

ISSUE THREE

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To your very good health

Life, the old saying goes, is not a dress rehearsal. You only get one shot, and it is worth making the most of it. That means different things to different people, but many of us would prioritise staying fit and healthy, leading an intellectually stimulating life, being both professionally and socially successful, and living to a ripe – and healthy – old age.

That is easier said than done. In a world full of contradictory advice, where health news seemingly keeps on flip-flopping (is red wine good or bad for you this week?), it can be hard to know what you should actually do.

Some things are obvious: stay physically and mentally active, get plenty of sleep, work hard but not too hard, and eat and drink in moderation. But the fine details are harder to negotiate. Should you really drink eight glasses of water a day? Is sugar really worse than fat? What kind of exercise is the right kind of exercise? Does brain training work? Why is it so easy to procrastinate and so hard to get on with things?

This third issue of *New Scientist: The Collection* is dedicated to giving you the tools to live a better life, based on scientific evidence rather than myths, fads or fashions. A compilation of classic articles from *New Scientist*, it aims to give you both an understanding of the research and practical advice about using it.

We kick off with the most important organ in your body: your brain. The brain-training craze of a few years ago popularised the idea that grey matter can be made stronger with exercise. Since then we have learned a lot more about what works and what doesn't, as well as the best ways to make the most of your mental powers, from creativity to meditation.

Chapter 2 demystifies some of the most important and contentious issues in nutrition science. Is sugar really that bad? What about salt? Is it worth quitting alcohol for a month?

Does intermittent fasting work? And what about those persistent but debatable nuggets of folk wisdom, such as the need to drink eight glasses of water a day – are they true or false?

Chapter 3 tackles an entirely normal, but often unwelcome, fact of life: ageing. Not everybody wants to live to 100, but if you do, there are many things you can do to boost your chances of getting there in good shape, as well as enjoying the journey.

Chapter 4 is all about exercise. Being physically fit has so many health benefits that if it were available in pill form we'd all swallow it daily. But getting and staying fit are challenging, not least because there are so many myths surrounding how to do it, and so many hidden hazards in everyday life, such as your office chair.

Chapter 5 delves into the world of self-help. Everyday life is full of challenges, from making the right choices to avoiding temptation. As usual, science and technology can help. If you want to learn how to be more persuasive, make better decisions, focus your mind and stop procrastinating, get on with it! (Oh, and there's probably an app for it too.)

Finally, Chapter 6 returns to matters of personal well-being. Once dismissed as New Age mumbo jumbo, the mind-body connection is now known to be an incredibly powerful route to health. Meanwhile, there are many practical ways to boost your defences against infection, and techniques for keeping your mind and body in balance so you can make the most of life. Here's to a better you.

Graham Lawton, Editor-in-chief

CONTENTS

NewScientist THE COLLECTION

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ISSUE THREE

A BETTER YOU

1

Get smart

- 6 Mental floss**
Supercharge your brain
- 12 Pimp my memory**
The art of total recall
- 16 Go with the flow**
How to get into the zone
- 20 Let yourself go**
Daydream your way to creativity
- 25 Everybody say *omm***
Meditation's what you need

The articles in this collection were first published in *New Scientist* between 2005 and 2014. They have been fully updated and revised.

2

What not to eat

- 28 Sickly sweet**
The truth about sugar
- 34 Friend or foe?**
What you need to know about salt
- 38 Here's to a dry January**
The benefits of a month off the booze
- 40 Deprive yourself**
Does a food-free day keep the doctor away?
- 44 Don't swallow them**
Six myths about diet and health

3

Grow old gracefully

- 49 How to live to 100...**
...and enjoy it
- 58 Use it don't lose it**
The secrets of keeping your faculties
- 62 Old dog, new tricks**
It's never too late to learn something new

4

Get physical

- 66 Exercise is good for you...**
... but only if you do it right
- 73 The best medicine**
A fit body is a healthy one too
- 76 Faster body, faster mind**
Train your body to train your brain
- 80 Are you sitting comfortably? Well, don't!**
The hazards of being sedentary

5

Recipes for success

- 84 You can't always get what you want...**
... but the science of persuasion can help
- 91 Decisions, decisions**
How to make better choices
- 101 Get on with it!**
Tricks to avoid procrastination
- 110 Quantify thyself**
Tech to keep track of your life

6

Mind and body

- 114 Inner healing**
How to use the power of your mind
- 119 Retune your immune system**
Eight tips for boosting your defences
- 124 Wishful thinking**
Kind thoughts are good for you



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output (engine) 170/231 kW/hp, power output (electric motor) 96/131 kW/hp, total average energy consumption per 62 miles/100 km average electric range value (e-Drive only) up to 23 miles. Figures may vary depending on different factors, including but not limited to individual driving style,

Mental floss

Brain training may not work, but there are lots of other ways to give your grey matter a quick boost, says Helen Thomson



BREATHE in, breathe out. Breathe in, breathe out. I crack open an eye. Everyone else has theirs closed. I shut it again. Breathe in, breathe out. Around me people are sitting cross-legged, meditating. For some it's spiritual, for others an oasis of calm. Me? I'm building a better brain.

