



LORENZO CECCHIN MASI/CONTRASTO/EVINE

and song and dance. Ultimately, it allowed rituals to be associated with religion, and this made super-groups possible.

Even though we can feel a bond with a super-group consisting of thousands, most of us have no more than around 150 in our personal social network. About half of these are family, and tend to remain constant throughout our lives. But non-kin friendships are very susceptible to decay if we do not invest in them. Failure to spend time with a friend for a year reduces the quality of that friendship by about one-third. Although our friends may change considerably over a lifetime, how we negotiate friendship remains surprisingly constant. Each of us has a characteristic pattern in the way we distribute our social capital, whether measured as time spent contacting friends or emotional closeness to them. Our best friend, for example, gets the same amount of time no matter who they happen to be. This is rather like a personal social signature, and it remains fixed even when our friends change. ■



SUZIE SZTERHAS/MINDEN PICTURES



Friends with benefits

There is a reason why friendship feels so good, says biologist Lauren Brent

WE NEED friends. They have a positive impact on our health, wealth and mental well-being. Social isolation, on the other hand, creates feelings akin to physical pain and leaves us stressed and susceptible to illness. In fact, our bodies react to a lack of friends as if a crucial biological need is going unfulfilled. This is not surprising. For us humans, friends are not an optional extra – we have evolved to rely on them.

But friendship comes at a cost; time spent socialising could be used in other activities key to survival such as preparing food, having sex and sleeping. Besides, just because something is good for us doesn't mean we will necessarily

do it. That's why evolution has equipped us with the desire to make friends and spend time with them. Like sex, eating or anything a species needs to survive, friendship is driven by a system of reinforcement and reward. In other words, being friendly is linked with the release of various neurotransmitters in the brain and biochemicals in the body that make us feel good.

Understanding what motivates friendship begins in a seemingly unlikely place – with lactation. As a baby suckles, a neuropeptide called oxytocin is released from the mother's pituitary gland. This causes muscles in the breast to contract, allowing milk to flow, but ➤

Can men and women be just friends? Catherine de Lange finds answers to some big questions

1

DO WE REALLY NEED FRIENDS?

Yes. People with weak social relationships are 50 per cent more likely to die in a given period than those with strong social ties. Social isolation is as bad for you as drinking or smoking – by some estimates equivalent to smoking 15 cigarettes per day – and worse than inactivity or obesity.

Friendships also contribute to happiness – although quality, not quantity, is what counts. A study of 423 college students found that the quality of friendships had a big impact on how happy people were, whereas the number of friends they had made no difference.

However, the benefits of friendship probably vary from person to person, which would explain why some people say they feel happiest when alone.

2

WHAT MAKES A GOOD FRIENDSHIP?

We forge friendships with people who are similar to ourselves. The six most important criteria are language, profession, world view (political, moral and religious), sense of humour, local identity and education. Personality appears to be less important than cultural preferences – the bands you like, the books you enjoy, the jokes you find funny. In fact, the best predictor of how well you will get on with a stranger is whether you like the same music.

3

WHY DO SOME PEOPLE HAVE MORE FRIENDS THAN OTHERS?

It may be in their biology. Neuroimaging studies have found that people with more grey matter in areas such as the amygdala – ➤

which are associated with memory and emotional processing – tend to have more friends. But it is not clear whether this is cause or effect. There are also cultural influences: people from big, extended families tend to have fewer non-kin friends than those from small families.

4

CAN STRAIGHT MEN AND WOMEN BE "JUST FRIENDS"?

Yes, but that doesn't mean they aren't attracted to each other. Numerous studies show that attraction is a frequent component of cross-gender friendships. A survey of US college students found that half had had sex with an otherwise platonic friend.

Young men tend to be more attracted to their female friends than the other way round. They are also more likely to become friends with a woman because they are attracted to her, and to overestimate how attractive their female friends find them.

Women are more interested in protection. They are also more likely than men to secretly test whether their opposite-sex friends fancy them. Researchers have identified 158 such tests – the most common are attempts to make a friend jealous, tests of fidelity and temporary physical separation.

5

DO MALE AND FEMALE FRIENDSHIPS DIFFER?

Women are more likely to have a best friend, whereas men more often hang out with a group. Women tend to consider friendships more in terms of emotional connection. By contrast, men think about how much time they spend together or how long they have known each other.

it also reduces anxiety, blood pressure and heart rate. For mothers and babies, the relaxed feeling produced by oxytocin encourages suckling and helps create a strong and loving bond. This occurs in all mammals, but in humans and the few other species that make friends the system has been co-opted and expanded. Rather than reinvent the wheel, evolution has economised and oxytocin has become associated with relationships beyond the mother-child bond. You release it in response to many types of positive physical contact with another person, including hugs, light touches and massage. The resulting pleasant feeling is your reward for the interaction and encourages you to see that person again. A budding friendship is born.

Of course, most interactions between friends do not involve physical contact – but oxytocin works in other ways too. It promotes prosocial decisions, increases feelings of trust and encourages generosity. And, while

important, it is not the only chemical driver of friendship. Another key player is a group of opioid chemicals called endorphins. Also produced by the pituitary gland, they are released in response to mild pain, such as exercise, and act as neurotransmitters in the brain to create a feeling of well-being. All vertebrates produce endorphins, so they must have evolved early on, but like oxytocin, they have come to play a role in motivating friendship. Endorphins also make physical contact feel good, but they underpin another aspect of friendship too.

Robin Dunbar and his colleagues at the

"Friends are as genetically similar to each other as fourth cousins are"



JOHN LAMB/GETTY

University of Oxford asked people to row a boat, either alone or in pairs, and measured their endorphin levels before and after. What they found was striking. Despite exerting the same physical effort, people who rowed as a synchronous pair released more endorphins than those who rowed alone. One of the major components of friendship is behavioural synchrony – friends must be in the same place at the same time to establish and maintain a relationship. Endorphins seem to promote friendships by making synchrony feel good.

The flip side of this is how bad it feels to be socially isolated. Lonely people have elevated levels of the stress hormone cortisol. Chronic stress damages your health, which probably explains why social isolation increases the risk of cardiovascular diseases and susceptibility to infection. But stress can be useful. The stress response is produced by activation of a system known as the hypothalamic-pituitary-adrenal axis. This

Babies would rather look at a face than anything else



activation acts as a warning that homeostasis – the body's maintenance of stable internal conditions – has been disrupted. So stress prompts us to behave in ways that restore homeostasis, including resting when tired and seeking shade when hot. Perhaps it also motivates us to seek out social contact when we are lonely. The fact that we produce less cortisol in a stressful situation if we have a friend with us suggests that friends either help us to restore homeostasis or prevent its disruption in the first place.

To select, acquire and maintain friends we need to gather social information. Again, this is something we enjoy. Even before babies can speak, they prefer looking at faces than other visual stimuli. We find social information intrinsically rewarding because it triggers reward-related areas of the brain. When Dar Meshi of the Free University in Berlin, Germany, showed people in an MRI scanner pictures from their Facebook accounts, he found strong activity in the nucleus accumbens, a brain region associated with drug addiction. Interestingly, people with the greatest response were the most frequent social media users.

Although the neural and biochemical processes that underlie friendship are the same in everyone, some people are friendlier than others. These people may simply be better at making friends, but Meshi's results hint that they are also more motivated to do so because it gives them a bigger kick. Friendlier people are more sociable, in part, because their genes make them that way. James Fowler at the University of California, San Diego, and Nicholas Christakis at Yale University compared the social networks of identical twins, who share all their genes, and paternal twins, who share 50 per cent on average. They found that genetic factors accounted for 46 per cent of differences in how popular among their peers individuals were.

Even social butterflies aren't friends with everyone. Of the many people we encounter,

how do we pick a select few? The answer, at first, seems quite simple – we are friends with people who are similar to us, whether they are the same age, gender or profession. But it turns out that this tendency for “like” to associate with “like”, termed homophily, also has a basis in our genes. Fowler and Christakis found that people are as genetically similar to their non-kin friends as they would be to fourth cousins. One of the mysteries of friendship has been why we would cooperate so readily with complete strangers. In evolutionary terms, you should cooperate with kin rather than kindred spirits because your genetic similarity to relatives allows you to reap indirect benefits. In other words, you succeed by proxy if they pass on more of the genes they share with you to future generations. But if friends are more genetically similar than we would expect by chance, perhaps we should think of them not so much as strangers than as “facultative relatives”.

“Stress may motivate us to seek social contact when we are lonely”

Identical twins tend to be as popular as one another



So, your genome may help determine not only how friendly you are, but also who you choose for your friends. No one knows how we recognise people who are genetically similar. It could be similarities in facial features, voice, gestures or smell. Our tendency to befriend people who share our traits may even hold an answer. Your personality is shaped in part by your genes so, if you choose friends with a similar personality, they will probably have genes in common with you.

Whatever attracts us to certain people, one thing is certain: befriending them will be rewarding. Because if there's one thing we all know about friendship, it's that it feels good. ■

Friends in high-tech places

In the internet age, friendship is not what it used to be, finds Michael Bond

FRIENDSHIP is the only cement that will ever hold the world together," said US president Woodrow Wilson. A century on, could it be that our fast-moving, high-tech and increasingly urbanised existence is causing that cement to crumble?

Much has been made of the US General Social Survey, which reported that between 1985 and 2004, the average US citizen's number of close friends – the people they can turn to in a crisis – fell from three to two, and individuals with no confidants at all increased from 8 to 23 per cent. In the UK, a rise in the number of people living alone and the weakening of community ties due to people moving house more often have led to warnings of a "crisis" in friendship. Other studies have linked the internet and cellphones with social isolation. However, while new technology may have changed the traditional notion of friendship, there is also evidence that it is having a positive impact.

Facebook was founded in 2004 at Harvard University to enhance the campus life of college students, and people still use it for the same reasons. "The underlying incentives have not changed – to find people who will

support you emotionally, gossip with you, flirt with you, just be there for you," says Danah Boyd, a principal researcher at Microsoft Research. We still have our core group of friends, the ones we hang out with the most, whether online or offline. "But the dynamics have changed because of the technology and because of contemporary youth culture."

The most conspicuous difference is the number of people with whom we have some kind of enduring contact. Researchers at the University of California, Los Angeles, found that the social network of the average college student increased from 137 in 2006 to 440 in 2009. A typical US teenager now has around 300 Facebook friends, a Pew study found in 2013, and 79 followers on Twitter – not all of whom would count as social ties as they may not be being followed in return (see diagram, page 84).

This is far more than the 150 that Robin Dunbar calculates to be the maximum number of "meaningful friends" our brains have evolved to deal with (see "The bright stuff", page 77). Who are all these extra people? Known as weak ties, they include high school or college friends, work colleagues past and

present, previous partners, people met travelling, casual acquaintances, friends of friends and occasionally strangers. Social networking sites allow us to maintain a relationship with these peripheral friends – via sporadic messaging, for example, or by browsing their photographs or status updates – where previously we would have let them fade away.

But the technology does more than that. Research suggests that Facebook can actually

"Like primates picking nits off one another, we have expectations of reciprocity"

improve the quality of these distant or fragile relationships. A study of more than 400 Facebook users by Jessica Vitak at the University of Maryland, College Park, reveals that the site is especially valuable for friends who live more than a few hours' drive away. The further away two friends live, the more they engage on the site. For such friends, says Vitak, Facebook may make the difference between a real relationship and the memory of one.

Engaging with others online – responding to a question or wishing someone happy birthday on Facebook, for instance, endorsing someone's skills on LinkedIn, or "liking" or commenting on a picture on Instagram – is a form of social grooming, a modern throwback to our prehistory. "These are all ways in which I am signalling that I'm paying attention to you," says Nicole Ellison at the University of Michigan at Ann Arbor. "Like primates picking nits off one another, we have expectations of reciprocity – we can expect attention back from them in the future." Ellison and Vitak have found that social grooming on Facebook is a highly effective way of maintaining weak ties, and that there are many good reasons to do so. The deep, emotional bonds that characterise our most important relationships are still mostly cultivated face to face, even if ➤



Apps like SnapChat and Instagram give us new ways to bond with friends



PHILIPPE LOPPARELLI/TENDANCE FLOU

Female-female friendships tend to be more intimate, and women make friends with similarly physically attractive women. That is a good mating strategy - their friends attract men who are likely to find them attractive too - but it also leads to competition.

6

ARE ALL FRIENDSHIPS

GOOD FOR YOU?

No. Relationships with "frenemies" can actually damage your health. These are people who bring us down but who we put up with anyway. About half of the people in your social networks are likely to be frenemies - most of them family members. Interacting with unreliable friends is stressful. Your blood pressure is likely to be more elevated when you are with a frenemy than it is with someone you do not like at all.

7

DOES FRIENDSHIP

CHANGE AS WE AGE?

Yes. Small children only really need one close friend - we don't develop the ability to juggle large numbers until our early 20s. Teenagers are hugely influenced by their friends, especially in behaviours such as substance use, violence and suicide.

The strongest and most enduring friendships are forged in our late teens and early 20s, possibly via intense, shared emotional experiences. Adults often find their friendships change as they get older. That is because friends reflect cultural preferences including music, books and jokes, and our tastes in these change.

Middle-aged adults tend to have fewer opposite-sex friends than young adults, possibly because they spend time with same-sex friends through circumstances ➤

such as motherhood. Older people tend to be involved in more group activities with casual friends but they continue to exchange confidences with close friends.

Men have fewer friends as they age and less desire for close friendships. The same is not true for women.

8

HOW DO FACEBOOK FRIENDS COMPARE WITH REAL-LIFE ONES?

The size of human social groups is naturally about 150, according to Robin Dunbar at the University of Oxford. Dunbar's number is in the right ballpark online as well. Facebook allows up to 5000 friends, but most users have between 150 and 250 – although many of these will be acquaintances and some will be strangers.

There is little evidence that social media is damaging real-life friendships. People with more Facebook friends also tend to have greater numbers of friends in their in-person social networks.

9

IS THERE A FORMULA FOR MAINTAINING FRIENDSHIPS?

According to Dunbar, you need to be in contact with very close friends about every other day and your next five closest pals about once a week – whether face-to-face or electronically.

Once a month is enough for the next 15. For the next 50 it's about every six months, and for the rest of your 150 or so personal connections, once a year. Less often than that and friends will quickly fall through the layers of your social networks.

The exception is close friendships forged in your late teens/early 20s – you can often pick these relationships up exactly where you left off, even after decades.

we nurture them online. But weak ties, which tend to be diverse and span different social groups, have benefits of their own. They can provide new ideas and perspectives, an incentive for innovation, job openings and the sense of being part of a wider community.

One of the most dramatic illustrations of how the reach of our social networks affects us day to day is the ease with which we soak up the moods and emotions of people we don't know well. This has always been the case in the real world – you see someone smile and you smile back. But in online networks, this contagion effect is amplified many times. After analysing more than a billion status updates on Facebook, a team led by James Fowler at the University of California, San Diego, discovered that people inadvertently transmit positive and negative moods via their written comments, even to friends and acquaintances living in different cities – their weak ties. "The online world has only recently made that possible at a massive scale," says Fowler. "I think this means we will see more global synchrony in emotions. Now more than ever, we feel what the world feels."

Human see, human do

Other behaviours, including drinking, eating and dieting habits, also spread online, but almost exclusively through people's strong ties – their close friends and family. This goes for voting too, as Fowler demonstrated in a separate study. On 2 November 2010, the day of the US congressional elections, his team posted a message in the newsfeeds of 61 million American Facebook users urging

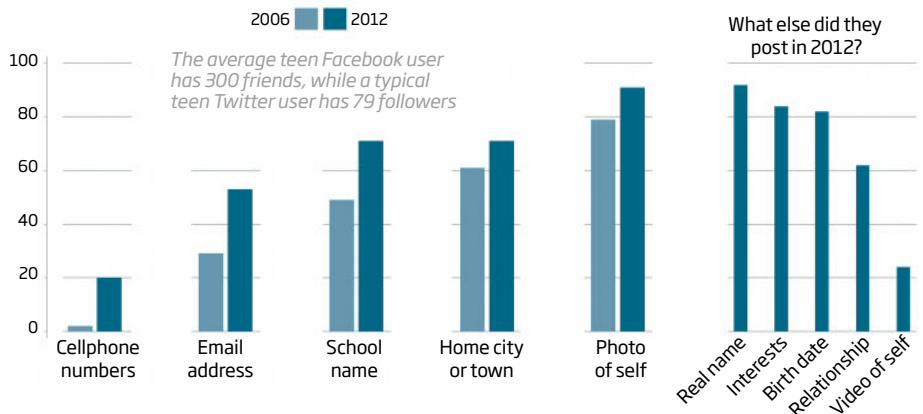
them to vote, and allowing them to broadcast their intention to vote to their network. Some 60,000 people who were not intending to vote changed their minds, as did 280,000 of their Facebook friends. When the researchers analysed those additional 280,000 voters, they found that the vast majority were close friends of the original recipients. "The top 10 friends were driving the whole social effect. That confirms that if you want to spread behaviour change, you need to focus on real-world networks. This is really exciting because it opens up the possibility of using the online world to make the real world a better place," says Fowler.

The landscape of friendship has certainly been transformed in the past decade, but whether this has been for the better is still hotly debated. Some studies indicate that interacting with people online is just as valuable psychologically as interacting in person, reducing anxiety and depression and increase feelings of well-being. Moira Burke, who researches computer science and social psychology at Facebook, found that the more people use the site to actively engage with their friends, the less lonely they are – although it is not clear whether Facebook use reduces loneliness or whether people who are already socially connected use it more.

However, there are risks to maintaining friendships online. "Because of the nature of digital communication, the nuances of interactions can be lost," says Rachel Grieve, a psychologist at the University of Tasmania, Australia. "What was once a relatively meaningless comment to a friend over coffee, somewhat misconstrued and then clarified in

Online giveaway

Young teenagers (12-17 year olds) are sharing more information about themselves on social media than ever before



a matter of moments, can now be an enduring statement, seen and misinterpreted by many."

Other risks are subtler, as Boyd points out in her book *It's Complicated*. The ability to hold on to every acquaintance makes it difficult for teenagers to build new meaningful relationships when they arrive at college. "They're dealing with the discomfort of their first semester, and they end up relying heavily on their peers from the past," she says.

Narcissism or necessity?