I could have bought a brain-training game, but alas, it turns out they are not much use. Although your performance on the games improves, that effect rarely translates into the real world (see "Does brain training work?", page 10). With that in mind, I wondered if there was anything else I could do to give my grey matter a boost.

Our brains are constantly adapting to

information from the world around us. However, some activities make a bigger impression than others. In recent years, researchers have been probing how outside influences, from music to meditation, might change and enhance our brains.

One of the most promising is music – and not via the famous but controversial "Mozart effect", whereby merely listening to classical music is supposed to improve brain performance. Learning to play an instrument brings about dramatic brain changes that not only improve musical skills but can also spill over into other cognitive abilities, including speech, language, memory, attention, IQ and even empathy. Should I dust off my trumpet

and get practising?

Musical training, especially at a young age, seems to significantly alter the structure of your brain. For instance, after 15 months of piano lessons young children had more highly developed auditory and motor areas than their untrained peers. These brain areas are very active when you play an instrument.

Professional musicians have an increased volume of grey matter, which routes information around the brain, in areas that deal with motor control, audition and visuospatial processing. Musicians who started training before the age of 7 also have a thicker corpus callosum, the bundle of nerve fibres that shunts information between the two halves of the brain.

These structural changes have been shown to tally with the development of musical ability. But can music reach outside its own domain and improve other aspects of cognition?

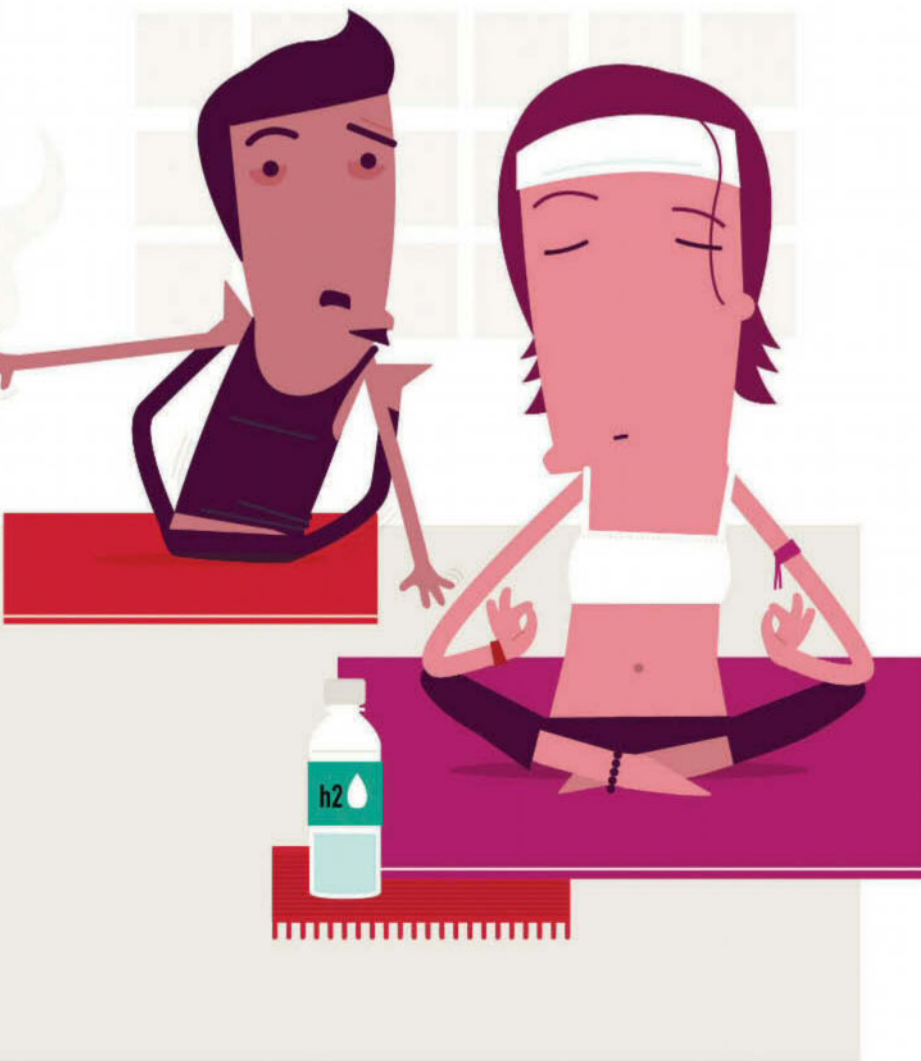
The tentative answer is yes. Musically trained people perform better on tests of auditory memory – the ability to remember lists of spoken words, for example – and auditory attention. Children with a musical training have larger vocabularies and higher reading ability than those who do not. There is even some evidence that early musical training increases IQ.

Better learning

Patrick Ragert at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, has an idea why this should be so. He found that professional pianists were much better than non-musicians at a standard test of spatial acuity – the ability to discriminate two closely separated points. Crucially, they also improved faster with practice. This is evidence that the brains of trained musicians are more plastic, says Ragert, suggesting that learning an instrument may enhance your capacity to learn other skills.

This can even extend to languages. Trained musicians are better at discriminating pitch changes in made-up words similar to those found in Mandarin, a tonal language where such changes can alter the meaning of a word. This is evidence that they are better equipped to learn new languages. And that is not all. Music training has even been shown to enhance empathy because it fine-tunes your ability to recognise emotional nuances in speech.

Much of this research has been done in children or professional musicians who started training very young. Developing



brains are known to be more malleable than adult ones – for music, there seems to be a sensitive period at around 7. So would the same kind of training make any difference to me? “Those who begin musical training earlier in life see greater enhancements,” says Dana Strait, who works in music cognition at the University of Maryland, College Park. “But all signs point toward musical training being powerful at any point in life.”

“All the signs point to musical training being powerful at any point in life”

So if I resumed trumpeting where I left off, I could potentially enhance my brain in all sorts of ways (while simultaneously delighting my neighbours, no doubt). But years of practise seemed a little daunting, so I went off in search of a shortcut.

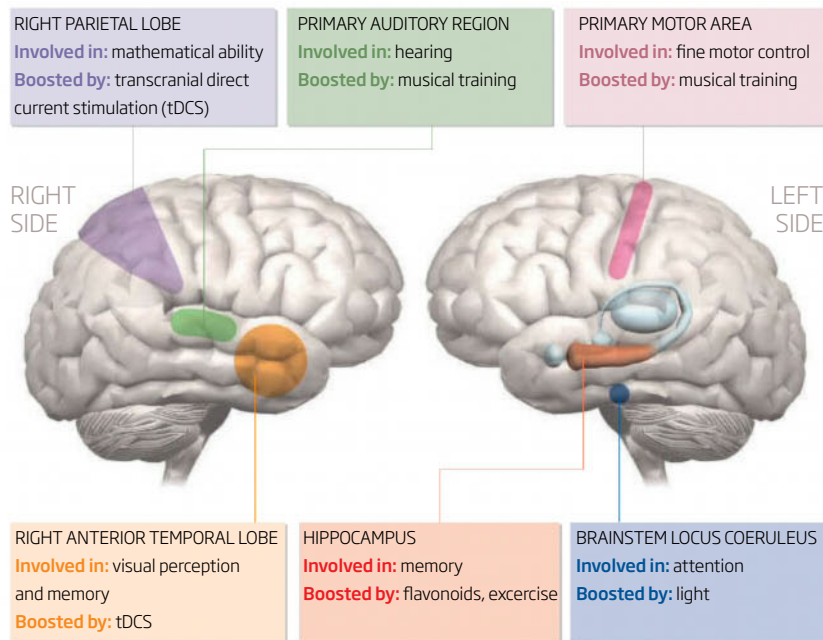
That’s why I found myself sitting in a small room with two electrodes stuck to my head. I was being set up for a trial of transcranial direct current stimulation (tDCS), a way of enhancing brain activity using an electrical current.

The current is tiny – just 1 to 2 milliamps. Although the mechanism is not fully clear, tDCS appears to change the excitability of neurons, depending on the direction of current flow. This can make active areas of the brain work even harder. Depending where you place the electrodes, it can lead to an enhancement in cognitive functions including



Get in the zone

Many brain areas can be boosted – you just need to pick the right stimuli



attention and vision.

Roi Cohen Kadosh, a neuroscientist at the University of Oxford, is particularly interested in tDCS’s potential to give our brains a boost, including our ability to do mathematics. In 2007, his team “short-circuited” an area of the brain called the right parietal lobe using transcranial magnetic stimulation (TMS) – a stream of magnetic pulses which temporarily disables a targeted area of the brain. They found that people got worse at numerical tasks. In fact, their performance resembled people with dyscalculia, who have difficulty comprehending mathematics. Other studies have since shown a similar effect when TMS is applied to the left parietal lobe.

Having disrupted the ability to use numbers, Cohen Kadosh wondered whether he could improve it too. To find out, he applied tDCS to the right parietal cortex in a small group of volunteers. He zapped his volunteers while they familiarised themselves with made-up symbols representing the numbers 1 to 9. The volunteers had no idea which symbols stood for which number but had to work it out by trial and error. After each training session they were given tests to see



how well they could perform calculations using the symbols.

Those given tDCS learned the symbols faster and did better in the tests than those given a sham procedure. It did not affect other brain functions, Cohen Kadosh's team found, and the improvements lasted six months.

In 2013, a group led by Lutz Jäncke at the University of Zurich in Switzerland carried out a similar experiment. They applied current to both the left and right parietal lobes but only saw an improvement in mathematical ability – as measured by subtraction prowess and a number comparison task – when it was applied to the left side.

Electricity can also boost visual memory. When Richard Chi, founder of neuro-tech start-up Creativity Cap, was at the University of Sydney, Australia, he and his colleagues used tDCS to increase activity in the right anterior temporal lobe, near the temple, which is involved in visual perception and memory. His volunteers experienced a 110 per cent improvement in a subsequent visual memory task compared with a group who received a sham treatment.

It doesn't take a huge leap of imagination

to see where this is heading – portable gadgets are already available to buy online. But the differing results in the tDCS studies of mathematical ability and discrepancies in other fields reflect the fact that scientists still don't understand exactly what the tiny flows of current are doing to our brains. "In my view it is premature to use it as an intervention," says Cohen Kadosh. "We are at the tip of the iceberg and much more research is needed," he cautions (for more on electrical brain stimulation, see "Go with the flow", page 17).