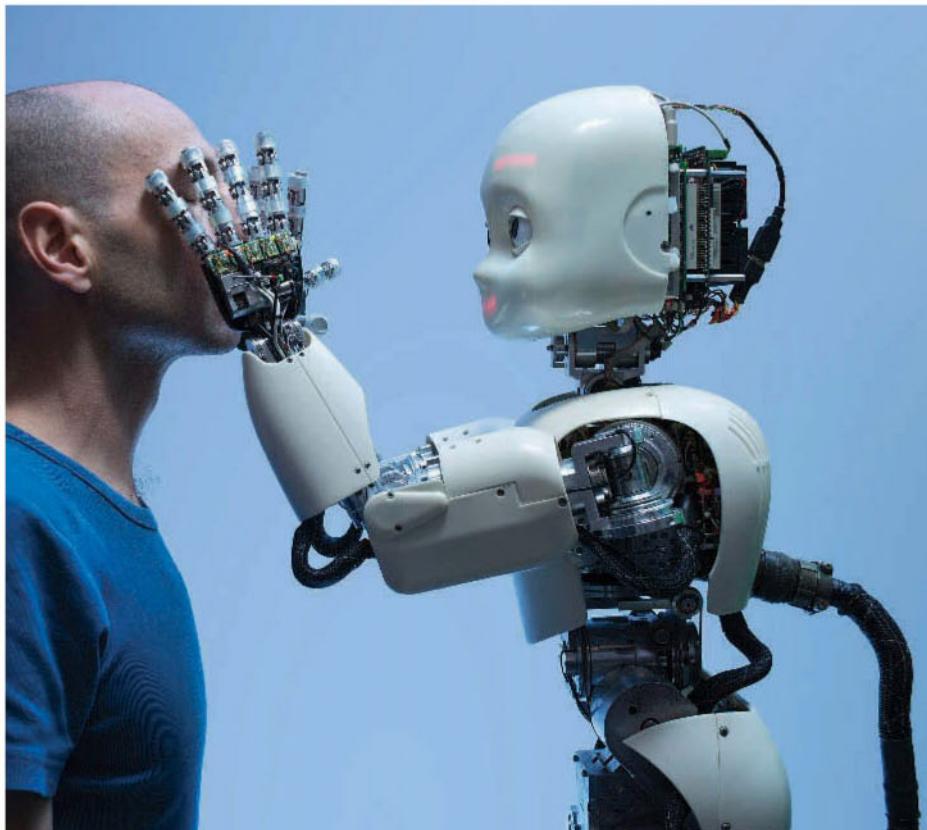
The most serious charge against modern-day social networking is that it fosters narcissism and individualism. "Emotional disclosure has gone public," says Patricia Greenfield, a developmental psychologist at the University of California, Los Angeles. She points to research by Jean Twenge at San Diego State University, which shows that since the early 1990s, US college students have scored progressively higher on measures for narcissistic traits. Other studies show that narcissistic people tend to be highly active users of Facebook and Twitter, which particularly lends itself to exhibitionism.

But some are more sceptical. New research shows that among today's college students, who are often accused of being the most self-orientated demographic of all, there is no association between narcissism and the use of Facebook. Boyd argues that avid use of social media is driven not by individualism or gadgetry but by the need for friendship. "Over and over when I interview teenagers, they tell me they would much rather get together in person, get on their bikes and just be left alone. But we've created such a level of fear-mongering that we've made it extraordinarily difficult for them to get together in any space that is not online."

Given the urgency of our need to connect with others, and the difficulty of doing so in today's urbanised milieu, how long before we start to reach out beyond our species into the world of artificial intelligence? And how sophisticated would a robot have to be to satisfy the essentials of human friendship, such as reciprocity and personality?

Already there are sociable technologies that press our "Darwinian buttons", as Sherry Turkle puts it in her book *Alone Together* – robots that make eye contact, track motions and gestures and give the impression there is "somebody home". For example, Takayuki Kanda at ATR Intelligent Robotics and Communication Laboratories in Kyoto, Japan, has developed a humanoid

EMILE LOREAU/PICTURETANK



robot called Robovie, whose basic interactive capabilities are sophisticated enough to convince 15-year-olds that it is a social being with feelings. Kanda says one of the most important challenges is to develop robots that can be with people all the time, not just inside the house. The more time someone spends with a robot, he reasons, the more likely they are to establish a "real relationship" with it.

The key to developing sociable robots is to make them fallible, says John Murray at the University of Lincoln, UK. Murray and his team are introducing human cognitive biases into their robots, such as a memory glitch that causes them to misattribute certain things they are told. "We are trying to develop the imperfect robot, to see if they will be more accepted by humans." The challenge, he adds, is to avoid the "uncanny

"We now feel what the world feels, through online contagion"

Already there are humanoid robots capable of convincing people they are emotional beings

valley" – a human-looking machine that interacts in a spookily not-quite-human way.

Is this the future of friendship? Turkle, who is director of the MIT Initiative on Technology and Self, hopes not. "People seem more than ever fixed on creating a robot best friend or teacher for children or a robot companion for the elderly," she says. "But the elderly deserve to be able to talk about the end of their lives, what they have lost and what they have loved, with people who understand what love and loss is. A robot can never offer this."

In the 21st century, as at any time, where friendship is concerned what matters is quality not quantity. "A large social network provides you with plenty of opportunities to make contacts or gather information," says Grieve. "But when it comes to feeling a sense of warmth and belongingness, having a few close friends is what matters." In other words, as everyone who grew up with the internet knows, true friendship is when you walk into someone's house and your smartphone's Wi-Fi connects automatically. ■

THE psychiatrist Alfred Adler, a contemporary of Sigmund Freud, was convinced that our place among our siblings influences what he termed "style of life". Eldest children, he argued, are more likely to be neurotic and authoritarian as a result of younger siblings displacing them from their king-of-the-castle position and burdening them with extra responsibilities. Youngest children are spoiled and lack empathy; only middle children are even-tempered and successful, albeit more rebellious and independent, he asserted. Perhaps it was no coincidence that Adler himself was the second child of seven.

His thinking struck a chord. Interest in birth order and its possible consequences grew rapidly in the early 20th century, spawning a new field of research. In the 1980s, however, there was a backlash against the idea, and most of the early studies are now discredited. But in recent years, the pendulum has swung back, with compelling research revealing the importance of birth order in animals. Now there is mounting evidence that we, too, are influenced by our position in the family hierarchy. This appears to be linked with all manner of things, from body shape and intelligence to disease susceptibility and sexuality. The reason it has such far-reaching repercussions is also becoming clearer as we untangle the complex web of factors involved.

Historically, the inheritance of firstborns has often extended beyond their genes. Even before Adler came along, Charles Darwin's half-cousin, the eminent

anthropologist, geographer and statistician Francis Galton, had claimed that it was exclusively firstborn males and only sons who went on to become renowned English scientists. It sounds like an outrageous generalisation but, in 1874, when his book *English Men of Science: Their nature and nurture* was published, there may well have been something to it. Back then, firstborn sons were often favoured when inheriting family wealth, giving them greater freedom to pursue the career or interests of their choosing.

In some families, even now, the firstborn may inherit the crown jewels or the family business – but, in general, cultural expectations based on family hierarchy are not as rigid as they once were. Nevertheless, Galton's work is highly relevant to modern researchers because of its emphasis on both "nature and nurture" – a phrase he coined. Distinguishing between biological and environmental factors is vital if we are to understand why someone's place among their siblings might affect his or her life chances. As a result, today's studies, unlike many in Adler's time, take account of factors such as socioeconomic status and family size. What have they found?

One of the most striking discoveries to emerge from animal studies is that birth order can have life-or-death consequences (see "Fatal pecking order", page 88). The same appears to be true in humans. A study of more than 600,000 people in Norway, by Hans Gravseth and colleagues at Oslo's National Institute of Occupational Health, found that ➤

Spot the middle children – they are the friendship specialists



Luck of the draw

Your place in the family pecking order has some surprising influences on how you turn out, finds Lesley Evans Ogden



STEPHANIE TETU/PICTURE TANK

FATAL PECKING ORDER

In some birds, birth order is a matter of life or death. Nazca boobies, seabirds that breed on the Galapagos Islands, lay two eggs. The first-hatched nestling always attacks its younger, smaller sibling, finally ejecting it from the pebble-strewn nest. Mother boobies do not intervene, leaving the expelled chick to face certain death from dehydration or predators. In the related blue-footed booby, both chicks may survive when food is plentiful but, if it is scarce, the older chick shows no mercy, attacking and killing its sibling.

Scott Forbes recalls being shocked when he first observed baby ospreys "beating the hell out of each other" during his doctoral research. Now at the University of Winnipeg, Canada, he studies sibling rivalry in red-winged blackbirds. Although not quite as dramatic as in ospreys, it is lethal all the same. In a typical brood of five eggs, he says, "the last-hatched chick has roughly a 10 per cent chance of surviving, while the first-hatched chick has a better than 80 per cent chance".

Clutches of blackbird's eggs, like those of many birds, do not hatch simultaneously, and this appears to provide a safety valve. When times are good and food is plentiful, even the runts may survive. When times are

tough, it is survival of the fittest, and older chicks almost always win.

In one experiment, Forbes manipulated the eggs of yellow-headed blackbirds so that they all hatched simultaneously. It was disastrous for the offspring: in lean years, all the chicks died. He likens the phenomenon to investing money, with blackbird parents dividing their offspring into core and marginal groups. The older siblings are the "blue chips", the younger ones their more risky holdings that only sometimes pay Darwinian dividends.

It is not just birds that play birth-order politics. The eldest piglets in a litter use their temporary teeth to fight their younger siblings for access to their mother's frontmost teats, which provide most milk. By achieving this position, they are more than twice as likely to survive than siblings further down the milk bar.

In sand tiger sharks, siblicide occurs before birth, with the largest embryo in each of the mother's two uteri breaking out of their egg capsules and engaging in cannibalism of smaller siblings.

"Birth order" even matters in some plants. Indian black plums produce seeds with up to 30 ovules, but the first to be fertilised secretes a toxin that kills off the rest.

the more older siblings someone had, the greater that individual's risk of committing suicide. The effect was more pronounced among women, although their suicide rate was one-quarter that of men. "If you are a firstborn, the first few years you are alone, and have full attention from your parents. You may develop your personality in a more robust and stable direction, and develop resilience to stressful conditions later in life," Gravseth speculates. That reasoning is similar to Adler's, although he concedes that it isn't totally clear what the link between suicide rate and birth order might be.

Psychologist Catherine Salmon at the University of Redlands in California has explored how birth order might affect family relationships. She finds that firstborns and last-borns tend to have the closest relationships with their parents, whereas middle children have stronger relationships outside the family. She puts this down to middle children tending to receive less parental attention, which she says helps hone their skills as "friendship specialists".

Who's a chancer?

Many effects of an individual's place in the family are not a matter of life and death, but to do with behaviour. Mark Mainwaring and Ian Hartley at Lancaster University, UK, found that when zebra finch chicks become adults, the youngest birds from a clutch are more likely to be adventurous than their older siblings when exploring novel surroundings. In humans too, there are hints that birth order is linked to risk-taking. Richard Zweigenhaft and Frank Sulloway at the University of California, Berkeley, found that younger siblings were more likely to participate in dangerous sports. And among 408 brothers who played professional baseball, the younger brothers were 10 times as likely to attempt the high-risk ploy of stealing a base – and three times as successful when they did.

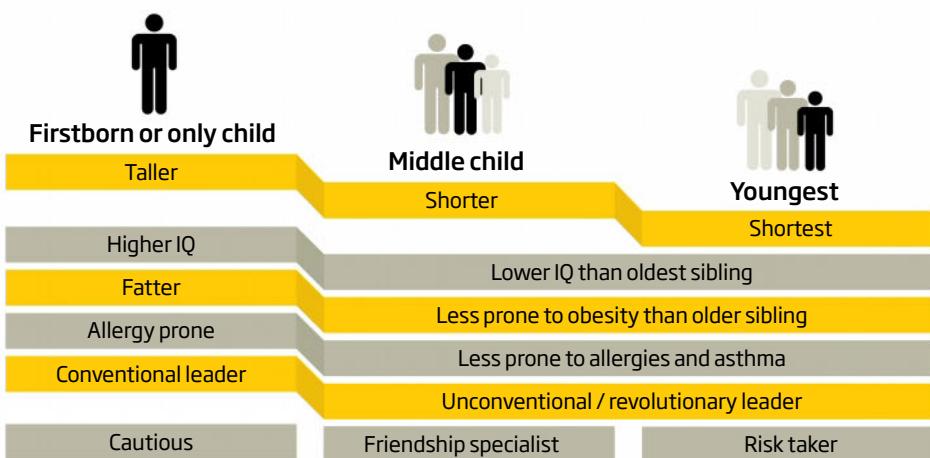
So firstborns may be more cautious, but they may be slightly more intelligent, too. An IQ study involving nearly 250,000 Norwegian male army conscripts found that eldest brothers had, on average, a 2.3-point advantage over second brothers – a trend that continued down the birth ranking. But when the researchers, led by Petter Kristensen at the University of Oslo, looked at males whose elder brother had died – in effect moving the surviving brother up the ranking – they found that these men had a higher IQ than the average for their original slot in the hierarchy. Their results suggest that what matters is one's



ROSANNE TACKABERRY / ALAMY

Born leader or natural rebel?

Your place within the family has a subtle influence on your tendency to exhibit a variety of characteristics



disease, stroke and hypertension. Birth order may influence our susceptibility to other diseases too, including the types of cancer we are prone to – although the picture is still very unclear.

A link with allergies is well documented, however. Matt Perzanowski of Columbia University in New York studied low-income kids in the US government-funded Head Start program, for example, found that 4 to 5-year-olds with older siblings were almost three times less likely to go to the emergency room with allergic asthma than children without older siblings. According to what is called the hygiene hypothesis, being exposed to more viruses, fungi and bacteria early in childhood somehow tempers the immune

fascinating insight. In 1992, Ray Blanchard at the University of Toronto, Canada, showed that the more older brothers a man has, the more likely he is to be gay. He suggested that male fetuses trigger an immune response in their mother, one that becomes stronger with each pregnancy. A link between homosexuality and being a younger brother has since been found in many populations.

As for the underlying mechanism, Tony Bogaert at Brock University in St Catharines, Canada, suspects that the target of the mother's immune response may be proteins on the surface of male fetal brain cells in the anterior hypothalamus, a brain area linked to sexual orientation. If her antibodies bind to these molecules and alter their role in typical sexual differentiation, that might lead some later-born males to be attracted to men, he suggests. Since blood retains an immunological "memory" of past immune responses, even after many years, Bogaert is now analysing blood samples from mothers of gay and straight sons to test this idea.

"A link between homosexuality and birth order has been found in many populations"

system, making later-borns, whose older siblings might bring pathogens into the home, less prone to allergies than firstborns.

An alternative explanation links allergies and asthma to the fetal environment. The idea is that the mother's body must downgrade its immune response to avoid rejecting the developing child. Perzanowski suggests that if this becomes more effective with each successive pregnancy, then later-borns will develop fewer antibodies against their mother in the womb, making them less likely to overreact to innocuous substances they encounter in the outside world.

But this idea runs counter to another

social position rather than actual order of birth. Although these differences in IQ scores are small, Kristensen suggests they could affect chances of getting a university place.

Birth order may also influence leadership style and potential. When researchers at Leiden University in the Netherlands surveyed 1200 Dutch men and women in public office, they found 36 per cent were firstborns and 19 per cent were last-borns. The eldest and youngest children in a family each make up about a quarter of the Dutch population, so firstborns are over-represented and last-borns under-represented among the country's politicians. However, when it comes to leadership that challenges the status quo, Sulloway says it is a different story. His research suggests that later-borns are more likely to embrace revolutionary ideas or movements. Darwin, he notes, was the fifth child in his family; firstborns, meanwhile, were vastly over-represented among opponents of his theory of evolution.

Marked physical differences between siblings are apparent in a variety of animals, and birth order also appears to have morphological repercussions in humans. For a start, firstborns tend to be taller: 2.5 centimetres taller on average than their siblings, according to research by Wayne Cutfield and colleagues at the University of Auckland, New Zealand, taking into account socioeconomic status, ethnicity and parental height. Other research found that firstborn males also have a larger waist size as young adults. Epidemiologist Darren Dahly at the University of Leeds, UK, who co-authored this study, suspects these differences arise before birth. "The utero-placental vasculature may not be as well developed in the earlier pregnancies," he says. As a result, the first child is less well nourished in the womb than later ones and tends to be lighter at birth. Individuals whose metabolism develops in an environment of scarcity and who subsequently experience plenty are thought to be at higher risk of obesity in adult life – an idea called the mismatch hypothesis, referring to the mismatch between pre- and postnatal environments. Dahly believes this may help explain his findings.

This could perhaps be linked to another discovery by Cutfield and colleagues. Studying prepubescent children, they found that the ability of the body to respond to insulin was 21 per cent lower in firstborns than in later-borns, and their blood pressure was significantly higher. They suggest that this may make firstborns more prone to adult diseases including type 2 diabetes, heart

If your life was rerun over and over, you would turn out differently every time despite having the same genes and environment. Helen Pilcher reports

BEYOND nature and nurture

AS TWIN pregnancies go, it was happily uneventful. The identical baby girls lazed in the comfort of their mother's belly until they were full term and born in a Dutch hospital. But after their birth, doctors noticed something was wrong. One girl was quite normal. The other had two vaginas, two colons and a spinal cord that split in two towards the bottom of her back.

It was the beginning of two new lives, and of years of surgery and care for one of the twins. It was also the start of a biological mystery that took the best part of a decade to solve. From looking at the placenta, doctors knew the girls were identical twins. So how could twins who shared the same genes be so different?

It is well known that identical twins can grow into very different adults, and not just with respect to their personalities: physical differences become increasingly apparent with age, too. These are usually attributed to differences in their environment. The twin girls' differences were there from birth. They had shared the same environment – their mother's womb. So what was going on?

Resolving this mystery is helping to explain not just why identical twins can be different, but why we all turn out as we do. For over a century, the orthodoxy has been that we are the product of both our genes and our environment. But the latest findings suggest there is more to it than that: if we could reset the clock to the moment you were conceived and rerun your life over and over, you would turn out differently every time despite having the same genes and being brought up in the same environment. How is that possible? What else is there besides nature and nurture?

Twins have been at the heart of the nature versus nurture debate ever since Darwin's cousin, the scientist Francis Galton, started looking at the issue over a century ago. Today, more than 1.5 million twins around the world take part in studies aiming to assess the relative roles of genes and the environment in everything from ageing to disease, and from bullying to religious belief.

Twin mystery

These twin studies rest on a few simple assumptions. Twins usually grow up together, so share the same environment. Identical twins develop when a fertilised egg splits in two, so their DNA is exactly the same. Non-identical twins develop when separate eggs are fertilised by separate sperm, so their DNA differs. If identical twins are more similar with regard to a particular trait than non-identical twins, the rationale goes, then that trait – hair colour, say – must be down to their genes. If identical twins are no more similar than non-identical twins with regard to a trait – such as the language they speak – then that trait is more likely to be due to the environment.

But cases like that of the Dutch twins threaten to throw a spanner in the works, so researchers were keen to discover what made them so physically different before they were even born. The first suggestion was that the twins were not entirely identical. "You can find identical twins who differ genetically, but they're the exception rather than the rule," says Dorret Boomsma of VU University Amsterdam, a member of the team that studied these two girls.

Two things can make identical twins genetically different. Sometimes, when a fertilised egg splits, mistakes are made. In extreme cases, entire chromosomes can be present in one twin but absent in the other. This turned out to be the case for identical triplets born in 1983. One lost a Y chromosome when the egg split, so the triplets developed into two boys and a girl.

Even when eggs split with no genetic errors, mutations later on can lead to differences. If a mutation occurs very early in development, almost all of the cells in the body of one twin may inherit it, while none of the cells in the other twin will have it. Most mutations have no discernible effect, but occasionally they hit key genes. The characteristics of the Dutch twin with a divided spine resembled those of a mouse strain with a bifurcating tail. These mice have a mutation in a gene called *Axin*, which helps guide body layout during development. So the team sequenced this gene in each girl but were surprised to find no difference between them. That led them to wonder if something else had happened to prevent the *Axin* gene from working.

We have long known about epigenetic marks – chemical labels added to DNA that alter the activity of genes without altering the actual sequence. In particular, if a stretch of DNA has lots of added methyl groups, the activity of nearby genes is suppressed. So the team took a closer look at the *Axin* gene in blood cells from the twins.

Sure enough, the girl with the split spine had unusually high levels of methylation around the gene. So while other causes cannot yet be ruled out, the researchers think the



JONATHAN ROOT/EYEVINE

most likely explanation is that in one twin something pushed methylation levels high enough to shut the gene down, affecting her physical development.

Mystery solved? Far from it. What pushed methylation levels above a critical threshold in one twin but not in the other? "That's the million-dollar question," says team member Nick Martin of the Queensland Institute of Medical Research in Brisbane, Australia.