Bright lights

It all sounds a bit premature for me, so how about a more benign way to boost your brain at the flick of a switch? Light, too, can have some surprising effects on cognition that have nothing to do with vision.

We understand pretty well how our brains process visual information and use light to regulate the body clock and hormone secretion, but we have only just begun to realise the extent to which light can directly affect brain function. Several studies have shown that simply exposing people to light improves

performance on many cognitive tasks.

In these studies, volunteers with normal vision were given a variety of tests while exposed to bright light during the day. Their performance in visual searches, mathematics, logical reasoning and reaction time all improved with exposure to bright light.

This appears to be because light boosts alertness. In another study, volunteers had their brains scanned as they performed a short-term memory task while exposed to either violet, blue or green light. The scans revealed that after just a few seconds of light exposure an area of the brain stem known to play a role in alertness became more active. Blue light was the most potent. Similarly, in simple reaction tasks, exposure to blue light is more effective in sustaining cognitive performance than green light.

These effects are probably mediated by a pigment in the retina called melanopsin, which is not involved in vision. Melanopsin absorbs pale blue light better than other wavelengths, which is not surprising as natural light contains a lot of blue. But exactly how it boosts cognition remains unclear.

Gilles Vandewalle, a neuroscientist at the ➤

DOES BRAIN TRAINING WORK?

Once touted as the surest way to hone your mental powers, brain training software is now dogged by doubts over its effectiveness.

The big question is whether getting better at the game translates into general cognitive improvements. Some trials have shown success, but no large trial has yet shown concrete evidence that brain training has an effect in the real world.

Quite the opposite, in fact. In 2010, 11,000 volunteers were asked to do either online brain training or surf the web to find answers to a set of questions. All showed improvements in the task they were assigned, but there was no difference between the groups on other tests of cognition. A follow-up study of 44,600 people produced similar results. Yet the idea that flexing your

mental muscle leads to wider improvements refuses to die. Susanne Jaeggi at the University of Maryland has shown that working memory training has a subsequent effect on visuospatial tasks. She reckons that brain training can work for tasks that utilise the same skill set as the one you trained. But it takes effort – booster sessions are probably needed to maintain the effect.

University of Liège in Belgium, thinks that melanopsin – which can become more or less light-sensitive depending on the wavelength of light present – is acting as a kind of switch, sending different signals to the brain depending on its state.

That, however, is one for the future. I am looking for a brain boost right now. Perhaps I should stop thinking about my brain and concentrate on my stomach.

Brain food

Many foods contain chemicals that have been claimed to boost mental performance. Perhaps the most famous are omega-3 fatty acids, found naturally in oily fish, walnuts and green vegetables, and increasingly added to processed foods such as bread and yogurt. For years these have been touted as the quintessential brain food – but recent evidence suggests that they do little or nothing to improve mental powers.

Even so, the dream of brain-boosting through diet lives on. Attention has now shifted to another group of chemicals, the flavonoids, found in fruits such as blueberries and blackcurrants and also in cocoa, green tea and red wine.

Jeremy Spencer at the University of Reading, UK, is investigating the brain-enhancing effects of food. In experiments on rodents his team has shown that eating dietary quantities of flavonoids can lead to enhancements in memory and protect against degeneration of the brain.

A pilot study suggests that something similar applies to humans. “We looked at the effect of blueberries and found they improve attention,” says Spencer.

Spencer also took blood samples from the volunteers. These suggest that flavonoids activate biochemical pathways that increase the expression of genes linked to memory. For example, flavonoids are able to raise levels of brain-derived neurotrophic factor (BDNF),

a protein known to be important for learning and memory. BDNF is a growth factor that stimulates the development of axons linking one brain cell to the next.

Spencer suggests that the effect may also trigger increased communication between brain cells. However, flavonoids are also known to affect the circulatory system, lowering blood pressure and increasing the elasticity of blood vessels. In this way, they have been shown to increase blood flow to the brain. This is known to be good for mental performance, possibly via the generation of new neurons in the hippocampus through the triggering of stem cell differentiation. “Eating blueberries could stimulate neuronal growth through increased blood flow to this area,” he says.

“They appear to have almost drug-like effects,” Spencer adds. “It’s quite possible that these food-derived components may be used in the future as precursors for mind-enhancing drugs.”

Chris Bird, a neuroscientist at University College London, says that the preliminary results look promising, but questions whether a flavonoid-rich diet would have noticeable effects in the real world. “I will continue to eat them and hope that they might be doing something good for me,” he says.

Another promising compound is based on magnesium. In 2010 Guosong Liu, now at Tsinghua University in Beijing, and colleagues reported the results of feeding a dietary supplement, magnesium-L-threonate (MgT), to rats. They found it significantly raised magnesium levels in the brain and led to increases in both spatial and associative memory in young and old rats.

Liu also showed that boosting magnesium in the brain increases synaptic plasticity in neurons and neurogenesis – the production of new neurons – in the hippocampus. The supplement has yet to be scientifically tested in humans, but the authors suggest that it could produce a similar boost to cognition.