Magic markers

Many other differences between twins are also being linked to variations in epigenetic marks. It is now relatively cheap and easy to study methylation levels, so the last few years have seen a surge in research. Of particular interest are identical twins like the Dutch girls, where one has a condition or disease and the other does not. For a wide range of disorders including cancer, rheumatoid arthritis and autism, researchers have found different methylation profiles in the affected twins.

Even more intriguingly, differences in methylation are starting to be linked to differences in behaviour. For instances, in one pair of identical twin sisters – one a danger-defying war journalist, the other a risk-averse office manager – differences were found in a gene implicated in stress and anxiety. No one is claiming that these marks alone explain the sisters' different behaviours. But they might help explain why the journalist is less anxious in dangerous situations, which could have influenced her career choice.

Or it could be that the methylation differences between the office manager and war journalist are the result of their different behaviours and environments, rather than the cause. None of the twin studies proves that methylation differences trigger diseases or alter behaviour. "The findings are correlative," cautions epigeneticist Jonathan Mill of the Institute of Psychiatry at King's College London, who has carried out such studies.

Indeed, it is clear that much, if not most, epigenetic variability is driven by the world we live in. All kinds of environmental factors, from pesticides and pollutants to diet, smoking and alcohol, can alter methylation patterns. And once they have changed, there can be lasting effects. When smokers kick the habit, for instance, their methylation patterns rapidly return almost to normal. But some changes can persist for decades – perhaps helping to explain why ex-smokers remain at an increased risk of cancer and respiratory problems years after they stub out their last cigarette. Many studies suggest that particular methylation changes contribute to cancers.

So methylation changes can be both effect and cause. The environment plays a key role in shaping our epigenetic profiles, which in turn influences the activity of our genes,

which in turn may shape our behaviour, lifestyle choices and health – our environment – and so it goes on. That might explain why the epigenomes of identical twins diverge over the years, as a 2012 study showed.

"It could be that the methylation patterns of identical twins become more dissimilar because they experience increasingly different environments," says Bastiaan Heijmans of Leiden University Medical Center in the Netherlands, who led the study. Our epigenetic profiles, it seems, mimic our individual, divergent paths, environments and experiences. They are as unique as we are.

Identically different

But if so much is down to the environment, how can identical twins, who share the same womb, be different even before they are born? Twin researchers Jeff Craig and Richard Saffery of the Murdoch Children's Research Institute in Melbourne, Australia, have identified unique methylation profiles in identical twins born as early as 32 weeks.

This could partly be due to subtle physical differences, such as variations in the size of their umbilical cords. It might also be partly due to random events, such as a failure to copy epigenetic marks when cells divide. A small change in a single cell early in development could end up affecting many organs in the resulting adult, for example.

Andrew Feinberg of Johns Hopkins University School of Medicine in Baltimore, Maryland, believes that some of the epigenetic differences between individuals are a result of random events, and that this randomness is built-in – an evolved feature. His studies suggest that within our genome, there are hundreds of regions where methylation patterns are neither genetically predestined nor set by the environment, but vary widely from individual to individual. These regions include many key developmental genes.

So what is going on? Feinberg thinks it is a way for evolution to hedge its bets. Many animals have to survive in a constantly changing environment. Random epigenetic changes produce more variation in genetically similar offspring, increasing the chances that some of them will survive, he argues.

If your head is starting to spin, brace yourself. It seems that the amount of random epigenetic variability can itself vary depending on the environment. In mice given certain dietary supplements, there was more variability in their methylation patterns.

Just how important these random variations are is not yet clear. The ideal study would be to raise a batch of clones in the same environment and see how they turn out. This clearly cannot be done with people, but it can be done with mice. In one such experiment, 40 radio-tagged mice spent three months

If there were clones of you, how similar would they be?



MEYER/TENDANCE FLUX

living together in the same five-storey cage, decked out with flower pots, tubes and toys, while researchers recorded their every move. At first the mice behaved in a similar way, but over time their exploratory patterns began to differ. "They developed different personalities," says team member Gerd Kempermann at the German Center for Neurodegenerative Diseases in Dresden.

The study adds to the evidence that animals can indeed turn out differently even if their genes and environment are identical. It also suggests that these differences can arise through a dynamic, interactive process. So a slightly more active mouse might explore a little more than a less active one. It might bump into more of its cage mates and take an enjoyable tumble down a plastic tube, which might in turn fuel its wanderlust, making it better at climbing and more likely and able to seek out further new experiences. Indeed,

"There is more to our uniqueness than genes and upbringing: even clones will all end up different"

Kempermann found that the most adventurous mice grew the most new neurons in their hippocampus, a brain region linked to learning and memory. Tiny initial differences become amplified, feeding back to biology and behaviour, sculpting individuality.

The study did not look at the cause of these subtle differences but, as the mediator between genes and the environment – nature and nurture – epigenetics is a prime candidate. Epigenetic variations could initially arise randomly or as a result of physical differences in the womb, or a mixture of both. These tiny initial epigenetic differences might influence

gene activity and sculpt our interaction with the environment, which then feeds back into the epigenome, amplifying the message. This then further influences gene expression, shaping our biology, behaviour and the way we experience the world.

"The environment isn't what happens to us. We make our own environment," says geneticist Robert Plomin of London's Institute of Psychiatry. Add a dash of serendipity – one twin having an accident or illness, say – and these unique experiences set them on a trajectory to individuality.

Of course, most of us don't worry too much about what makes us unique. We don't have clones running around in the form of a twin brother or sister. But these findings suggest there is more to our uniqueness than our genes and upbringing, that even if we were just one of thousands of clones we would still all end up different in some ways. Put another way, creating a clone army may be harder than the movies suggest.

Where does this leave the nature versus nurture debate? It is clear that some traits, such as hair colour, are mostly down to genes, whereas others, such as the language we speak, are due to the environment. But you could argue that there's a third factor too – call it chance or serendipity – in the form of random events occurring in our bodies or in the environment. That may be why the two Dutch twins were so different.

What's more, many aspects of our bodies and behaviours seem to be the result of complex interactions between genes and the environment, mediated by epigenetics and with a large dash of chance thrown in. In these cases it seems pointless arguing about nature versus nurture. "The debate is outdated," says epigeneticist Manel Esteller of the Bellvitge Biomedical Research Institute in Barcelona, Spain. "It doesn't make sense any more." ■

“...miracle patients

'We don't see a lot of long term survivors and these intrigue me. It's our job to study the miracle patients and extend that success to, not just a few, but the vast majority of patients. I think that is possible within 10 years.'

- A/Prof Kerrie McDonald
Chair of Cure Brain Cancer
Neuro-oncology Group, UNSW



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The curious lives of the people who feel no fear

Some people really are not scared of anything. Understanding why could explain how the rest of us process terror, says Christie Aschwanden

FOR the first six years that he knew her, Justin Feinstein could find nothing to scare the woman known as "SM". It wasn't for lack of trying. He showed her films like *The Blair Witch Project*, *Arachnophobia*, *The Shining* and *Silence of the Lambs*, but none elicited even a hint of fear. He then took her to an exotic pet store where, without provocation, she approached a terrarium of snakes and reached in to hold one. She even touched its flicking tongue and declared, "This is so cool!" SM approached the animals with so little caution that a shop assistant had to intervene to stop her petting a tarantula.

Next, Feinstein took her to Waverly Hills Sanatorium in Louisville, Kentucky – a haunted house tourist attraction billed as "one of the scariest places on Earth". Once again, nothing rattled her. While others taking the tour started or screamed at the strange noises, creepy music and eerie scenes featuring actors dressed as murderers, monsters and ghosts, SM smiled and laughed. In an ironic twist, she managed to frighten one of the "monsters" when she reached out to touch its head – just to find out what it felt like, she later explained.

Feinstein's mission to scare SM might sound like the pranks of a mischievous sibling, but it has a serious purpose. He is a clinical neuropsychologist, now at the Laureate Institute for Brain Research in Tulsa,

Oklahoma, and he believes that studying SM, and a handful of people with a similar lack of fear, could pave the way for a better understanding of how the brain processes terror. Strangely, Feinstein's theory only fell into place once he had finally managed to scare SM. In the future, this work might lead to treatments for post-traumatic stress disorder.

SM first attracted the attention of scientists when she arrived in Daniel Tranel's neurology lab at the University of Iowa in the mid-1980s. She had just been diagnosed with Urbach-Wiethe disease, a genetic condition so rare that fewer than 300 cases have ever been identified. Its symptoms include skin lesions and a build up of calcium deposits in the brain. In SM's case, the disease destroyed the almond-shaped amygdala region of each brain hemisphere (see diagram, page 96).

"To have a lesion that's so localised is rare," says Daniel Kennedy, a neuroscientist at Indiana University in Bloomington. "She's one of only a couple dozen known cases." Seeing

such restricted damage, Tranel realised that SM's condition could provide a unique opportunity to understand what this region of the brain does.

The amygdala has long been thought to play an important part in the processing of emotions, particularly fear, though its exact role was unknown. Brain imaging studies show amygdala activity during fear, but "what those studies can't tell you is whether it is absolutely necessary for the experience", says Mike Koenigs, a neurobiologist at the University of Wisconsin-Madison. It's possible, he says, that the amygdala activity is a result of processes in other brain structures, without being essential to the feeling.

SM's experience would seem to rule out this possibility, since the feeling of fear vanished from her life soon after the onset of her brain damage (see "Snapshots of fearless living", page 97). What's more, the rest of her emotional palette remains intact, which suggests that the amygdala is not the centre of all our emotions, as some had proposed. "She's not unemotional in any way," says Feinstein.

Indeed, her lively personality reveals a more nuanced picture of the amygdala's responsibilities in our daily lives. Some of these insights come from her relationships with other people. "She's very social, and you might even put her in the category of a slight

"She called out 'help me' and raised her hands. It was the first time she had felt scared"



sensation seeker," says Feinstein. Naotsugu Tsuchiya, a neuroscientist at Monash University in Melbourne, Australia, agrees. He recalls once taking SM to a restaurant while he was working at Caltech. She enjoyed chatting with the waiter during their brief encounter and the next day she wanted to eat at the same place. When they returned, she became visibly happy when she saw the waiter and was extremely genial towards him.

Such openness may seem a virtue, but in other situations it suggests that SM can't read

the subtle cues that would cause most of us to feel reticent. This is particularly true when dealing with shady characters. "People that you and I would identify as untrustworthy, she would identify as more trustworthy," Kennedy says. "She has a bias towards trusting people and wanting to approach them." All of which would suggest that the amygdala deals not just with immediate threats to our life, but also the smaller signs that might curb our social behaviour.

Kennedy recently tested SM's openness in

the lab by examining her sense of personal space. He asked a woman to slowly approach SM, who had to signal the distance at which she felt most at ease. Her preferred distance from the other person was 0.34 metres, almost half the distance chosen by other volunteers. "You have this physiological reaction when someone comes too close and invades your personal space, and your amygdala helps to create that," says Kennedy. "It's almost like a car's brakes – it helps to protect us by giving us the ability to regulate our distance."

Look into my eyes

Further clues to the amygdala's function come from SM's inability to read the subtle cues in certain facial expressions. Again, the deficit is very selective – she can recognise joy or sadness, but struggles to identify fear. Initially, the researchers thought her ability to recognise the emotion was completely lost, but Tsuchiya's experiments showed that she does retain a short-lived, non-conscious reaction. He presented SM with a string of fearful or angry faces, or threatening scenes next to a neutral stimulus, showing each for just 40 milliseconds – too fast to consciously process. Each time, SM was asked to push a button as fast as she could to choose which face showed more fear or anger or which scene was most threatening. Surprisingly, her performance was completely normal, and it was only when she was given unlimited time to decide that her performance plummeted.

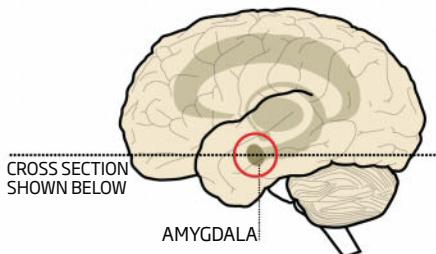
Digging deeper, Kennedy has found that the problems lie in the way her brain directs her gaze. When left to her own devices, SM doesn't naturally look into someone's eyes, which offer the surest signs of fear. "They get wide, and you get a lot of white in the eyes – it's a very clear way to distinguish fear," he says. When the experiment was rigged so that her gaze went straight to the eyes, her performance improved dramatically.

Such differences suggest that the amygdala has a more advanced job than that of a simple "danger detector" as some theories had it. Instead, that initial recognition seems to happen in other regions, below our conscious radar, and it is only once we have registered the threat in our non-conscious that the amygdala orients our attention to gather the critical information – in this case, the eyes – and assess the danger at hand.

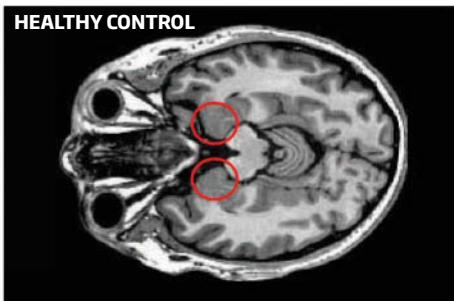
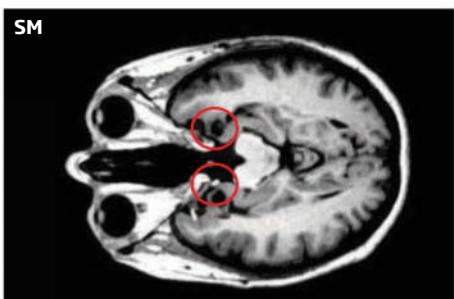
This evaluative step may be essential to the ability to experience fear. Without it, SM's brain misinterprets the non-conscious cues signalling danger – they may still elicit a ➤

The fear factory

Experiences of terror are thought to be processed in the amygdala region of each brain hemisphere



A rare neurological condition known as Urbach-Wiethe disease damaged this area in a woman known as "SM", meaning it is now almost impossible to scare her



feeling of arousal, but without the amygdala's assessment of the situation, it creates a sense of excitement rather than terror. This could explain SM's curiosity on her trips to the haunted house and exotic pet shops. Rather than behaving indifferently, she was fascinated by sights that terrify most people.

At least, that's how it seemed until Feinstein finally managed to scare SM. She was joined in the study by "AM" and "BG", a pair of identical twins who had the same medical condition and similar amygdala damage. Turning to an established method of studying panic, Feinstein asked the group to don a mask that delivers a short burst of air containing 35 per cent carbon dioxide.

"The majority of healthy people who do this feel an immediate change in their physiology," Feinstein says. Commonly reported symptoms include breathlessness, a racing heart, sweat on the skin and light-headedness. It can be an unsettling experience, and about a quarter of people react with feelings of panic.

To Feinstein's surprise, all three subjects with amygdala damage experienced a dramatic panic attack. SM called out, "Help me!" and put her hands to the mask, gesturing for the researchers to remove it. When asked what she was feeling she responded: "Panic mostly, because I didn't know what the hell was going on." It was the first time she had experienced fear since the onset of her disease.

Two kinds of fear

The other two amygdala-impaired volunteers had similar reactions. AM grimaced and her left hand clenched into a fist as she tried to escape from the mask. She reported feeling "a strong fear of suffocation" and said it was the strongest fear she had ever experienced – she thought she might be dying. BG, meanwhile, gasped for air and ripped the mask off her face. She also told the researchers that she thought she might die if the experiment continued, and said the panic she had felt was "totally new".

Initially, the results seemed to contradict everything that Feinstein thought he knew about amygdala function. How could someone without the structure suddenly feel fear? "It threw me for a bit of a loop," he says. "So much of our research over the past several decades has been focused on the amygdala as the quintessential structure for fear."

After a bit of careful thought, however, he began to see how the findings could fit with

There is a fine line between fear and excitement



his previous theories. Feinstein suggests that the brain processes internal threats, such as an asthma or heart attack, differently from external ones. "It's a primal layer, a very basic form of fear," he says. This makes sense, given that high levels of CO₂ change the blood's acidity, which triggers a cascade of reactions across the brain. The resulting neural activity is so widespread that it can create a feeling of panic without the amygdala, whose primary job seems to be to assess threats in our surroundings and direct our behaviour accordingly.

"It makes a lot of sense that something like CO₂ could activate some other circuit downstream of the amygdala," says Cornelius Gross at the European Molecular Biology Laboratory in Monterotondo, Italy. He points to parts of the hypothalamus and the periaqueductal grey (PAG) region of the brain as probable candidates.

Indeed, the "fearless" volunteers may have reacted so strongly to the CO₂ experiment precisely because they lacked the ability to interpret the context of the situation. Although other participants felt the unpleasant sensations that signal the onset of

"A life without fear might seem like bliss, but SM says that she wouldn't wish it upon anybody"



JUN AHN/BARCROFT MEDIA

SNAPSHOTS OF FEARLESS LIVING

It took researchers years to find any instances of SM experiencing fear (see main story). Indeed, her grown-up son cannot recall a single occasion on which SM seemed fearful. He remembers a time when an enormous snake had stretched itself across the one-lane road in front of their house. Without flinching, SM grabbed the animal with her bare hands and placed it on the grass where it could safely slink away. Surprisingly, she appears to have had little insight into her own extraordinary behaviour. "She would always tell me how she was scared of snakes and stuff like that, but then, all of a sudden, she's fearless of them. I thought that was kind of weird," her son told a team of researchers that included Justin Feinstein, then at the California Institute of Technology.

People have sometimes taken

advantage of this fearless nature, which has put her life in danger on more than one occasion. One night when SM was 30, she was walking home, alone, through a park where a man she would later describe as looking "drugged out" was sitting on a bench. The man called out and gestured for her to come over. Without hesitation, she walked over to him and when she reached striking distance, the stranger stood up, grabbed her shirt and held a knife to her throat, threatening to cut her. SM didn't flinch. Fearlessly, she told him, "If you're going to kill me, you're gonna have to go through my God's angels first." The man released his hold and SM calmly walked away. The next day, she strolled the same route without a trace of anxiety.

That's not to say that SM isn't aware of everyday dangers and

how to avoid them. "She's able to do rule-based fear learning," says Feinstein. This is particularly true for routine risk avoidance - she never steps into the street without looking both ways first, for example.

SM also fails to perceive risks in social situations, which makes her an easy target for internet scammers and she has had few long-term friendships. In such precarious circumstances, her frequent lab visits provide an anchor of stability. "One relationship that hasn't disappointed her has been her relationship with our research laboratory," Feinstein says. "It's something that weighs on me quite a bit." He feels a sense of responsibility to SM after all she has done to further his research. "I view it as, I'm the student and she's the teacher," he says.

suffocation, their other senses told them that the researchers wouldn't let that happen, damping down their sense of panic. Without the amygdala to weigh up those external cues, however, SM, AM and BG couldn't calibrate the internal sensations with the signs of safety around them, and so found no comfort to ease their terror.

Anticipating threat

The amygdala's role in risk assessment could shed some light on another puzzling finding from the same experiment. Healthy participants usually develop an anticipatory response before a repeat trial – minute changes in their sweat patterns and a slight increase in heart rate. By contrast, the volunteers diagnosed with Urbach-Wiethe disease showed no signs of anticipation as they approached the apparatus for the second time, even though they could clearly remember the panic they experienced on their previous visit. So it seems the amygdala is necessary to draw on memories of fear when assessing a current situation.

Besides advancing our understanding of this mysterious brain region, these results may one day help people who feel an inordinate amount of anxiety. Koenigs has studied veterans of the Vietnam war who were wounded during heavy combat. In a sample of 200 veterans with brain injuries, half had experienced post-traumatic stress disorder. However, none of those with damage to their amygdala had developed the condition.

"We know the amygdala is often overactive in people with fear and anxiety disorders," Koenigs says. His research implies that a functional amygdala may be required to develop post-traumatic stress disorder, though he cautions that it is too soon to know for sure. "This is an active, ongoing area of research," he says. The hope is that researchers might develop drugs or other tools to alter the amygdala's response and reduce the symptoms of these conditions.

Even so, the researchers will have to tread carefully, says Feinstein – knocking out the amygdala would not be a solution, as SM illustrates. Her lack of a sense of risk has made her vulnerable to muggers, and the difficulty she has in reading social signals means she struggles to develop long-term relationships.

A life without fear might seem like bliss, but when Feinstein asked SM what she would say to someone who wanted to be like her, her opinion was definite: "I wouldn't wish it upon anyone." ■

We tend to think of anger as a negative emotion, but used in the right way it can be surprisingly constructive, finds Emma Young

Do get mad



REUTERS

ANYBODY can become angry, that is easy; but to be angry with the right person, and to the right degree, and at the right time, and for the right purpose, and in the right way, that is not within everybody's power, that is not easy."

So wrote Aristotle, more than 2000 years ago, in his classic work *The Art of Rhetoric*. His words don't quite square with our modern concept of anger. Today, we tend to think of it as a destructive emotion that can wreck relationships and blight careers. Indeed, the field of anger management is awash with theories on how best to control or

suppress excess anger. But anger, it now seems, is not all bad. In fact, we might do well to cultivate our anger in some situations – in personal relationships, in negotiating certain business deals and within social action groups, for example.

"To the extent that anger is usually unpleasant to experience, it could be viewed as a negative emotion," says psychologist Brett Ford at the University of California, Berkeley. "But experiencing anger can help us pursue our goals, and be happier and healthier in the long run." To reap these benefits, the knack, as Aristotle understood, is to know when, where,

why and how to get angry. We need to learn to use our anger strategically, rather than letting it control us.

Philosophers have long pondered the causes of anger, but it is generally recognised as an emotional response to being provoked. A slight from a junior employee, an insult directed at your child, a decision by your boss that suggests your feelings are irrelevant – all are likely to trigger feelings of anger, usually accompanied by physical changes such as an increase in heart rate and levels of the hormone adrenalin. How we respond to such triggers – how much anger we feel and to what extent we express it – varies from person to person (see "The angry brigade", page 101). And there is no doubt that people who experience and express frequent, uninhibited anger do suffer. Even if the impact on their health is debatable, the effect on their relationships is clear. "Their children, wives, bosses, families are frightened of them, and they scare everyone away," says Mike Fisher, director of the British Association of Anger Management, based in East Grinstead. "You can't believe the number of people we get like that. They have no friends. Their family has left. All they do is work or act out with a whole variety of addictions."

Although nobody would argue that anger, from road rage to riots, can't be enormously destructive, the idea that it is also sometimes beneficial is steadily gaining ground. One particularly influential study came in the wake of the 9/11 terrorist attacks on the US. Jennifer Lerner, now at Harvard University, gathered information on the emotions and attitudes of almost 1000 American adults and teenagers just nine days after the attacks, with follow-up studies in subsequent years. She found that people who felt angry about terrorism were more optimistic about the future than those who were afraid of terrorism. The men in the study were angrier than the women, and were generally more optimistic. She also found that media stories angled to make people angry made them less afraid of being hurt in a terrorist attack and more willing to support an aggressive rather than conciliatory public response.

A healthy rage

In a lab study, Lerner discovered that people made angry rather than fearful by a stressful situation have a lower biological response, in terms of blood pressure and levels of stress hormones. This shows, she says, that when you're in a situation that is maddening, and your anger is justified, the emotion isn't necessarily bad for you. Ford's research takes this one step further. Working with Maya Tamir, then at the Hebrew University of Jerusalem, Israel, she found that people who tend to feel angry rather than happy when ➤



Anger can help in negotiations, particularly for men – but there are limits

"People who generally suppress their anger in a dispute with their partner die earlier than those who just let their anger out and resolve conflicts"

confronting others report higher well-being overall. The naturally tetchy also scored higher for emotional intelligence, which might seem counter-intuitive but is consistent with the idea that feeling angry, however unpleasant, can have its uses.

Lerner's 9/11 research also highlights the importance of anger in prompting collective action against a common threat, an idea that has been explored by Andrew Livingstone at the University of Exeter, UK. His team studied groups of people with something in common (such as coming from south Wales) and random groups, measuring the participants' emotional reactions to triggers such as a suggestion that government support for heritage sites in south Wales be withdrawn. They found that anger, more than any other emotion, helps unite people with a shared conviction, and prompt them to take action.

"By its nature, anger tends to be a fairly energising emotion," says Ford. His own work suggests that feeling angry makes people seek out rewards. If the desired reward is better working conditions, say, or broader social change, anger can play an enormous role in

helping you achieve these goals. "Mahatma Gandhi, and his passive resistance, is a beautiful example of controlled anger," says Fisher. "You've seen it with Nelson Mandela, with Malcolm X – these are huge figures in our history who stand out as incredible leaders, who have taken their anger and transformed nations. But they have channelled and directed their anger to heal as opposed to hurt."

Anger is vitally important in mobilising support for a social movement, says Nicole Tausch at the University of St Andrews, UK. When they looked at student protests against tuition fees in Germany, the response of Indian Muslims to inequality in India, and how British Muslims reacted to the British government's "war on terror", Tausch and her colleagues found that anger played a positive role. In particular, it motivated people to stage peaceful demonstrations that they hoped would persuade their adversary to rectify social injustices. In political contexts, anger can signal that individuals still feel connected to and represented by the political system, she says. "Expressions of anger, such as during protests,

should therefore be viewed not as threats to the system but as signs of a healthy democracy."

If anger can serve a higher cause, it can also be harnessed for our own personal ends. There is plenty of evidence that anger can be beneficial in a professional context – provided you are careful about how you express it and to whom.

Angry outbursts can pay dividends in the workplace if managers subsequently address the underlying problems rather than simply punishing aggrieved individuals. Some forward-thinking managers might even want to foster anger, at least at certain times, as people who feel angry brainstorm in a more unstructured way, consistent with creative problem-solving.

Professional ire

There is also evidence that political and business leaders who get angry rather than sad in response to a scandal are granted higher status – as long as they are male, that is. Both men and women confer lower status on angry female professionals than on angry male professionals, whether the female is a CEO or a trainee. A woman's emotional reactions are generally attributed to her character ("she is an angry person") whereas men are perceived as merely reacting to external circumstances. Hillary Clinton is just one female politician who has suffered criticism for being "too angry", says Victoria Brescoll of Yale University.

Several studies have found that angry negotiators can get a better result for their side. But in 2010, Hajo Adam – then at INSEAD, a graduate business school in France – uncovered an important exception. His research was inspired in part by observing how colleagues at INSEAD campuses around the world reacted differently to outbursts of anger and how Japanese trade envoys responded negatively to former US president Bill Clinton taking an angry stance in negotiations in the early 1990s. In lab-based studies with student volunteers at the University of California, Berkeley, Adam's team found that Americans of European descent made larger concessions to an angry opponent than to a non-emotional one, whereas Asians and Asian Americans made smaller concessions. Adam thinks this reflects cultural norms about whether or not it is appropriate to get mad.

These caveats aside, anger used judiciously has all sorts of benefits both in the workplace and in the wider social sphere. But what

The physiology of fury

Full-blown anger has some powerful effects on the human body

Eyes stare

☐ Face becomes flushed

Jaw clenches

☐ Voice becomes shrill (women)

Voice deepens (men)

☐ Heart pounds

Jittery stomach or nausea

☐ Limbs may shake

Adrenalin is produced

☐ Hands have increased blood flow

Breathing rate increases

☐ Sweating increases

Torso lifts

☐ Nostrils flare

THE ANGRY BRIGADE

The same social slight can make one person anxious, another irritated, and a third so angry they react with their fists. No one is quite sure why some people are fearful when provoked and others become angry, but what is certain is that some types of people are likely to be angrier than others.

For a start, men are angrier than women. Within each sex, physically strong men are angrier than weaker men, and beautiful women are angrier than less attractive women. In fact, strength accounts for about 20 per cent of the variance in male anger, according to Aaron Sell of Griffith University, Queensland, Australia. "The theory is that strength and attractiveness lead individual men and women to feel more entitled." In our evolutionary past, these attributes would have given them an advantage in competition with others. "If the world doesn't deliver these benefits, they are more likely to turn angry as a result," says Sell.

Following similar logic, some researchers think that high self-esteem makes people angrier. However, Mike Fisher, director of the British Association of Anger Management, believes the reverse is true. His experience has convinced him that people with low self-esteem - which can include high achievers - suffer more stress, which feeds their anger. People get more angry in stressful times like now when much of the developed world is worrying about the economy, Fisher argues.

Susceptibility to stress could also explain why highly strung, Type A, individuals are thought to be angrier than the more laid-back Type Bs. Physiology could sometimes be to blame: there is a link between poor blood-sugar control and disturbed mood, including feeling angry. Anger has even been linked with a gene, MAO-A, dubbed the "warrior" gene. However, while people with the gene tend to be more aggressive, this is not necessarily because they feel angrier.

And no one really knows what lies behind intermittent explosive disorder, says Ronald Kessler of Harvard Medical School. It's a psychological condition characterised by eruptions of uncontrollable anger, which usually develops in late childhood. In 2012, Kessler's team reported that about 1 in 12 US teenagers and adults have it - a far higher rate than anyone had suspected.

Whatever the causes, there is no "cure" for excessive anger. A person who frequently feels inappropriately angry must generally always work to manage it, says Fisher. As a sufferer himself, he knows how difficult that can be. But there is one ray of hope. As a rule, we tend to get less angry - or at least less aggressive - as we get older.



KYM SMITH/NEWSPIX/REX FEATURES



FAR LEFT: ALDO SPERBER/PICTURE TANK; LEFT: MANSSELL/TIME & LIFE PICTURES/GETTY

Former Australian prime minister Julia Gillard's anti-sexism rant did her no harm (top), and Gandhi used controlled anger to great effect

about your home life? Surely when it comes to your nearest and dearest it is always best to keep calm and avoid an altercation?

Not according to Ernest Harburg, emeritus professor at the University of Michigan in Ann Arbor. He believes that a fight with your partner might actually be healthy. His team has found that people who generally suppress their anger in a dispute with their partner die earlier than those who just let their anger out and resolve conflicts. And his results, from a study spanning over three decades, reveal that couples in which both partners express their anger have significantly longer lives.

Harburg thinks that suppressing anger raises blood pressure, and in the long term, this affects lifespan. "The idea of inhibiting your anger all the time, which is promoted by religions and pacifists, is simply not a healthy thought," he says.

Fisher cautions that when getting angry in a relationship, you have to be respectful. "It's as simple as saying, 'I feel angry with you, I need you to listen to me and take me seriously and care for me and prioritise me.'" That, he concedes, is not what people usually say.

As Aristotle recognised, controlling one's anger is not easy. But even that is not enough. We also need to learn to respond appropriately to the anger of others. If it prompts more anger, or even if it is simply ignored, the consequences can be grave. Everyone has personal experience of this, but in a political context the results can be disastrous. Tausch and her team have consistently found that if the target of the anger expressed by a political group does not respond with change, the group can become contemptuous of that target (perhaps the government), and engage in what she calls "out-of-system" forms of political action – namely, violence or support for terrorism.

All the more reason, then, to "be angry with the right person, and to the right degree, and at the right time, and for the right purpose, and in the right way". And all the more reason to pay attention to anger, rather than ignore it. Anger should be viewed not as driving destructive forms of behaviour, says Tausch, but rather as a way of fostering behaviours that are positive and constructive for social relationships. ■

Words can never hurt me?

Rejection and heartbreak have a lot in common with the pain of cuts and bruises. Understanding why could change your life, says **Lisa Raffensperger**

I STRUCK suddenly. First there was an ache in my chest, as if my sternum was laced too tightly. Then came the headaches and chronic tiredness. The feelings lingered for weeks, and were often at their worst just before I fell asleep each night. Though it was more than a decade ago, I remember it well, as it marked my first bout of an ailment that would be unmistakable forever after: heartbreak.

Betrayal, rejection and lost love are a fact of life, but it is only in the past 10 years that we have begun to unravel the basis of these hurt feelings in the brain. Scientists have found that the sting of rejection fires up the same neural pathways as the pain from a burn or bruise. Besides explaining why some people have thicker skins than others, this fact reveals an intimate link between your social life and your health – you really can die of loneliness.

Our language has long borrowed physical terms to describe our darkest emotions, with phrases such as “she broke my heart”, “he burned me”, and “he stabbed me in the back”. Such comparisons occur around the world: Germans talk about being emotionally “wounded”, while Tibetans describe rejection as a “hit in the heart”.

Although these expressions were always taken to be metaphorical, there had been some early hints that more was afoot. Animal studies in the 1990s, for instance, showed that morphine not only relieves pain after

injury, but can also reduce the grief of rat pups separated from their mother.

Still, when Naomi Eisenberger at the University of California, Los Angeles, started studying hurt feelings in humans in the early 2000s, she did not know what she would find. She was intrigued by the way that past rejections linger with us throughout life; we can all remember a time when we weren’t picked for the school sports team or felt excluded by a group of friends. “I was curious – why is it such a big deal?” she says.

To find out what the brain is up to when people feel social rejection, Eisenberger asked volunteers to play a simple computer game called *Cyberball*, in which three players pass a ball among themselves. Each volunteer was led to believe they were playing with two people who were in another room, but in fact the playmates were controlled by the computer.

Although they started out friendly, the computerised players soon stopped throwing the ball to the volunteer. It might seem like a trifling insult, but some subjects responded strongly to the slight – slumping in their seats or making a rude hand gesture at the screen.

All the while, a functional MRI scanner recorded the volunteer’s brain activity, revealing a surge in the dorsal anterior cingulate cortex (dACC) when they began to feel isolated. This region is known to be an important part of the brain’s “pain network”,





"The sting of rejection fires up the same neural pathways as pain from a burn, revealing that social life and health are linked"

determining how upsetting we find an injury. The response can vary depending on the situation; bumping your head might seem like a big deal in the office, but during a football game you might barely notice the blow.

Crucially, the more distressing you find an injury, the more the dACC lights up, a fact that also seemed to play out during the games of *Cyberball*: those who reported feeling worst after the rejection showed the greatest activity in this region.

Other studies confirmed the link, finding that social rejection provokes not just the dACC but also the anterior insula, another part of the pain network that responds to our distress at a cut finger or broken bone. But although these results all suggest that our anguish after an insult is the same as our emotional response to an injury, it took until 2011 to show how those feelings might spill over into tangible bodily sensations.

Ethan Kross at the University of Michigan in Ann Arbor decided to set *Cyberball* aside in favour of a more serious form of rejection – a broken heart. He recruited 40 people who had been through a break-up within the past six months and asked them to view a photo of their ex while reclining in an fMRI scanner. He also instructed them to think in detail about the break-up. After a brief intermission, the volunteers' forearms were given a painful jolt of heat, allowing Kross to compare brain activity associated with the two situations.

Numbing the hurt

As expected, the dACC and the anterior insula lit up in both cases. But surprisingly, the brain's sensory centres, which reflect the physical discomfort that accompanies a wound, also showed pronounced activity – the first evidence that the feeling of heartbreak can literally hurt.

Cementing the connection between physical pain and emotional anguish, further studies have found that the two experiences sometimes feed off one another. When people feel excluded, they are more sensitive to the burn of a hot probe, and submerging a hand in ice water for 1 minute leads people to report feeling ignored and isolated.

The converse is also true: soothing the body's response to pain can alleviate the sting of an insult. Nathan DeWall of the University of Kentucky, Lexington, recruited 62 students who either dosed themselves up on two paracetamol (acetaminophen) pills every day for three weeks, or took a placebo. Each evening, the students completed a

questionnaire measuring their feelings of rejection during the day. By the end of the three weeks, the group on paracetamol had developed significantly thicker skins, reporting fewer hurt feelings during their day-to-day encounters. A subsequent game of *Cyberball* confirmed the effect: those given paracetamol showed significantly less activity in the dACC and the anterior insula compared to those taking the placebo.

"The idea that you can actually affect people's experience socially with what is seen as such a mild, common drug [as paracetamol], that was a rather important validation," says Geoff MacDonald at the University of Toronto, Canada, one of the authors of the study. "This is exactly the kind of thing you would expect if this social pain thing is really true." Needless to say, due to the harmful side effects of pain-killing drugs, you should not try this for yourself.

The work might explain why certain people find it harder to withstand the rough and tumble of their social lives than others. Extroverts have been shown to have a higher pain tolerance than introverts, and this is mirrored by their greater tolerance for social rejection. Eisenberger, meanwhile, has found that people who feel more pain when a hot electrode touches their arm are also more sensitive to hurt feelings during *Cyberball*.

These diverse reactions may be partly genetic. Eisenberger's team has shown that people with a small mutation to the gene *OPRM1*, which codes for one of the body's opioid receptors, are more likely to slip into depressed feelings after rejection than are those without the mutation. This same mutation also makes people more sensitive to physical pain, and they typically need more morphine following surgery.

Importantly, these receptors are particularly dense in the dACC. As you might expect, in people with the mutation, the dACC tends to react more strongly to perceived insults.

As with many traits, a child's early environment can also determine their sensitivity. For instance, people with some forms of chronic pain are more likely to have had traumatic experiences, such as emotional abuse, during their early years. Perhaps it puts their pain network into overdrive, making them more sensitive to any discomfort.

Adolescents seem particularly sensitive to rejection. The brain's pain network is still developing at their age and, compared to the adult brain, it tends to show a more exaggerated response to small slights and ➤

insults. On the positive side, social support during this period can carry lasting benefits. For instance, young adults who enjoyed tighter social networks in their late teens show more muted reactions to the sting of rejection than those who had felt lonelier in the past, perhaps because memories of past acceptance subconsciously soothe their feelings.

When you consider our ancestors' dependence on their social connections for survival, it makes sense for us to have evolved to feel rejection so keenly. Being kicked out of a tribe would have been akin to a death sentence, exposing our predecessors to starvation and predation. As a result, we needed a warning system that alerts us to a potential spat, preventing us from causing further offence and teaching us to toe the line in the future. The pain network, able to give us a jolt when we face physical injury from a fire or knife edge, would have been ideally equipped to curb our social behaviour.

Some have taken this line of thinking further, suggesting it might hold the secret to some of the more mysterious symptoms of loneliness. People who are lonely tend to have an increase in the expression of genes for inflammation, particularly in immune cells, and a decrease in the expression of antiviral genes.

Why would the body deal with isolation in this way? "That was kind of a puzzle to us for the last five or 10 years," says Steve Cole, a behavioural geneticist at the University of California, Los Angeles. An answer began to emerge when he looked at the way different conditions affect people with different social lives. Viruses spread quickly among large

from George Slavich, also at UCLA. He has found that socially stressful tasks, such as delivering an impromptu speech, trigger heightened activity in the dACC, prompting an inflammatory immune response – as if the brain were pre-empting the threat of isolation and injury.

That response would have saved our ancestors from infection in the tooth-and-claw struggles of evolution, but it could backfire in the modern world. Increased inflammation has been linked to a host of conditions, including heart disease, cancer and Alzheimer's disease – and lonely people are at a greater risk of all of these. A meta-analysis in 2010 of 148 studies determined

Memories of rejection at school can linger throughout life, with potentially important ramifications for our health

the elderly and infirm, and anyone recovering from illness. Even so, much more research will be needed to understand the way our social lives influence our health, says John Cacioppo of the University of Chicago, who studies loneliness. He is sceptical that the *Cyberball* experiments tell us much about the impact of long-term isolation, pointing out that the known physiological responses to rejection are short-lived. "Loneliness may not be affected at all by those transient events," Cacioppo says. "The little things are not the things that are killing people – it's the brain being on alert in an unrelenting way."