And after all that brain food, it might be time to pay a visit to the gym. While regular exercise certainly increases blood flow to the brain, in rats at least, whether it holds true for humans is still a matter of debate.

Since monkeys are more comparable to humans, Judy Cameron at the University of Pittsburgh, Pennsylvania, trained monkeys to use treadmills to see if it affected their mental agility. One group of monkeys worked out for an hour a day, five days a week; another group spent the time sitting on an immobile treadmill.

Five weeks in, all the monkeys were given a task where they had to learn which object covered a food reward. The monkeys that had worked up a sweat were twice as fast at this test as those that had been sedentary.

Analysis of brain tissue showed that the runners had a greater volume of blood vessels. Since blood delivers oxygen and nutrients to the brain, this could explain why exercise increased their cognitive function.

Concrete evidence that exercise improves brain function in humans has been harder to find. Numerous studies have shown that moderate exercise can slow age-related decline. But in 2010, researchers at the University of Illinois at Urbana-Champaign showed that daily walking improved executive



“Just 20 minutes of yoga-based meditation improves both visual memory and spatial skills”

functions such as planning and abstract thinking in younger adults. The same group has also shown that older adults that exercise can increase the size of their hippocampus and improve their memory.

Although scientists are still piecing together how exercise benefits the brain, studies like these, together with those in animals, hint that physical activity may spur the growth of neurons in regions important to memory and improve activity in areas that are responsible for executive function.

Key chemicals that might be involved include BDNF and vascular endothelial growth factor (VEGF), which aids blood vessel growth. Several animal studies have shown greater concentrations of these chemicals in animals that have exercised, suggesting that a workout literally helps them grow a better brain. In humans BDNF levels have also been shown to increase after exercise, as have levels of a hormone called insulin-like growth factor 1.

In both animals and humans excessive exercise had the opposite effect, diminishing levels of BDNF, which might mean that moderate bursts of activity promote the right chemical building blocks for a better brain.

So if I can improve my brain with music, light, blueberries and exercise, why am I here, sitting cross-legged, concentrating on my

breathing? Humans have striven to gain enlightenment and control over the mind through meditation for centuries. But although practitioners have claimed a number of brain benefits, few have been well tested scientifically.

So when, in 2005, the Dalai Lama famously challenged neuroscientists to test the memories of monks, several groups of investigators jumped at the chance. They travelled to monasteries in Nepal to test Buddhist monks. The initial results were disappointing. They found no difference in visual memory tests between monks who meditated regularly and non-meditators.

Meditate to accumulate

Then the researchers tested a monk immediately after a meditation session. “He showed unbelievable performance,” says neuroscientist Maria Kozhevnikov, then at George Mason University in Fairfax, Virginia. It turns out just 20 minutes of daily yoga meditation improved both visual memory and spatial skills dramatically, but the boost was short-lived.

Since then, evidence has piled up that intensive meditation training – say 10 hours a day for three months – enhances attention and executive function. In 2010 a team led by Fadel Zeidan of Wake Forest University School of Medicine in Winston-Salem, North Carolina, reported that just four 20-minute training sessions improved visuospatial processing, working memory and executive functions in people who had never meditated before. Bruce O’Hara at the University of Kentucky in Lexington even showed that meditation appears to improve vigilance and reaction times.