In the meantime, there are measures we can take to smooth the bumpy road of our social lives. We all like to be comforted after an upset, but Eisenberger has found that giving support to others also softens our own response to rejection. To test this, she gave a man an electric shock while his female partner, lying in an fMRI scanner, could either hold his hand in support or was prohibited from doing so. When the woman could support her partner, her brain's response to threat and rejection was significantly subdued.

So although we can't stop life's situations from immediately shaping our emotional landscape, perhaps we do have a say in the way we respond to those events. Words may be as painful as sticks and stones, but by caring for others as well as ourselves, we can at least make sure that they hurt us only briefly. ■

"We all like to be comforted after an upset, but giving support to others also softens our own response to rejection"

groups of people, whereas life-threatening bacterial infections generally come from wounds which our ancestors may have been more likely to receive when alone, without the protection of their peers. As a result, Cole suggests, our immune system may be "listening in" on our brain's signals of social status. If it looks as if we are enjoying a lively social life in a big group, we are geared up to deal with viruses; if we feel alone, the dACC and other regions tune up inflammation, which helps us battle bacterial infection.

One piece of evidence for the idea comes

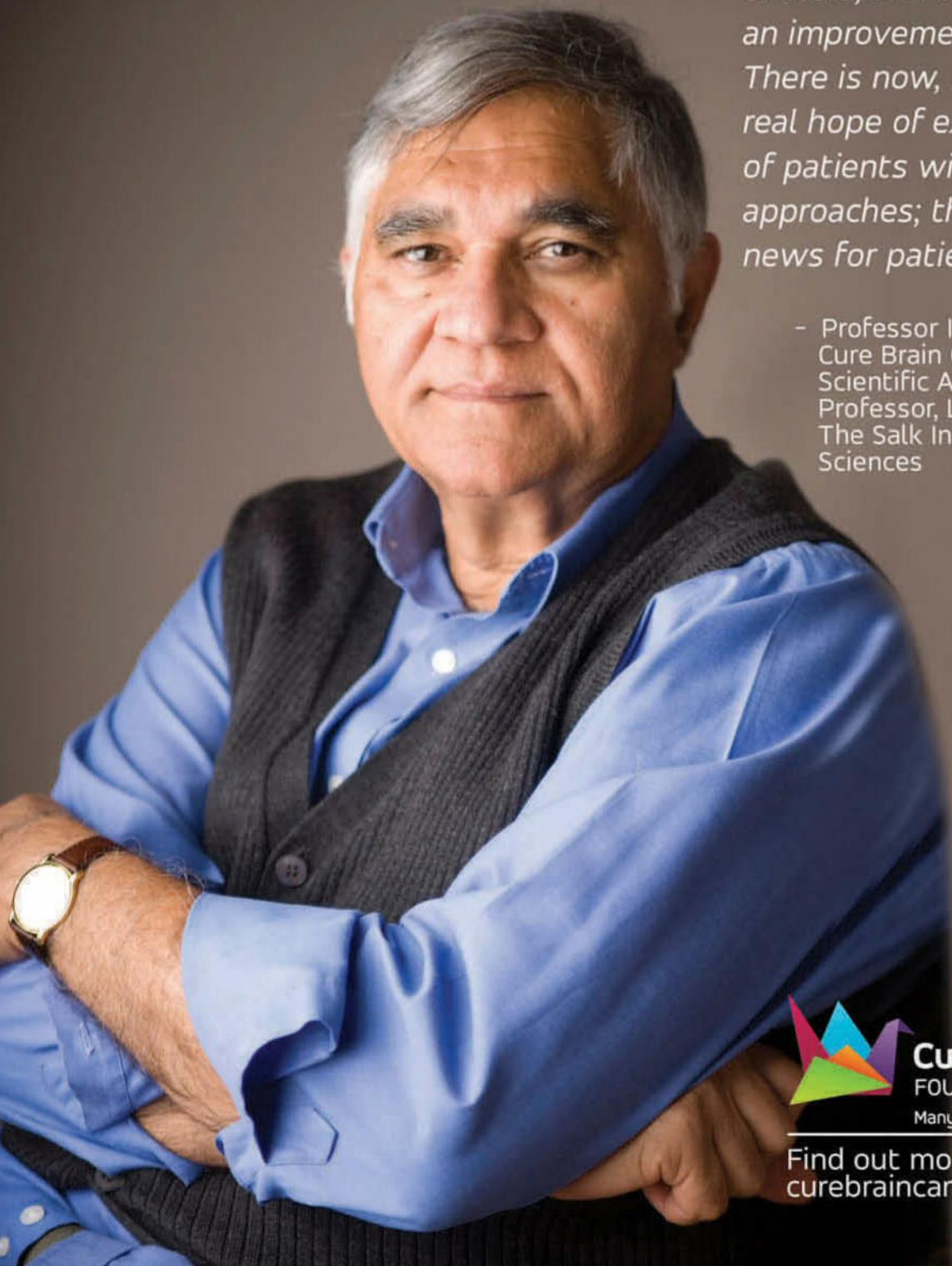
that people with adequate social connections were 1.5 times as likely to live to the end of the study period as lonely people – an effect on par with abstaining from smoking or excessive drinking. Another study, published in 2012, tracked the health of 2000 middle-aged and elderly US citizens. It found that those reporting the greatest feelings of loneliness were nearly twice as likely to die during the six-year study as those with the lowest levels of loneliness.

The work would seem to emphasise the importance of social support programmes for



LYNN WEDDE/MILLENNIAL IMAGES, UK

“...there is now real hope



‘Brain cancers are the deadliest cancers, and we’ve barely seen an improvement in 3 decades. There is now, for the first time, real hope of extending the life of patients with new therapeutic approaches; this is wonderful news for patients.’

- Professor Inder M. Verma, Ph.D,
Cure Brain Cancer Foundation
Scientific Advisory Committee,
Professor, Laboratory of Genetics,
The Salk Institute for Biological Sciences



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The yuck factor



DAVID LEVENE / EYEVINE

You know it when you feel it, but disgust affects you in surprisingly subtle ways, too, discovers Alison George

DAVID PIZARRO can change the way you think, and all he needs is a small vial of liquid. You simply have to smell it. The psychologist spent many weeks tracking down the perfect aroma. It had to be just right. "Not too powerful," he explains. "And it had to smell of real farts."

It's no joke. Pizarro needed a suitable fart spray for an experiment to investigate whether a whiff of something disgusting can influence people's judgements.

His experiment, together with a growing body of research, has revealed the profound power of disgust, showing that this emotion is a much more potent trigger for our behaviour and choices than we ever thought. The results play out in all sorts of unexpected areas, such as politics, the judicial system and our spending habits. The triggers also affect some people far more than others, and often without their knowledge. Disgust, once dubbed "the forgotten emotion of psychiatry", is showing its true colours.

Disgust is experienced by all humans, typically accompanied by a puckered-lipped facial expression. It is well established that it evolved to protect us from illness and death. "Before we had developed any theory of disease, disgust prevented us from contagion," says Pizarro, based at Cornell University in Ithaca, New York. The sense of revulsion makes us shy away from biologically harmful things like vomit, faeces, rotting meat and, to a certain extent, insects.

Disgust's remit broadened when we became a supersocial species. After all, other humans are all potential disease-carriers, says Valerie Curtis, director of the Hygiene Centre at the London School of Hygiene and Tropical Medicine. "We've got to be very careful about our contact with others; we've got to mitigate those disease-transfer risks," she says. Disgust is the mechanism for doing this – causing

us to shun people who violate the social conventions linked to disgust, or those we think, rightly or wrongly, are carriers of disease. As such, disgust is probably an essential characteristic for thriving on a cooperative, crowded planet.

Yet the idea that disgust plays a deeper role in people's everyday behaviour emerged only recently. It began when researchers decided to investigate the interplay between disgust and morality. One of the first was psychologist Jonathan Haidt at New York University, who in 2001 published a landmark paper proposing that instinctive gut feelings, rather than logical reasoning, govern our judgements of right and wrong.

Haidt and colleagues went on to demonstrate that a subliminal sense of disgust – induced by hypnosis – increased the severity of people's moral judgements about shoplifting or political bribery, for example. Since then, a number of studies have illustrated the unexpected ways in which disgust can influence our notions of right and wrong.

In 2008, Simone Schnall, now at the University of Cambridge, showed that placing people in a room with an unacknowledged aroma of fart spray and a filthy desk increased the severity of their moral judgements about, say, whether it's OK to eat your dead pet dog. "One would think that one makes decisions about whether a behaviour is right or wrong by considering the pros and cons and arriving at a balanced judgement. We showed this wasn't the case," says Schnall.

Perhaps it's no surprise, then, to find that the more "disgustable" you are, the more likely you are to be politically conservative, says Pizarro, who has studied this correlation. Similarly, the more conservative that people are, the harsher their moral judgements become in the presence of disgust stimuli.

Together, these findings raise all sorts of interesting, and troubling, questions about people's prejudices, and the ways in which they might be influenced or even deliberately

manipulated. Humanity already has a track record of using disgust as a weapon against "outsiders" – lower castes, immigrants and homosexuals. Nazi propaganda notoriously depicted Jewish people as filthy rats.

Now there is empirical evidence that inducing disgust can cause people to shun certain minority groups – at least temporarily. That's what Pizarro acquired his fart spray to explore. Along with Yoel Inbar at the University of Toronto, Canada, and colleagues, he primed a room with the foul-smelling spray, then invited people in to complete a questionnaire, asking them to rate their feelings of warmth towards various social groups, such as the elderly or homosexuals. The researchers didn't mention the pong to the participants, who were a mix of heterosexual male and female US college students.

Reeking of prejudice

While the whiff did not influence people's feelings towards many social groups, one effect was stark: those in the smelly room, on average, felt less warmth towards homosexual men compared to participants in a non-smelly room. The effect was of equal strength among political liberals and conservatives. This finding is consistent with previous studies showing that a stronger susceptibility to disgust is linked with disapproval of gay people.

In another experiment, making Western people feel more vulnerable to disease – by showing pictures of different pathogens – made them view foreign groups, such as Nigerian immigrants, less favourably.

"It's not that I think we could change liberals to conservatives by grossing them out, but sometimes all you need is a temporary little boost," says Pizarro. He points out that if there happen to be disgust triggers in or around a polling station, for example, it could in principle sway undecided voters to a more conservative decision. "Subtle influences in ➤



ALAIN NGUICHI/SYGMA/CORBIS

The politics of disgust:
“Fascism is like a stink
bomb”, the banner says

places where you’re voting might actually have an effect.”

To an extent, many politicians have already come to the same conclusions about disgust’s ability to sway the views of their electorates. In April 2012, Republicans made hay of a story about President Barack Obama eating dog meat as a boy, which was recounted in his memoir. The criticism of Obama might have seemed like the typical, if surreal, electioneering you would expect in the run-up to a presidential election, but the psychology of disgust suggests

it would have struck deeper with many voters than the Democrats might have realised.

Other politicians have gone further when employing disgust to win votes. Ahead of the primaries for the 2010 gubernatorial election in New York state, candidate Carl Paladino of the Tea Party sent out thousands of flyers impregnated with the smell of rotten garbage, with a message to “get rid of the stink” alongside pictures of his rivals. While Paladino didn’t manage to beat his Democrat opponent in the race to be governor, some political analysts believe his bold tactics and smelly flyers helped him thrash rivals to win the Republican nomination against the odds.

At the same time as the role that disgust

plays in politics was emerging, others were searching for its effects in yet more realms of life. Given that disgust influences judgements of right and wrong, it made sense to look to the legal system.

Sometimes disgust is arguably among the main reasons that a society chooses to deem an act illegal – necrophilia, some forms of pornography, or sex between men, for example. In court, disgusting crimes can attract harsher penalties. For example, in some US states, the death penalty is sought for murders with an “outrageously or wantonly vile” element.

Research led by Sophieke Russell, then at the University of Kent in Canterbury, UK, holds important lessons about how juries arrive at decisions of guilt and sentencing – and possible pointers for achieving genuine justice in courts. She showed that once people feel a sense of disgust, it is difficult for them to take into account mitigating factors important in the process of law, such as the intentions of the people involved in a case. Disgust also clouds a juror’s judgement more than feelings of anger.

It is for these reasons that philosopher Martha Nussbaum at the University of Chicago Law School has argued strongly to stop using the “politics of disgust” as a basis for legal judgements. She argues instead for John Stuart Mill’s principle of harm, whereby crimes are judged solely on the basis of the harm they cause. It is a contentious view. Others, such as Dan Kahan of Yale Law School, argue that “it would certainly be a mistake –

CHEESE AND CULTURE

On a summer’s day, a stench filled *New Scientist*’s London office. It smelled like sweaty feet bathed in vomit, or something long past its sell-by date.

Soon its source became clear: someone had returned from Paris with a selection of France’s finest soft cheeses. How can something that smells revolting be so delicious?

For a start, no matter how potent, smells can be ambiguous. We need more information to tell us whether something really is revolting or not.

“With smell, the meaning is based on context much more so than with vision,” says smell researcher Rachel Herz, author of the book *That’s Disgusting*. In other words, a vomit smell in an alley beside a bar will immediately conjure up a mental

picture of a disgusting source, but exactly the same aroma would evoke deliciousness in a fine restaurant, she says.

The stinky cheese also illustrates the power of culture over our minds. Westerners have learned that cheese is a good thing to eat – a badge of cultural distinction, even. This explains why rotten shark meat is a delicacy in Iceland, says Herz, and the liquor chicha, made from chewed and spat-out maize, a popular drink in parts of South America. Food choices mark out who is part of our group – hence the strong religious taboos about pork which have endured long past the time when consuming it carried a serious risk of food poisoning.

The influence of culture on disgust

isn’t limited to food. Kissing in public is seen as distasteful in India, whereas Brits are more revolted by mistreatment of animals. Christian participants in one study even experienced a sense of disgust when reading a passage from Richard Dawkins’s atheist manifesto *The God Delusion*. As Herz says: “To a large extent, what is disgusting or not is in the mind of the beholder.”

Many things probably transcend cultural influence, however. Using a selection of disgusting images, Valerie Curtis at the London School of Hygiene and Tropical Medicine discovered a universal disgust towards faeces, with vomit, pus, spit and a variety of insects following close behind in the revulsion stakes. Delicious, these are not.

Disgust affects women more at certain times in the menstrual cycle

a horrible one – to accept the guidance of disgust uncritically. But it would be just as big an error to discount it in all contexts.” Besides, disgust could never be eliminated from trials, because this would mean never exposing the jury to descriptions of crimes or pictures of crime scenes.

Beyond the courtroom, psychologists searching for disgust’s influence have found it in various everyday scenarios. Take financial transactions. It’s possible that a particularly unhygienic car dealer, for instance, could make a difference to the price for which you agree to sell your vehicle. Jennifer Lerner and colleagues at Carnegie Mellon University showed that a feeling of disgust can cause people to sell their property at knock-down prices. After watching a scene from the film *Trainspotting*, in which a character reaches into the bowl of an indescribably filthy toilet, they sold a pack of pens for an average of \$2.74, compared with a price of \$4.58 for participants shown a neutral clip of coral reefs. Curiously, the disgusted participants denied being influenced by the *Trainspotting* clip, and instead justified their actions with more rational reasons.

Lerner, now at Harvard, calls it the “disgust-disposal” effect, in which the yuck factor causes you to expel objects in close proximity, regardless of whether or not they are the cause of your disgust. She also found that people were less likely to buy something when feeling disgust. Perhaps this is why, aside from public health campaigns, there is little evidence of advertisers using disgust as part of their

JACK HOLLOWSWORTH/BLEND/AURORA



to encourage xenophobia or homophobia? “I think it’s very possible to override disgust. That’s my hope, in fact,” says Pizarro. “Even though we might have very strong disgust reactions, we should be tasked with coming up with reasons independent of this reflexive gut reaction.”

For those seeking to avoid disgust’s influence, it’s first worth noting that some

If they so choose, it is possible for anybody to become desensitised to disgusting things by continued exposure over time. For example, while faeces is the most potent disgust trigger, it’s amazing how easy it is to overcome it when you have to deal with your own offspring’s bowel movements. And psychologists have shown that after spending months dissecting bodies, medical students become less sensitive to disgust relating to death and bodily deformity.

Pizarro suspects that there may also be shortcuts to overriding disgust – even if the tips he has found so far may not be especially practical for day-to-day life. One of his experiments shows that if you can prevent people from making that snarled-lip expression when they experience disgust – by simply asking them to hold a pencil between their lips – you can reduce their feeling of disgust when they are made to view revolting images. This, in turn, makes their judgement of moral transgressions less severe.

Happily, our lives are already a triumph over disgust. If we let it rule us completely, we’d never leave the house in the morning. As Paul Rozin, often called the “father of the psychology of disgust”, has pointed out, we live in a world where the air we breathe comes from the lungs of other people, and contains molecules of animal and human faeces.

It would be wise not to think about that too much. It really is quite disgusting. ■

“Once jurors feel a sense of disgust, it is difficult for them to take into account mitigating factors important in a case, such as the intentions of those involved”

marketing strategies.

So, armed with all this knowledge about the psychology of disgust, is it possible to spot and overcome the subtle triggers that influence behaviour? And would we want to?

Some would argue that instead of trying to overcome our sense of disgust, we should listen to our gut feelings and be guided by them. The physician Leon Kass, who was chairman of George W. Bush’s bioethics council from 2001 to 2005, has made the case for the “wisdom of repugnance”. “Repugnance is the emotional expression of deep wisdom, beyond reason’s power to fully articulate it,” he wrote in his 2002 book *Life, Liberty and the Defense of Dignity*.

Still, is it really desirable for, say, bad smells

people are more likely to be grossed out than others, and that the triggers vary according to culture (see “Cheese and culture”, left). In general, women tend to be more easily disgusted than men, and are far more likely to be disgusted about sex. Women are also particularly sensitive to disgust in the early stages of pregnancy or just after ovulation – both times when their immune system is dampened.

The young are more likely to be influenced by the yuck factor, and we tend to become less easily disgusted as we grow old. This could boil down to the fact that our senses become less acute with age, or perhaps it is simply that older people have had more life experience and take a more rational view of potential threats.



Strange feelings

The list of human emotions just ballooned. **Jessica Griggs** explores the outer fringes of our feelings

CAN you name the six basic emotions? Take a straw poll of your friends and we guarantee that you will find no consensus. Yet psychologists are unequivocal: joy, sadness, anger, fear, surprise and disgust. These are the Big Six, quite literally, the in-your-face emotions – the ones that everyone the world over exhibits with the same dramatic and characteristic facial expressions. They have been the subjects of intense research for over half a century, not least because of the role they have played in our survival as a species.

Times have changed, though. Our ancestors may have had daily need of fear to flee predators, anger to conquer foes and disgust to avoid diseases, but we live in a more subtle world in which other emotions have come to the fore. There are many contenders. Avarice, embarrassment, boredom, depression, jealousy and love, for example, might epitomise the modern age. Yet some more obscure emotions may be increasingly relevant today. Here we explore five of them, any one of which could have a case to be promoted to a place alongside the Big Six.



ELEVATION THE UPLIFTING EMOTION

"Let it be said by our children's children that when we were tested we refused to let this journey end, that we did not turn back nor did we falter; and with eyes fixed on the horizon and God's grace upon us, we carried forth that great gift of freedom and delivered it safely to future generations."

In the midst of economic turmoil, President Barack Obama's inauguration speech in 2009 was powerful, inspiring stuff. Some of his supporters, hanging on his every word, will have had tears in their eyes, a tingling sensation on the back of their necks and a warm feeling in their chest as though it was opening up to let love and hope flood out. This feeling is what Jonathan Haidt at New York University has labelled "elevation".

Elevation seems to be a universal feeling. Although not yet studied in modern-day pre-literate societies, it has been documented in people from Japan, India, the US and the Palestinian territories. That puts it in the same league as the Big Six.

But to be considered as a basic emotion it should also have a purpose. If emotions are to fulfil their role as survival aids, they must motivate activities that help us thrive. So what is elevation for? Originally Haidt thought that it makes us nobler towards others. But when he asked volunteers to watch either an uplifting episode of *Oprah* or a non-uplifting scene from the sitcom *Seinfeld*, and then gave them a chance to help a stranger, there was no difference in behaviour between the two groups.

Haidt's next idea was born of the choked feelings that people often report when they describe experiencing elevation. This hints that the vagus nerve is involved because it is responsible for stimulating the throat and neck muscles. Activation of the vagus nerve is also linked to the release of a hormone called oxytocin, which generates warm, calm

feelings – just the sort associated with elevation. Could oxytocin be the key? The inspiration for how to test this idea came from his former student, Jennifer Silvers, who pointed out that oxytocin makes nursing mothers release milk.

So in a second round of experiments, Haidt and Silvers showed the same videos to breastfeeding mothers. They found that after watching *Oprah* mothers were more likely to leak milk into a nursing pad. They also spent more time nursing and hugging their babies than the mothers who watched the *Seinfeld* video. "Oxytocin doesn't make people go out and give money to charity, it doesn't make people help strangers jump-start their cars, it makes them want to touch, hug and be more open and trusting with each other," says Haidt.

So elevation has a physiological component and motivational one too. However, unlike the Big Six emotions, it does not have an obvious characteristic facial expression, which may explain why it has slipped under the research radar for so long. If you appreciate the context, you may be able to detect a slight softening of the features, says Haidt. Sometimes the eyebrows are raised as if the person is sad.

Elevation is also relatively rare. People typically experience it less than once a week, although there are wide individual differences. Where it does score, though, is in being highly significant. "If you ask people to remember their most cherished experiences of their whole life, elevatory moments are likely to feature in their top five," says Haidt. What's more, if we can harness elevation to build trust, it could have particular relevance in the modern world for strengthening or repairing personal relationships. Haidt envisages a time, for example, when marital therapists might try to induce it so as to enhance the effectiveness of couples' counselling sessions.

Elevation may be rare, but it is a memorable and significant emotion

ERIC BOUVET/WI NETWORK

INTEREST

THE CURIOUS EMOTION

Your head tilts to one side, your speech quickens and the muscles in your forehead and around your eyes contract as you become engrossed in mastering a bassoon sonata, understanding the thermodynamics of the universe, or perhaps just browsing your stamp collection. Interest may be trickier to pin down than fear or joy, but it nevertheless possesses one of the hallmarks of a basic emotion - its own facial expression. Since the 1960s when Paul Ekman pioneered the field, psychologists have looked for universal, characteristic facial expressions to help measure and classify emotions.

Interest also seems to have a purpose. Psychologist Paul Silvia at the University of North Carolina at Greensboro believes it motivates people to learn - not for money, not for an exam, but for its own sake, to increase their knowledge just because they want to.

This could explain why interest has come into its own in the modern world: it can be seen as a counterbalance to the fear and anxiety that surrounds unfamiliar experiences. Without interest we would shy away from new or complicated things because they tend to make us nervous. "This makes sense if we think in terms of evolutionary history, as unfamiliar situations could often be dangerous," says Silvia. "But in the modern world, it would be disastrous because we couldn't flourish intellectually."

Another strong argument for interest deserving a status boost is that it can go wrong. One criterion that some psychologists use to define a basic emotion is that it should have associated aberrations or pathologies. Excessive fear, for example, generates panic or chronic anxiety. Likewise, too much interest results in repetitive, consuming and compulsive behaviour.

So how does interest fare in the emotions league? As naturally curious creatures, we experience it daily and devote a lot of time and brainpower to things that interest us. That alone could make it a major emotional player. But the real power of interest, according to Silvia, lies in its ability to keep us engaged in our frenetic lives rather than becoming overwhelmed by information overload. That's also a reason for trying to understand what stimulates interest. "We have to find ways of helping people learn, to keep them from becoming anxious and tuning out in the face of this monstrous amount of information," he says.

GRATITUDE

THE RELATIONSHIP-BOOSTING EMOTION

Gratitude has a way to go before it satisfies the most stringent emotion criteria. The facial expression has yet to be identified, although it is easy to speculate what it might involve - a smile and a dip of the head, perhaps. Furthermore, studies have yet to be carried out in non-Western cultures. This could be important, as expressions of gratitude may be culturally ingrained. Expectations of which situations will generate gratitude certainly are: waiters in the US will stand at your elbow until you tip, for example, whereas in Japan they will chase you down the street to return the extra cash you left on the table.

Like all emotions worth their salt, though, gratitude motivates us to act: it makes us want to acknowledge and repay a kindness or thoughtful gesture. So gratitude might simply ensure a quid pro quo repayment mechanism, but there may be more to it than that. Sara Algoe of the University of North Carolina at Chapel Hill has found that gratitude makes cohabiting couples feel more connected. She reasons that truly thoughtful gestures help us find the individuals who really "get us". The grateful feeling is a signal that we should get to know them better as they are the ones likely to be there for us in the future.

So, once you are in a romantic relationship, feelings of gratitude serve as a little reminder of how great your partner is. Long term, Algoe says, gratitude is there to help promote a positive cycle of give and take, creating an upward spiral of satisfaction in the relationship (see "Friends with benefits", page 79).

If Algoe is correct, gratitude has big potential benefits in the modern world. High-quality relationships are good for our health, notes her colleague Barbara Fredrickson. She goes further in her book, *Positivity*, suggesting that by cultivating gratitude we might increase social harmony in groups, fostering lower employee turnover, more volunteering in communities, perhaps even less crime, less littering and less wasting of resources.



PETER DENCH/CORBIS

MEYER/TENDANCEFLOUÉ



Interest motivates us to learn just for the hell of it

PRIDE

THE EMOTION WITH TWO FACES

The conceited, arrogant feeling of pride has been called the deadliest of the seven deadly sins. Yet pride can also be noble. We all know the contented sense of achievement and self-worth that comes with having done well at something, whether it be achieving a promotion, building something, winning a race or figuring out a cryptic crossword clue. That's why Jessica Tracy at the University of British Columbia (UBC) in Vancouver, Canada, one of the few psychologists focused on pride, makes the distinction between what she calls "hubristic pride" and "authentic pride".

Pride may manifest itself in two different ways, but we cannot tell these

apart by their outward appearance, she says. Both types cause people to tilt their heads back, extend their arms from their body and try to look as large as possible. As Charles Darwin noted in his book *The Expression of Emotions in Man and Animals*, a proud person looks "swollen or puffed up". So there is a characteristic prideful look, but in contrast to the basic emotions, the face only plays a small role, with a slight smile creeping across it.

Pride also differs from the Big Six in being a "self-conscious" emotion. Like shame, guilt and embarrassment, it requires a sense of self and the ability to self-evaluate. "In order to experience pride," Tracy says, "I need to think about



Gratitude is not all about reciprocity, it helps in bonding too

who I am, who I want to be and how the event that's just happened reflects on me and my ambitions." Nevertheless, she believes there is a strong case for thinking of pride as a basic emotion. Her research suggests that the physical expression of pride is recognised in pre-literate, isolated tribes. She has even found it in people who were born blind, indicating that it is innate rather than learned.

So what is the point of pride, and why do we have two prides that feel different but look the same? In general, when people see pride expressed they associate it with high status. So pride motivates us to do well so that we gain respect. There are two distinct ways to do this, which

perhaps explains the flip sides of pride.

Status can take two forms, says anthropologist Joe Henrich, also at UBC. The first is based on dominance and commonly seen in non-human primates, whereby bigger and stronger individuals are revered because they could overwhelm or kill others. The human equivalents include the playground bully and the officious boss. The second kind of status is prestige. In this case, respect and power is gained through knowledge or skill. "This fits in with the two kinds of pride," says Tracy. "One is associated with aggression and overconfidence, while the other motivates achievement, hard work and altruistic behaviour."

"In a romantic relationship, the feeling of gratitude serves as a reminder of how great your partner is"

CONFUSION THE TIME-FOR- CHANGE EMOTION

It's a feeling we have all experienced, whether in a lecture theatre, an art gallery or wandering around an unfamiliar city, but confusion is tricky to describe. Dacher Keltner at the University of California, Berkeley, suggests that it is the "feeling that the environment is giving insufficient or contradictory information". But is confusion really an emotion?

For some psychologists, the idea is scandalous. Others describe confusion as the fringiest of the fringe. Nevertheless, Silvia thinks there is a good case to be made for considering confusion as a basic emotion, not least because it is so easy to spot. The brow furrows, the eyes narrow, the lip might even get bitten - you know confusion when you see it. In fact, one study found it was the second most recognisable everyday expression, only surpassed by joy.

What, then, is confusion for? It's a knowledge-based emotion, in the same "family" as interest and surprise, says Silvia. He believes it is our brain's way of telling us that the way we are thinking about things is not working, that our mental model of the world is flawed or inadequate. Sometimes this will make us withdraw, but it can also motivate us to shift our attention or change our learning strategy, he says.

A related idea is that a confused facial expression alerts others to help the confused person. If so, confusion serves to bring new knowledge and encourage social relationships, making it, perhaps, the perfect 21st-century emotion. ■



Confusion is one of the most recognisable emotions

THE SECRET OF SUCCESS

What does it take to succeed – and are we doing all we can as individuals and societies to help? Michael Bond reports

"**W**HILE we don't promise equal outcomes, we have strived to deliver equal opportunity – the idea that success... depends on effort and merit," President Obama said in a speech in December 2013. Yet as Obama went on to acknowledge, success in the US is now more dependent than ever on being born into wealth and privilege.

Over in the UK, the mayor of London, Boris Johnson – seen by some as a future prime minister – also addressed the issue of growing inequality, but his vision was rather different. Success is all about IQ, Johnson suggested, so all we can do is give the brightest kids the best chance to succeed.

These speeches raise all kinds of issues, but at their heart are two opposing ideas about what it takes to succeed. To some, it's all about nature, that success is determined by genes. To others, it's all about nurture – just about anyone can succeed given a chance. So which of these ideas is closer to reality?

The truth, needless to say, is more complex. The genes people inherit matter, but so does their environment. Even IQ, which has been claimed to measure innate intelligence, can be changed by a person's upbringing. This means that there are plenty of things that can be done to make people more successful – but are governments, schools and parents doing the right things?

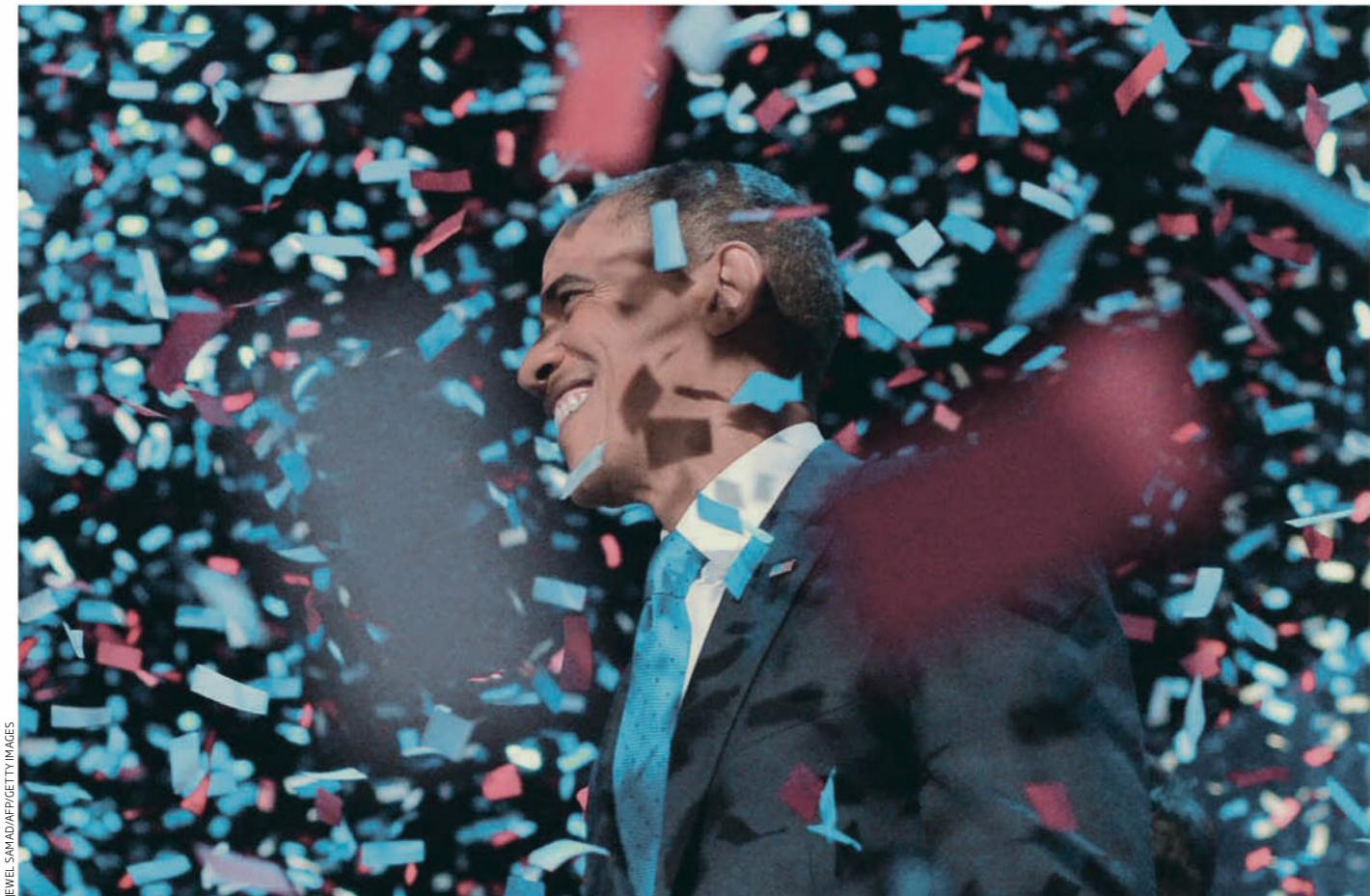
The debate about success has been fuelled by a twin study led by Robert Plomin of King's College London, which found that differences in children's academic performances in UK schools owe more to heritable traits than to

teaching or other environmental factors. This result should not be too surprising, given that there is little doubt that intelligence depends in a large part on our genes, and that smart kids usually do better in school.

But the results do not mean that teaching does not matter. That's like arguing that because differences in height are mostly down to genes, food does not affect height in well-fed children. In fact, says Plomin, the large role of genes could be seen as a good thing because the more equal the environment, the more genes – as opposed to parental wealth, say – matter. Nor, he says, does it follow from his findings that we should pour resources into a small elite.

For one thing, children with the highest IQs aren't necessarily the greatest achievers in later life. In the 1920s, Lewis Terman, a psychologist at Stanford University, recruited 1528 children in California who had scored very highly on the Stanford-Binet IQ test. Like

"Intellect and achievement are far from perfectly correlated"



JEWEL SAMAD/AFP/GETTY IMAGES

Obama is far from happy
about falling social mobility

Johnson, Terman was convinced that IQ was the key to success in later life, defined in terms of earnings and achievements (success could also be measured in terms of, say, happiness, but this article will focus on the narrower, materialistic definitions).

He was right up to a point: by the middle of their lives, his "Termite" had published around 2000 research papers and articles, won at least 230 patents and written 33 novels and 375 short stories and plays. Their median income was around three times that of the US as a whole.

But this is not quite as impressive as it sounds. Even though the median IQ of Terman's subjects was 147, around a quarter ended up in less prestigious jobs, becoming clerical workers, police officers, salesmen or craftsmen. None of the group matched the academic output of Nobel laureates or others among the nation's intellectual elite at the time. Indeed, by focusing on IQ scores,

Terman excluded children such as Luis Alvarez and William Shockley, both of whom went on to win the Nobel prize in physics.

What's more, none of the Termite went on to found leading businesses, so they were not great "wealth creators" – one of the arguments for favouring an elite is that they will create wealth for a country. Instead, after 25 years Terman had to acknowledge that "intellect and achievement are far from perfectly correlated".

Genes versus environment

While intelligence clearly matters, then, by itself it is no guarantee of success. There is also overwhelming evidence of the importance of environmental factors, particularly those related to socio-economic status. Children who grow up in poor areas with limited access to computers and books, and who may also have little routine and little parental attention, not only have worse health but are also more

likely to do badly at school. This makes it far harder for them to flourish in adulthood.

By contrast, many successful entrepreneurs, leaders and artistic high achievers grow up in stimulating homes surrounded by a diversity of books, and are party to inspiring mealtime conversations.

Children whose parents split up or who grow up in emotionally unstable homes also start out at a disadvantage, regardless of their social background. They tend to be more badly behaved and underperform at school.

Edward Melhuish at the University of Oxford, who studies child development, warns that children under 5 who don't receive consistent affection and responsive communication from their parents or caregivers have impaired social and emotional development. Crucially, this affects their language skills, which Melhuish says is a major reason why children from disadvantaged families generally do poorly ➤

HOW TO RAISE SUCCESSFUL KIDS

What can parents do to ensure their child gets the best chance to fulfil their potential? This is far from straightforward, since it won't be immediately apparent where a child's strengths and talents lie. Instead, the best approach is to encourage whatever inclinations and interests they show.

This means not just allowing them to pursue directions that would not be the parents' first choice, like becoming a poet rather than a physician, says Dean Keith Simonton of the University of California, Davis, but encouraging them and recognising that some investments may not pan out. "After spending all that money on ice hockey gear, finding your kid drops out in the first year - ouch!"

Even if children don't end up pursuing a particular subject, sport or instrument, attaining proficiency in one domain helps them understand how to build long-lasting skills in others. Perhaps the best advice of all is for parents to teach their children what Carol Dweck of Stanford University calls a "growth mindset" - the belief that abilities can be developed through dedication and practice and aren't fixed by biology (see main story). She counsels parents to praise effort and progress, not intelligence and talent. The former will encourage them to keep trying; the latter will make them want to give up at the first scent of failure.

at school. "Improved language development helps boost cognitive development, literacy and educational attainment as well as social skills," he says.

The effects of the environment, in other words, are profound. An impoverished upbringing can dent a child's cognitive ability by as much as nine IQ points. By contrast, a privileged background can boost IQ. Adopted children born into poverty but brought up in well-off households have shown big gains in IQ compared with their non-adopted siblings.

These findings have clear implications. To help all children reach their potential, it's not enough to wait until they start school - by then it may already be too late. What's needed, says Melhuish, are high-quality "early education centres" that combine childcare, parenting support, healthcare and learning in one place, an intervention that has already proved beneficial to children from all

backgrounds, and to disadvantaged children most of all.

The importance of early intervention is now widely recognised, and has led to child development initiatives such as Sure Start in the UK and Head Start in the US. President Obama is seeking cross-party support for his plans to expand access to pre-kindergarten education. "Research shows that one of the best investments we can make in a child's life is high-quality early education," Obama said last year. In the UK, however, funding for the Sure Start initiative has been cut by a third in the past five years.

There is more to success, though, than innate potential and growing up in an environment that helps you realise that potential. "Cognitive ability and intelligence do not seem to predict individual differences in performance among skilled expert performers," says psychologist K. Anders Ericsson at Florida State University in Tallahassee. He and others argue that the accomplishments of elite performers in many fields, including music and sports but also chess and others involving memory, owe far more to focused practice than to innate talent.