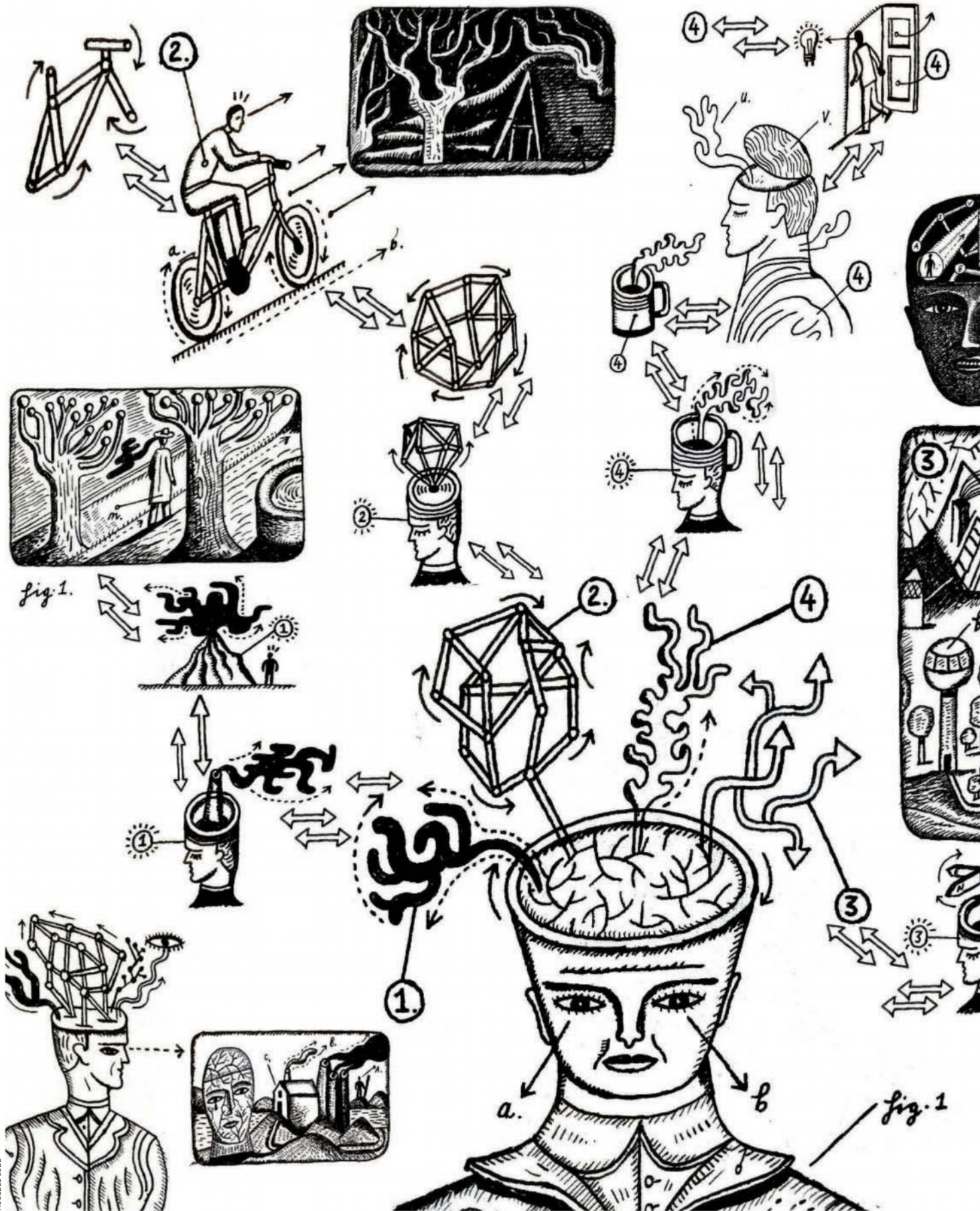
Do these findings suggest that it’s worth practising meditation before doing something mentally challenging? Although the data is limited, O’Hara thinks it might help. “Meditating prior to studying or taking an exam could be beneficial. The improvements may be small, but worthwhile.” (For more on the benefits of meditation, see “Everybody say *omm*”, page 24.)

So who needs brain training? With so many options at my disposal, I have no excuse for not keeping my brain in tip-top condition. The right diet, a spot of exercise and meditation and a bit of sunshine are all I need. Perhaps some of it really will help me to build a better brain over the coming years.

At the very least, I’ve got an excuse for a glass of red wine. ■



SPENCER WILSON





IN THE age of Google, with limitless information at our fingertips, it is tempting to think that a good memory is obsolete. Of course anyone studying for exams or learning a new skill, or just trying to remember their myriad passwords, knows otherwise. In truth, many of us aspire to better recall. The trouble is that memory is a bit like a muscle – it can be hard work to keep it in top condition. But the good news is that scientists are now on to the problem. If you want to know how to get the most out of your memory with the least possible effort – and without resorting to dubious memory-boosting drugs – read on.

How do memory champions do it?

In November 2005, Chinese businessman Chao Lu became a world record holder by reciting pi to 67,890 places. It took him a year to memorise the stream of digits and over 24 hours to reel them off. Like most extraordinary memorists, Chao Lu used a set of formal memory aids, or mnemonics. To memorise a long list of numbers, for example, a mnemonist might assign consonants to each number from 0 to 9, then group the stream into four-digit chunks and convert these into words by judiciously adding vowels – a mnemonic known as the phonetic system. They might then create an image for each word and weave these into a familiar journey or arrange them in the rooms of a mental “memory palace”. This creation of a narrative or mental map in which to place memories is called the “method of loci”. Later, retracing the journey or walking through the rooms brings back the images, which can then be decoded into the string of digits. A similar approach can help you to remember a list

“Unless particularly witty, rhymes or acronyms you learned at school often fail to help you remember lists”

of random words, even the order of a pack of cards in one viewing.

Some memory champions have talents that most of us cannot emulate, however. A century ago, Russian journalist Solomon Shereshevsky was studied extensively for his amazing ability to remember long lists of numbers and words. This apparently required very little effort: he could recite a list of 50 numbers, forwards and backwards, after just 3 minutes of study. It turned out that as well as using mnemonics, Shereshevsky was aided by his synaesthesia. For him, each number had a different personality – 1 was a proud, well-built man, 2 a high-spirited woman, and so on – while the sounds of other words would produce vivid colours and tastes, making them more memorable.

Do mnemonics work in everyday situations?

The oldest known memory aid is the method of loci, invented by the ancient Greeks at least 2000 years ago. These days there are any number of mnemonics, but while memory champions may swear by them, how useful are they in day-to-day life? Two psychologists, James B. Worthen and R. Reed Hunt, attempt to answer this question in their 2010 book *Mnemonicology*. “We tried to cover everything that’s out there,” says Worthen, of Southeastern Louisiana University in Hammond.