Why do some people practise more than others? Early on, perhaps because of pushy parents. But certain factors appear essential for anyone plotting a path to the top. For instance, you won't get far without the ability to persevere and stay committed to far-off goals, or "grit". "Grittier individuals are more successful than others, particularly in very challenging situations," says Angela Duckworth at the University of Pennsylvania in Philadelphia.

What makes people gritty? Part of the answer is motivation. Duckworth has shown that people score higher on IQ tests when they are given an incentive, such as a small financial reward. This finding has major implications for the study of success. Psychologists, economists and social scientists often point to the association between IQ scores and attainment in life as evidence that success depends largely on intelligence. Yet Duckworth's work suggests that IQ tests measure more than intelligence - and that motivation is a potent asset.

"Adopted children born into poverty but brought up by well-off families have shown big gains in IQ"



MOLLY RILEY/UP/VEIN



Grit demands something else as well: the willpower to see something through to the end. It involves hard work, and the resisting of distracting desires and impulses. Willpower is largely about having self-control, which makes it relevant to the pursuit of achievement in two important ways.

First, self-control – like intelligence – has lifelong benefits. It is a better predictor of exam results among adolescents than IQ scores. Students with more self-control are more likely to turn up to school on time, do their homework and watch less television, Duckworth has found, all of which translated into better grades. A more recent study, which followed 1000 children in New Zealand from birth to 32 years old, found that those who exhibited greater self-control in childhood grew into healthier, more emotionally stable adults. They were also better off financially.

Self-control

This mirrors a famous observation by the psychologist Walter Mischel, now at Columbia University in New York City. In the late 1960s, Mischel offered young children a choice between eating one treat immediately, or holding off for 15 minutes and getting two. Years later, Mischel discovered that the children who had managed to wait did better at high school than those who had succumbed to temptation. As adults, those able to delay gratification were also more popular with their peers, less likely to be overweight and earned higher salaries.

The second important thing about self-control is that it can be improved. Roy Baumeister at Florida State University in Tallahassee likens it to a muscle that can be strengthened with exercise. His team has found that exercising self-control in one area of life will improve it in all. His team has also noticed that some people improve more than others, possibly because they have more self-control to start with and so are better at committing to the exercises. “It’s a circular process, which is all the more reason why parents should give priority early in their child’s life to promoting willpower,” says Baumeister.

Self-control is also key to focused practice – which is necessary for the development of any skill – since deliberate practice is about pushing yourself to do the most difficult things, rather than just going through the motions, he says.

Knowing that we can improve our willpower and become grittier in the face of obstacles



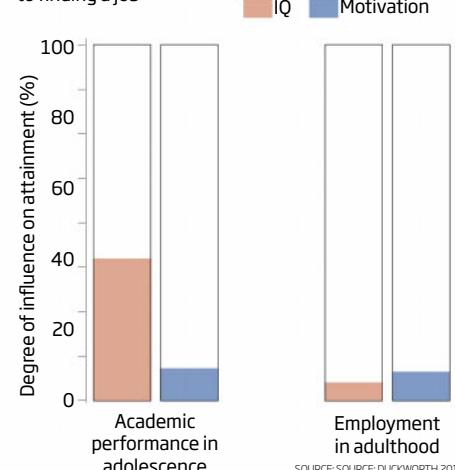
Practice makes perfect even for the musically gifted. Whatever the career true grit is the key (see left)

should make us more optimistic about what we are capable of. Unfortunately, we are often held back by our own beliefs about ourselves and our capacity for change. Developmental psychologists have shown that having a fixed mindset – viewing attributes such as intelligence and personality as set in stone – causes people to fear failure, react badly to criticism and avoid new or difficult assignments, hardly a recipe for success. The belief that your traits are malleable, on the other hand, makes you more willing to stretch yourself and learn new skills.

Over the last decade, a team led by Carol Dweck at Stanford University has improved the grades and attendance records of thousands of school and college students ➤

Motivation matters

IQ plays a big role in academic performance but motivation matters too, especially when it comes to finding a job



SOURCE: SOURCE: DUCKWORTH 2011

across the US simply by teaching them that intelligence isn't fixed, that hard work can make you smarter, and that struggling to adjust to college is a normal learning process and not a sign of poor intellect. A "growth" mindset is advantageous at all stages of life, says Dweck. "It allows you to take on more challenges, and you don't get discouraged by setbacks or find effort undermining."

The dangers of a fixed mindset are particularly acute for members of groups about which society holds negative stereotypes, such as African Americans or women, who may inadvertently conform to the stereotypes. While social attitudes are hard to change, changing mindsets is comparatively easy. Dweck's team has helped to improve African American high-school leavers' performance in college simply by encouraging a growth mindset.

The research on willpower and mindset suggests that we have some influence over the cards we are dealt at birth. However, it would be erroneous to cast this as a triumph of nurture over nature. "There is a genetic contribution to individual differences in virtually every psychological trait you can measure, including personality traits and cognitive abilities," says Scott Barry Kaufman, who studies intelligence and creativity at the University of Pennsylvania. Nonetheless, he adds, all traits need to be developed (see "How to raise successful kids", page 116). "The environment, and life decisions on the part of the individual, are crucial in enabling that development," he says.

Ericsson argues that in most cases a person can attain expertise in any domain provided

An impoverished upbringing lowers children's IQ scores



ALEX WEBB/MAGNUM

they practise long enough in the right way. But quicker learners – those with more talent – will always outcompete slower ones, says Dean Keith Simonton of the University of California, Davis. "Sure, I might be able to become a violin virtuoso if I just practised hard enough for long enough, but if it's not until I'm 50 years old that I'm ready to audition for a second chair position in a regional orchestra, what's the point?"

Dreams matter

And not only are some people more talented than others, but people also have talents in different areas. Yet if all children are taught the same things in the same way, only some will have a chance to excel. The UK's one-size-fits-all school system, with a national curriculum intended to minimise inequalities of opportunity, may inadvertently be favouring a subset of children. Almost all the psychologists and development experts contacted by *New Scientist* favour a school system that caters for a broader range of talents and interests, and focuses less on measures and targets.

"Not every student is the same, so multiple options are needed," says Ericsson. Think of it this way: the more niches there are in a garden – sunny, shady, damp and so on – the wider the range of plants that can thrive there.

Schools should encourage deep, personal learning in more narrow subject areas, and let children develop at their own rate, says Kaufman. Plenty of people bloom late, particularly in the arts and sciences, which

demand a range of social and cognitive skills, he says. "It might take someone a long time to overcome some hurdles, and then eventually they break through to greatness."

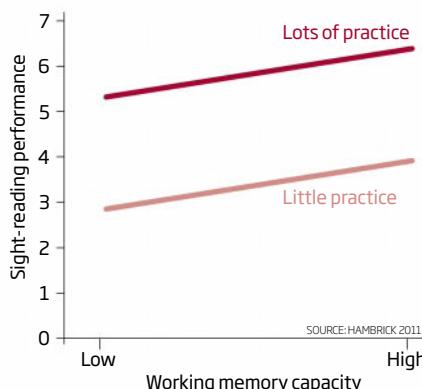
What doesn't help, say the experts, is introducing yet more standardised tests, as the UK is doing. While the US system is less centralised, it, too, is dominated by standardised testing. "Listen to children's dreams, and encourage them, no matter their test scores or prior background. Reward effort and the process, not the standardised academic outcome," Kaufman advises.

Encourage dreaming? That may not seem like a recipe for success to some, but it is perhaps the most important factor of all. US psychologist Ellis Paul Torrance followed the lives of several hundred creative high-achievers from high school into middle age, among them academics, writers, inventors, teachers, consultants, business executives and a songwriter. He noticed that it wasn't scholastic or technical abilities or achievements at school that set them apart, but characteristics such as having a sense of purpose, the courage to be creative, delighting in deep thinking and feeling comfortable in a minority of one. Most important of all, he thought, was to "fall in love with a dream", preferably at a young age, and then pursue it with intensity.

Torrance called his group of high-flyers "beyonders". He reckoned their accomplishments went beyond anything that standard quantitative tests could have predicted – and beyond anyone's wildest dreams but their own. ■

Talent versus work

Practice matters more than innate ability for sight-reading music, but people with better working memory outperform others if they practise



What's your Superpower?



No matter what your age, you may still discover a hidden talent if you just take a systematic approach, finds Catherine de Lange

GOSH, you're good, you're really good." Finally, the words I've been hoping to hear for months. I look down at my fingers, still doubtful of my own abilities. Perhaps it was a fluke. I move on to the next test, and when I'm done the researcher is equally agitated. "My God, it's a record," she says, "how are you that good?"

By the time we reach adulthood, we think we know where our strengths and weaknesses lie, but if you are anything like me, you will probably have wondered whether you possess a hitherto undiscovered talent. Pursuing my urge to find out has taken several months and batteries of tests exploring my mental, physical, emotional and sensory abilities. And now, finally, I've found what I've been searching for.

This is not just a personal victory. It also validates the idea that science can help reveal talents we didn't know we had, allowing us to make better career and leisure choices and increasing our confidence in our abilities. You don't even need a lab or specialist equipment to tap into much of this knowledge: on my journey I have found a whole range of tests that anyone can do. Try them online at <http://bit.ly/ZGql13>, and you could discover untapped abilities in a range of areas, from sporting prowess and leadership potential to risk assessment and, my own personal strength, the mysterious "interoception".

Prodigious talent

My quest was inspired by a recent study by psychologist Joanne Ruthsatz of Ohio State University at Mansfield, and violin virtuoso Jourdan Urbach. To investigate the biology of prodigiousness, they tested the cognitive and developmental profiles of eight children whose exceptional talents included music, cooking, art and language. There has been much debate about what underpins prodigy. Some argue that high general intelligence is the key, others emphasise environmental factors such as practice, or a combination of both. But Ruthsatz and Urbach found that just one trait connected all eight children – exceptional working memory.

Working memory is the ability to retain information and manipulate it at the same time – you use it when multiplying two double-digit numbers in your head, for instance. People with a good working memory have more "space" to carry out such mental manipulations, which might help explain its abundance in child prodigies. But what about the rest of us? Might some ordinary people unknowingly possess this talent of talents? Might I?

There is a fast-and-dirty way to see how your working memory measures up, says cognitive psychologist Susan Gathercole at the University of Cambridge. Ask a friend to read out a list of random numerals, one every second. Start with a string of three. Remember the ➤

Supertaster

In the next phase of my quest I find myself sitting in a sterile white room at a table covered with a daunting array of jars and cups. I have come here curious to know whether I might have what it takes to do one of my fantasy jobs – food critic. Food and flavour research company MMR, based at the University of Reading, UK, has agreed to put me through the tests it uses to select food tasters for R&D of new products. According to Christine Barnagaud, one of its lead flavour scientists, only about a tenth of the population would make it through the screening process. Am I one of them?

A good sense of smell is a vital part of being a professional taster, so first I sniff my way through a series of jars stuffed with odour-infused cotton wool, and say what I think they

"SUPERTASTERS HAVE MORE THAN 50 TASTE BUDS IN AN AREA THE SIZE OF A HOLE-PUNCHER CIRCLE. THE AVERAGE PERSON HAS 20"

numbers, then repeat them back in reverse order. If you can manage three, try four, then five and so on. An average 30-year-old should be able to achieve five or six, a 40-year-old about five, and a 50-year-old about four.

Gathercole also pointed me towards a series of working memory tests devised by Cambridge Brain Sciences.

My results are disappointingly mediocre. But I also discover there are things I can do to improve. Despite a strong genetic component, evidence is mounting that working memory can be increased using computerised training programs and some mainstream computer games. Even upping my intake of omega-3 fish oils might help. So perhaps I still have a chance of becoming a concert pianist or world-class chef.

Born to run?

Discovering that working memory is not my forte only makes me want to find out more, so I turn my attention from mental gymnastics to something more physical. In the London 2012 Olympics, Helen Glover brought home Great Britain's first-ever gold medal in women's rowing. Just four years earlier, she was a schoolteacher and had never set foot in a rowing boat. If she can do it, what about the rest of us?

To find out whether I have a latent sporting talent, I visit sports physiologist Chris Easton at Kingston University in London. I am training for a half-marathon, so I want to know whether I have an aptitude for endurance running. He identifies muscle composition as the key. Type two, or fast-twitch, muscles are powerful but tire easily, perfect for power sports like sprinting or weightlifting, whereas type one, slow-twitch, are better for endurance running. "The evidence is quite strong that you cannot change muscle fibre type," says Easton. "If you have 90 per cent type-two muscle fibres, you can train hard but you are unlikely to ever get a sub-3-hours marathon."

Muscle composition is normally assessed using invasive biopsies, but there are simple alternatives that anyone can try. A good test of fast-twitch muscle fibres is the vertical jump test, which entails jumping as high as you can from a standing position and then measuring the difference between your jump reach and your reach at full standing stretch. A very good score is 65 centimetres for a man and

50 centimetres for a woman. To test for slow-twitch fibres, simply get into a sitting squat position with your back resting against a wall and hold it for as long as you can. "If you can maintain that contraction for longer than 30 seconds, then the chances are you have a high percentage of those fatigue-resistant type-one fibres," says Easton. It's a crude prediction, but for me, the tests are unequivocal: my jump height is pathetic, but when it comes to holding the squat position, I am still going strong after several minutes. That's good news for my half-marathon.

Next comes the classic of the sports-science laboratory – the VO₂ max test. This measures the maximum volume of oxygen the body can use in a minute, which is a predictor of endurance potential. It can be improved somewhat with training, but we all have a genetically predetermined ceiling. The test is particularly unpleasant. It involves wearing a mask, which analyses my breath composition while I run on a treadmill at ever-increasing speeds. Looking at my score, Easton suggests I didn't push myself hard enough. However, my body fat percentage and BMI indicate a good level of fitness for long-distance running. But just as I'm starting to feel smug, I receive a decisive blow. A simple blood test reveals that I have below-average levels of red blood cells and haemoglobin, affecting the amount of oxygen my blood can carry. Despite all the positive signs, train as I may, I will never be a top-class marathoner.



are. Next, I am instructed to take sips from a set of cups and write down the flavours they contain. In other tests, I try to distinguish between the basic tastes: bitter, sweet, salty, sour and umami. A quarter of the population would fail this test because they have a variation in their PTC gene that impairs their ability to taste bitter food. If a strong espresso tastes bland to you, chances are you are “bitter blind”. The hardest test involves identifying several tastes in the same liquid. (Go online for instructions on how to try all of these tests yourself.) Overall, Barnagaud is impressed with my performance: I got 65 per cent of the answers right, around the benchmark for being taken on for further training.

“Very generally, there is a correlation that the more taste buds you have, the more

sensitive you are,” Barnagaud says. You can find out how you measure up by swabbing your tongue with blue food dye and counting the pink bumps. The average person has about 20 in an area the size of a hole-puncher circle, though the number varies widely: so-called “supertasters” have 50 or more. Paradoxically, they would be disqualified from becoming professional food tasters as they may find foods such as rocket, broccoli and chilli taste overwhelmingly strong. Whatever your starting point, you can tune your taste buds simply by exposing them to more flavours. Smelling different products, such as herbs, and putting names to them even for just a few minutes a day, can help improve your sense of taste. I will need these techniques if I am going to cultivate my palate for that dream job.



Natural-born leader

In my everyday life I don't have many opportunities to take a leadership role, but I've always thought I would make a rather good boss. To discover whether I am deluding myself, I visit Mark van Vugt and his team at VU University in Amsterdam, the Netherlands. He takes an evolutionary perspective on leadership, arguing that our early ancestors, who lived in small groups and faced high threat levels, would have needed effective leaders to survive. As a result, he says, we are evolved to look for certain characteristics in leaders, and his group is identifying these.

Some leadership traits are physical, the most important being height. Former team member Nancy Blaker found that for both sexes, taller individuals are considered more “leader-like”. Why? Because we associate stature with various qualities a good leader should have. “Tall males are seen as more dominant, more healthy and vigorous and also more intelligent,” she says. “For females the only thing is that they are seen as more intelligent.” To qualify as “tall” you must be at least 10 centimetres above the average for your same-sex peers, which unfortunately means that at 170 centimetres I don't make the grade.

My youthful looks, on the other hand, may be a boon – in certain situations. Two other former team members, Allen Grabo and Brian Spisak, have found that we prefer younger-looking leaders to see us through change and more mature faces during times of stability. Their studies also show that when cooperation is needed, we pick leaders from ➤



SAM FALCONER

both sexes with more feminine features, but during conflict we prefer leaders with more masculine faces. "Someone who has a much more masculine-looking face is more likely to behave aggressively," says Grabo, "and is probably going to do better at defending the group."

How masculine or feminine you look partly depends on how much testosterone you were exposed to in the womb. A 2003 study by John Manning, now at Northumbria University in Newcastle upon Tyne, UK, suggested that you could assess this exposure by calculating the ratio of lengths of your index and ring fingers, a low ratio indicating high testosterone exposure. This conclusion has been called into question recently, but a mass of studies show that the ratio is stably linked to a variety of traits. Leander van der Meij found, for example, that men with a low ratio had more aggressive, dominant personalities. He suspects their leadership style would tend to be more autocratic and less participatory than those of leaders with a higher ratio. My own digit ratio is extremely low – off the scale for "normal" women – which he suggests could contribute to my having a "male, competitive brain". It might also steer my leadership style towards the unappealingly autocratic.

"*MY OWN FINGER-LENGTH RATIO IS OFF THE SCALE FOR 'NORMAL' WOMEN – WHICH COULD INDICATE I HAVE A 'MALE, COMPETITIVE BRAIN'*"



Stick or twist?

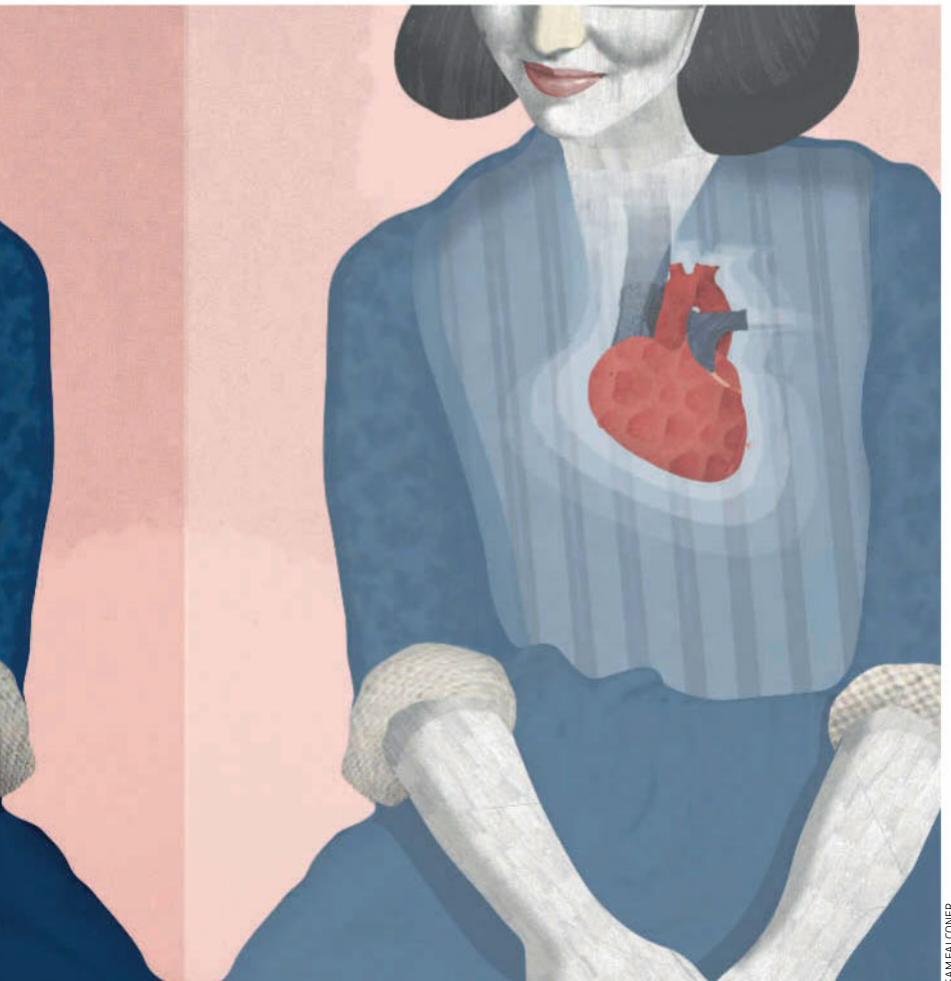
Half a century of research on judgement and decision-making has shown that most people, most of the time, are pretty hopeless at weighing up risky choices. However, a few individuals are able to overcome their subconscious biases and make good decisions in difficult circumstances. I have no ambitions to be a gambler, test pilot or explorer, but this would be a very useful talent to possess in everyday life. It turns out there are a couple of ways to find out whether I do.