So what did they find? Disappointingly, many mnemonics fail to live up to their reputation. Take the keyword method, which is often taught to language students. To help remember an unfamiliar word, the student creates an elaborate image based on the sound – the Spanish word for moustache, *bigote*, might be visualised as a big goat with a handlebar moustache, for example. Although widely used, several studies suggest that this method is of little value to experienced language learners, and even beginners reap minimal benefits. While it slightly improves the accuracy of their memory compared to rote repetition, it also slows down the speed at which they can recall a word.

The phonetic system, in which numbers are encoded as letters, fared little better. ➤

Pimp my memory

Improving your memory needn't be too much hard work, as David Robson discovers

Developed in the Renaissance, it is often touted in books on memory improvement, which suggest using it to create memorable phrases from strings of numbers. While there is good evidence that it improves recall, the difficulties of applying the technique led Worthen and Hunt to conclude that it would often be impractical in everyday situations. Even more disappointingly, their analysis revealed that the rhymes and acronyms you might have been taught at school often fail, unless they are particularly witty or apt.

One mnemonic did stand out, though. Most studies indicate that the method of loci is good not only for memory tricks but also for anyone trying to remember a list – whether a shopping list or the kings and queens of England. It has even proven its worth in on-the-spot tasks. In one study, a group of high-school students used the technique to accurately remember the contents of a complex lecture, by attaching keywords from the speaker’s arguments to various locations in their mental map. Still, even this method has its drawbacks. It takes a while to learn – the students in the study underwent 6 hours of training – and it is not particularly suited to the kinds of information that need to be recalled spontaneously, such as words in a foreign language. Also, while the method of loci is excellent for remembering spoken lectures, it was no better than rote rehearsal for another group of students who attempted to memorise a written passage.

What’s the best way to bone up for a test?

Come exam time, we all have our preferred revision technique. Some students swear by colourful mind maps. Others go for flash cards. The most common practice is rereading notes and highlighting the relevant material. The million-dollar question, though, is which method provides the biggest pay-off from those hours of hard graft.

It turns out that one technique stands head

“One of the easiest ways to increase how much you remember is to carefully time when you study”



and shoulders above the rest – simple recall. Although it is more than two millennia since Aristotle wrote that “repeatedly recalling a thing strengthens the memory”, cognitive scientists have only recently come to appreciate the effectiveness of so-called “retrieval practice”.

In a landmark study in 2008, Jeffrey Karpicke at Purdue University in West Lafayette, Indiana, asked 40 students to learn the meaning of 40 Swahili words. Despite receiving no feedback on whether they were correct or not, those who were repeatedly asked to recall the words during the learning session aced the final test a week later, with an average score of 80 per cent. In contrast, those

who repeatedly studied the words without actively testing themselves scored an average of just 36 per cent.

Another study, published in 2011, showed that retrieval practice also outstrips more active methods of study, such as drawing complex bubble diagrams to represent the information in a passage of text. Other researchers have found that schoolchildren, university medical students and neurological patients in cognitive rehabilitation all do better at their tasks when they test their memory at regular intervals. “The results have been very striking, showing benefits in all these different settings,” says Andrew Butler of Duke University in Durham, North Carolina, who recently wrote a review of the evidence.

Despite the benefits of retrieval practice, when Karpicke, Butler and colleagues asked students how they actually revise for exams, fewer than half said they use any form of self-testing or retrieval. Yet all the evidence indicates that this much-overlooked technique should be at the core of any study regime.

Can I learn subliminally?

The idea that we could learn while asleep was once the stuff of dystopian science fiction. In both Aldous Huxley’s *Brave New World* and Anthony Burgess’s *A Clockwork Orange*, authoritarian regimes use sleep learning to brainwash the lead characters. For a while it also became the mainstay of numerous teach-yourself courses that claimed you could learn a foreign language while you napped.

Experiments to test this idea produced some promising results initially, though critics wondered whether the subjects might be feigning sleep as the recordings played. Sure enough, when researchers started measuring participants’ brainwaves to make sure they were truly in the land of Nod, the effects all but disappeared.

The hope of effortless learning has not completely vanished, however. Now there is a suggestion that you don’t always have to actively pay attention to remember something. Beverly Wright at Northwestern University in Evanston, Illinois, has trained volunteers to discriminate between two sounds of nearly identical pitch. Some groups slaved away at the task for the whole study period. Others trained actively for half the time, then listened passively to the sounds for the rest of the period while performing an unrelated written task.

The result? Both achieved pretty much the

MEMORIES ARE MADE OF THIS

If your brain were a bank, it would have three different vaults:

Sensory memory - contains the fleeting impression of a sight or sound immediately after you experience it

Short-term memory - the temporary store of information from second to second or minute to minute. It is where you hold a

telephone number you are just about to dial.

Long-term memory - a more permanent store, hoarding information over hours, days or years. This information can take the form of declarative memories, which include simple facts or specific episodes in your life, or procedural memories to do with skills, such as how to ride a bike.



ISTOCK/WILDCARDIMAGES/UK

Taking a nap after learning helps you remember

same level of accuracy on the subsequent test – provided that passive listening came soon after active learning. “Within half an hour the effect begins to go away and by 4 hours it’s definitely gone,” says Wright. Intriguingly, the outcome was the same when the passive stimulation came first. You cannot skip active practice completely, however: passive stimulation on its own held absolutely no benefits.