The Berlin numeracy test comprises a series of probability-based puzzles that assess "risk literacy", the ability to accurately interpret and act on information about risk. I find it tough, but my results are surprisingly good. "Relative to the general population, you are among the most statistically literate in the world," says the online results page. It's a good start, but this feels like a mathematics test rather than an exploration of whether or not I should trust my instincts. Even the man who devised it, Edward Cokely at Michigan Technological University in Houghton, agrees that risk literacy is not just about calculating the odds –

as often as not, we lack enough information to do that – so a key related skill is knowing how confident we should be in our judgements.

This is where the second test comes in. It asks me to decide whether various statements are true or false, and to rate my confidence in my answers. My score does not depend on being right or wrong, but on my ability to understand my limitations – or as the test's inventor, Dylan Evans, would put it, how "risk intelligent" I am. Evans, author of *Risk Intelligence: How to live with uncertainty*, says it measures how good people are at predicting whether an uncertain outcome is likely to happen.

If, like mine, your results are not stellar, you can still work on your risk intelligence. Evans reckons the reason some people are particularly good at assessing risk is because they get the right kind of feedback each time they take a chance on something. "A bit like adjusting your aim with each throw to get a dart in the bullseye, getting feedback about your accuracy can help to improve your risk intelligence," he says. Provided you learn from your mistakes, that is.



SAM FALCONER



"**PEOPLE WITH THE ABILITY TO TUNE IN TO SIGNALS FROM THEIR OWN BODY ARE MORE EMOTIONALLY SENSITIVE AND EMPATHIC"**

Sixth sense

Still in search of a superpower I didn't know I had, I decide to explore a potential talent that has intrigued me since I first read about it in *New Scientist*. Interoception is the ability to tune in to signals from your own body, and is measured by how accurately you can count your heartbeat without taking a pulse.

This might sound like a strange skill to have, but it is increasingly being linked to a range of useful cognitive and behavioural traits. For example, people with high interoceptive sensitivity are more intuitive, suggesting that "gut feelings" stem from subconscious body signals. Such people can sense dangers that are "masked" from consciousness. They are also better at remembering emotional information and have richer emotional lives, which may stem from the fact that internal body signals are detected in the brain's insular cortex, a region also responsible for emotional processing. In addition, these people are more emotionally sensitive and empathic, and have

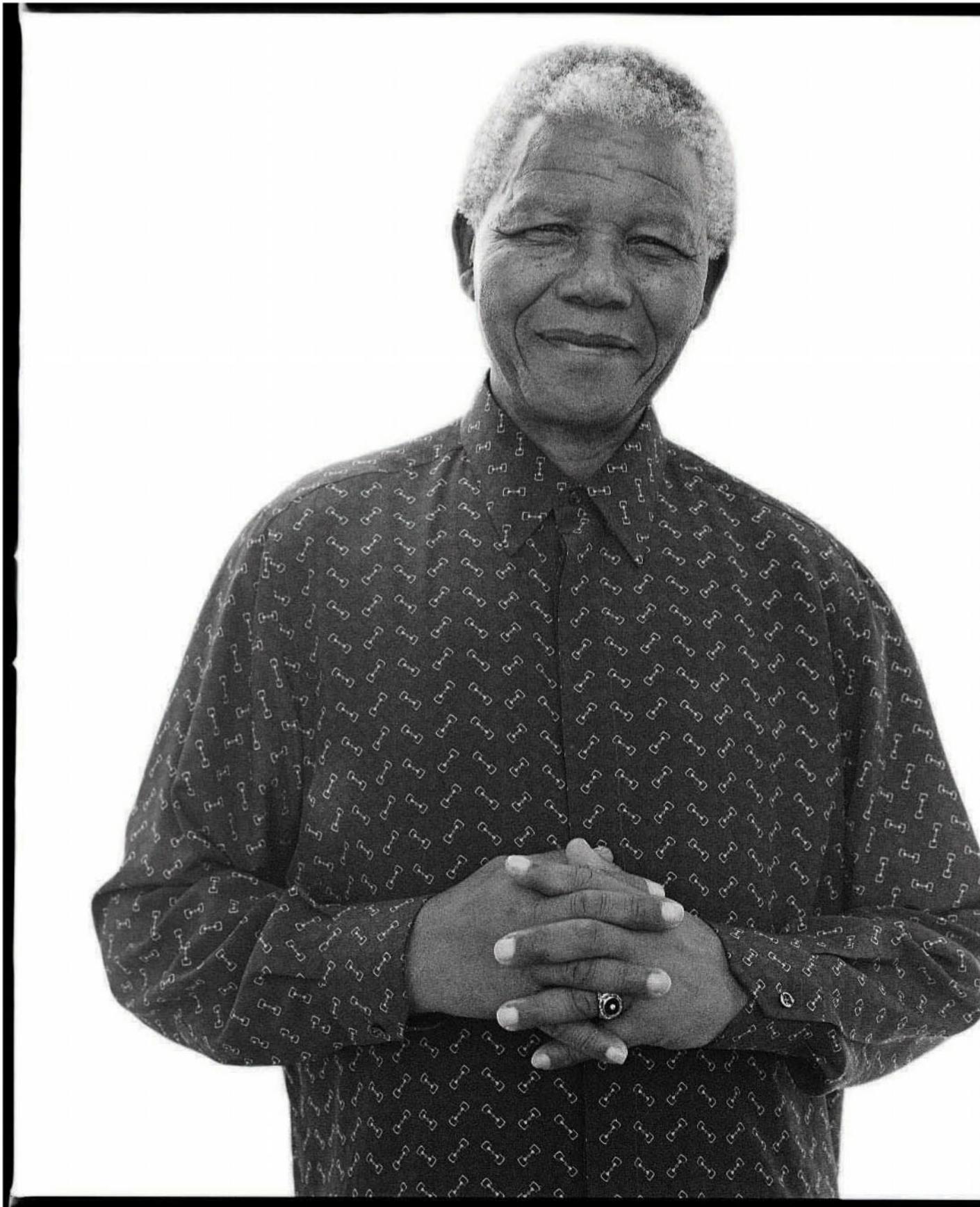
been shown to get less anxious when speaking in public.

Keen to explore my own interoceptive abilities, I visit the Sackler Centre for Consciousness Science at the University of Sussex, UK, to meet Hugo Critchley and Sarah Garfinkel. First, Garfinkel asks me to assess how many times my heart has beaten in a given period, while monitoring my actual heart rate. I do well. Only about a quarter of the population can assess their heart rate with an accuracy of 80 per cent or more, which is what I have achieved.

Individual differences in interoceptive sensitivity seem to be fairly fixed, although sensitivity declines with age. However, Garfinkel and Critchley believe training can lead to improvement. Associating heartbeats or other internal bodily signals with external sensations seems to be a useful intermediate step. Garfinkel suggests concentrating your awareness on one area of the body at a time to find out where you are most sensitive to your pulse. For me, it's my fingertips. Garfinkel, after some practice, can feel her heartbeat pulsing in her head. There is potential therapeutic value in training people to be more aware of their internal body states, not least because low interoceptive sensitivity has been linked with depression.

One of the methods they use at the Sackler Centre to help increase interoception is autonomic biofeedback. Soon I am wired up to a device that measures skin conductance, and challenged to manipulate an on-screen cartoon caterpillar using an unusual controller – my bodily state. With the hardware reading my physiological arousal levels, the more relaxation I achieve, the more the caterpillar will move to the right, towards the finishing line. If I am anxious, it will move towards the left. To complete the game you need to be in tune with your body, but even if your interoceptive sensitivity is low, the game itself helps you. "People who are not very good at knowing what body state is a relaxed state can use the external cue of the caterpillar to help them understand their body better," says Garfinkel. As a result, the game can actually help people learn to relax.

As for me, my performance suggests I'm a natural. "I can't believe it. That was amazing," Garfield says as my grub crosses the finishing line in 20 seconds flat. Some people fail to complete the task in the maximum 3 minutes allowed. "It's very unusual to be that good," she adds. "You've found a new skill." At last! I have discovered my hidden talent – I'm a world-class caterpillar herder. ■



JILLIAN EDELSSTEIN/CAMERA PRESS

Charm school

Charisma is not just something you're born with – it can be learned and lost, finds **Emma Young**

NELSON MANDELA had it. Richard Branson has it. Aung San Suu Kyi has it in her own quiet way. Steve Jobs had it, although he used tricks to enhance it. Barack Obama has it – or at least he used to. Charisma is one of our most prized personal qualities. But what exactly is it? Are you born with it, or can you learn it? Why are we such suckers for it? And, most importantly – for US president Obama at least – can you lose it?

Although we know it when we see it, charisma is a rather slippery concept. To the ancient Greeks, it was *ethos*, meaning persuasive appeal. Japanese playwright Zeami, a contemporary of Geoffrey Chaucer, called it *hana*, the highest level of which he called the “flower of peerless charm”. In dictionaries, it still carries magical connotations as a “divinely conferred power or talent” that makes one individual capable of influencing or inspiring others.

Modern-day psychologists cannot agree on a definition, but they are starting to understand what charisma is and just how far it can get you. The good news for anyone who aspires to revolutionise a nation or just hold dinner-party guests in thrall is that some aspects of charisma can be learned. Perhaps this should make us question the value we place on this most alluring of personal qualities.

In our media-saturated, globally connected, 24/7 world, charisma is more important than ever, particularly for anyone in the spotlight. Actors have to be charismatic or they will struggle to find roles, says Joseph Roach, a theatre historian at Yale University who has written a book on charisma called *It*.

Being perceived as charismatic is crucial for leaders too, says Michael Morris of Columbia Business School in New York. And it is not just world leaders who benefit. Charisma is an important tool for uniting a group and raising expectations, so it can be invaluable for anyone who has to lead a team or convince

others of a new idea. “It’s not necessary to be charismatic to be a good manager, but it is very useful to be perceived as charismatic when trying to start an organisation or change one,” says Morris.

So what makes some people charismatic and others not? Genes may play a part. Nathan Fox, a social development researcher at the University of Maryland in College Park, has studied social functioning in young children and found that some can be classed as socially outgoing from as early as 4 months old, interacting with adults and peers and being generally exuberant in their temperament. They may be more likely to grow into charismatic adults, but they need other qualities too. “I would imagine charisma is a function not only of social competence, but positive self-image as well,” says Fox, pointing out that this tends to emerge in middle childhood as a product of innate temperament and a child’s circumstances and environment.

Roach takes a different view. “The key is an enigmatic attractiveness that persuades others to subject themselves to the enigmatic person,” he says. He believes that contradictions are vital. Obama, for example, is warm and tough, black and white, from tropical Hawaii and gritty Chicago. Likewise, he argues, the actor Julianne Moore is fascinating because she manages to convey both strength and vulnerability. Certain circumstances may cause charisma to emerge or develop. Roach points out that “Shy Di” at the time of her marriage to Prince Charles eventually became “The People’s Princess”. Princess Diana had to dig deep to find the charisma she had always carried inside, he says.

In Roach’s view, charisma is a sort of X factor that some people are lucky enough to be born with. He likens it to perfect pitch: if you have it, it can be cultivated, if you don’t, it’s hard to improve and you will never fully attain it. Others, however, see it as a ➤

CULT OF PERSONALITY

Janja Lalich was 30 when she joined what she now regards as a cult. The Democratic Workers Party was a radical Marxist-Leninist group established in San Francisco in 1974 by Marlene Dixon, a former sociology professor. "She could talk a blue streak and give these lectures that just seemed awesome. We all thought she was the new Lenin," says Lalich, a sociologist at California State University in Chico, who has written several books on cults.

Anyone starting a cult needs charisma to persuade others to join, says Lalich. Without it, "they're just a nut standing on a corner". What's more, a cult leader with charisma can wield huge influence with virtually no ongoing effort. Take the Indian guru Bhagwan Shree Rashneesh, who headed a popular spiritual retreat, or ashram, in Poona, India, in the 1970s before moving to the US and establishing an international community in Oregon (where he amassed a collection of Rolls Royces purchased for him by followers). "There were years when he didn't even speak," says Lalich. "All he did was sit in front of his followers, stoned."

Dixon was undoubtedly charismatic, but she also had a dark side. In fact, the most common personality trait of cult leaders is not charisma but psychopathy, says Lalich. "All of the things I did that I now think were horrible, I did because she demanded it, and I had a belief in her that she knew what was right."

Lalich describes her experiences in *Bounded Choice: True believers and charismatic cults*. It wasn't until her own mother died and she was urged not to attend the funeral that she started to appreciate the grim reality of life in the Democratic Workers Party. In 1986, when Dixon was overseas, the burnt-out party leadership had a meeting. "We looked at each other and said, 'we're in a cult!' Then we dissolved the organisation, and everybody got out."

ADAM DEAN/PANOS PICTURES



suite of characteristics that may come more or less naturally to different individuals – although not everyone agrees on what these characteristics are.

Based on more than three decades of research, Ronald Riggio, a psychologist at Claremont McKenna College in California, has identified six traits or skills that he believes are essential: emotional expressiveness, enthusiasm, eloquence, self-confidence, vision and responsiveness to others. To be perceived as charismatic, it is vital to have a balance between these components, he says. A surfeit of emotional expressiveness, for instance, can detract from personal charisma – think comic actor Jim Carrey.

The idea that charisma comprises a combination of qualities is also reflected in the Conger-Kanungo scale of charismatic leadership, one of the most popular and strongly validated measures of charisma. It consists of 20 statements designed to assess strengths in five areas: vision; responsiveness to others; responsiveness to opportunities; risk-taking; and unconventionality.

The implication of this modular view of charisma is that aspects of it can be cultivated. Eloquence improves with practice. Enthusiasm can be faked. People can learn how to be more responsive to others. Even emotional expressiveness can be improved, says Dean Simonton of the University of California, Davis, in his classic book *Why*

Presidents Succeed. He found that the most successful US presidents used language rich in words conveying basic emotions that connect with an audience, such as love, hate or greed. Any would-be charismatic should use a phrase like "I feel your pain" rather than "I can relate to your viewpoint".

Vision, or the appearance of being a visionary, can also be acquired or enhanced. Steve Jobs, co-founder of Apple, spent up to 10 hours practising for apparently off-the-cuff 10 minute presentations that were central to his reputation as a visionary, charismatic leader, says Morris, who has published a paper on the subject.

Visionary leaders

Obama has also sought to boost his "visionary" status. After the raid that killed Osama bin Laden, the founder of Al-Qaida, "Obama announced that the intelligence was only 50 per cent certain the site held bin Laden, but he had a feeling about it, so he rolled the dice", Morris says. "It seemed to me that the intelligence was more like 99 per cent certain. However, his version makes him look more visionary."

Leaders who can move an audience with their oratory, who are comfortable with theatrical events and who are willing to express a vision of the future can trigger our subconscious, in the way that shamans do in



Charismatics can be revolutionaries - for good or ill

some traditional societies, says Morris. These are things he thinks can be taught: Morris runs courses at Columbia Business School that aim to improve performance in these areas.

The Massachusetts Institute of Technology also offers training programmes for business executives who want to enhance their charisma. Instead of teaching them to be more visionary, emotionally expressive or eloquent, however, Alex Pentland and his colleagues take a different approach. Using gadgets including electronic badges that record information such as tone of voice, proximity to others and gesticulations, they have identified four types of non-verbal social signal that they believe underpin charisma.

First there's mimicry: interactions involving a charismatic individual tend to include more unconscious copying of body language such as back-and-forth of smiles and head nodding. Second, charismatic people display high levels of activity – for example, they seem bubbly rather than listless – signalling interest and excitement. Third, their speech and movements show more consistency and fluidity. Finally, a person's influence can be gauged by the extent to

which they cause others to unconsciously match their speech patterns.

By analysing these signs alone, Pentland can predict which executives will be most successful at selling their business plans to a group of their peers. "What counts may not be what you say, but rather how you say it," he says. These kinds of social signals are hard to fake, Pentland adds. Nevertheless, his team has developed a tool called the "meeting mediator", which collects audio and motion information from each member of a group and provides real-time feedback about their interaction patterns, with the aim of improving the social signals they display, and so the outcome of the meeting.

Aside from providing clues about how to enhance charisma, Pentland's findings could also shed light on its origins. If charisma's key components are pre-linguistic social signals, that suggests it is evolutionarily ancient, he says. In general, social signalling tends to encourage consensus between individuals, so it may have evolved to help create stable social groups (see "The death of individuality", page 24). But human societies must not be too stable or they will never make the kinds of strides that have led to technological and social revolutions – and that's where charismatic individuals come in, says Pentland. It takes someone charismatic to change a culture.

"Charisma can be cultivated: eloquence improves with practice, enthusiasm can be faked, responsiveness to others can be learned"

Pentland is not alone in believing that charisma seeds revolution. Others argue that only leaders who generate radical change can be deemed truly charismatic. One proponent of this idea, Takis Pappas at the European University Institute in Florence, Italy, says that Steve Jobs falls into this group, as do Charles de Gaulle, Margaret Thatcher, Adolf Hitler and Joseph Stalin. As some of the names on this list attest, true charisma can be very powerful and its use can have highly divisive or even disastrous consequences. Democracy provides checks and balances to limit abuses of power by charismatic revolutionaries, but charisma can still be a malevolent force (see "Cult of personality", left).

There is another reason we should be wary of charisma: it may not be backed up with real ability. Rakesh Khurana of Harvard Business School has found that US companies looking for a new leader seek charisma above all else, but the results can be disappointing. In uncertain market conditions, a charismatic CEO can boost a company's stock price, but this can be short-lived because that individual may be better at conveying an image than running a business, says Khurana. Although more able executives can learn to be more charismatic, the fact that charisma is now being taught in business schools could actually compound the problem.

Besides, if we put our faith in charismatic leaders there is always the chance their charisma will evaporate. It happened to Tony Blair and Bill Clinton. Both are generally thought to have great personal charisma, but while they were in office unpopular policies or personal weaknesses saw their leadership charisma slip. Obama may be suffering a similar fate. In the early day of his presidency, he was hailed as an icon of hope. Then he was criticised as condescending, self-interested and detached. He is still the same man, of course, but perception is what matters. "Part of his charisma was in the eyes of his followers," according to Joseph Nye of Harvard University's John F. Kennedy School of Government. "Hard economic times make it hard to maintain charisma," he added, noting that personal charisma also depends on the situation.

Even Roach accepts that a politician's charisma can diminish when he is linked with unpopular policies. "But," he says, "I imagine if Barack Obama walked into the room right now you wouldn't say he had lost his charisma." ■

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