Although Wright’s study involved a highly specific task, she believes students learning a language, or musicians learning a tune, should benefit from a similar mix of active study and passive listening. You could spend 30 minutes speaking a language and then 30 minutes listening to a podcast in that language while playing on the Wii, for example.

Does when I study affect how much I remember?

Yes. One of the easiest ways to increase how much you remember without any additional effort is to carefully time when you study. Numerous experiments have found that sleep shortly after learning new facts or skills helps the brain reinforce its memory traces – whether that sleep is a good night’s heavy slumber or just a well-timed afternoon nap. This seems to be because sleep promotes the growth of new dendritic spines in the brain – the neural projections that help pass electric signals from one neuron to another. You might also want to consider the timing between different study sessions. It is well known that we learn much better if we revisit material after an interval rather than hammering it home during a single session. Surprisingly, the length of this interval

determines how much you remember – to the extent that it could easily bump you up a grade or two. Hal Pashler at the University of California, San Diego, has noticed a peculiar “sweet spot” in revision times. According to his studies, you should revisit your subject at a time equivalent to between 10 and 20 per cent of the interval between learning the material and subsequently taking the exam. If you are learning for a class test in 24 hours, for example, you should revise again roughly 2 to 4 hours after your initial revision. Do this, and exactly the same amount of study time will give you at least a 10 per cent higher test score.

Can I expand my short-term memory?

Never mind mastering a second language or a subject syllabus, most of us have enough difficulty remembering the orders for a round of drinks at the pub. That’s because the average short-term, working memory can only hold five to seven pieces of information at any one time. This limit constrains pretty much everything you want to do with your brain, so wouldn’t it be great if you could overcome it?

Unfortunately, past attempts by cognitive



scientists to increase people’s working memories have largely failed. Although subjects trained in specific strategies, such as rehearsing long strings of numbers, often improved their performance on the particular task at hand, they were no better at other problems. As a result, researchers are now testing the effect of more variable and demanding tasks. For example, Jason Chein at Temple University in Philadelphia, Pennsylvania, uses software that asks people to answer questions about a string of successive sentences while simultaneously remembering the last word of each sentence. It is very difficult to develop conscious shortcuts to deal with the two conflicting sources of information, so the brain is forced to make more long-lasting changes. The idea is that these will then enable you to perform better on other types of memory tasks.

The new techniques work a treat, typically increasing memory span by around 15 per cent over a training course of five weeks. In practice that could mean expanding your working memory from seven to eight items. What this means for intelligence, though, is hotly contested. Some researchers doubt that a better working memory will help in other areas of cognition. But others point out that working memory underpins a whole swathe of cognitive abilities, from logical reasoning and arithmetic to verbal skills and reading comprehension. The jury is still out on whether these mental skills improve following working memory training.

When is it too late to bother?

Even if your student days are long gone, your memory can still do great things with a bit of effort. In 2011, John Seamon at Wesleyan University in Connecticut published a study of a septuagenarian who started training his memory at the age of 58. The former high-school teacher, known in the study as JB, can now faultlessly recite all 60,000 words of John Milton’s epic poem *Paradise Lost*.

JB had not shown an exceptional predisposition to memorisation beforehand, and he didn’t even use mnemonics – just willpower and over 3000 hours of practice. “Many other people could do it, with enough time and effort,” says Seamon.

It seems it’s never too late to learn (for more, see “Old dog, new tricks”, page 62). Even if Milton is not to your taste and you lack JB’s perseverance, these tried-and-tested tips should help you get the most out of your memory with the least effort, whatever your age. ■



Go with the flow

Is there an easy way to prime your brain for proficiency in any skill? **Sally Adee** finds out

I'm close to tears behind my thin cover of sandbags as 20 screaming, masked men run towards me at full speed, strapped into suicide bomb vests and clutching rifles. For every one I manage to shoot dead, three new assailants pop up from nowhere. I'm clearly not shooting fast enough, and panic and incompetence are making me continually jam my rifle.

My salvation lies in the fact that my attackers are only a video, projected on screens to the front and sides. It's the very simulation that trains US troops to take their first steps with a rifle, and everything about it has been engineered to feel like an overpowering assault. But I am failing miserably. In fact, I'm so demoralised that I'm tempted to put down the rifle and leave.

Then they put the electrodes on me.

I am in a lab in Carlsbad, California, in pursuit of an elusive mental state known as "flow" – that feeling of effortless concentration that characterises outstanding performance in all kinds of skills.

Flow has been maddeningly difficult to pin down, let alone harness, but a wealth of new technologies could soon allow us all to conjure up this state. The plan is to provide a short cut to virtuosity, slashing the amount of time it

takes to master a new skill – be it tennis, playing the piano or marksmanship.

That will be welcome news to anyone embarking on the tortuous road to expertise. According to pioneering research by Anders Ericsson at Florida State University in Tallahassee, it normally takes 10,000 hours of practice to become expert in any discipline. Over that time, your brain knits together a wealth of new circuits that eventually allow you to execute the skill automatically, without consciously considering each action. Think of the way tennis champion Rafael Nadal, after years of training, can gracefully combine a complicated series of actions – keeping one eye on the ball and the other on his opponent, while he lines up his shot and then unleashes an unstoppable forehand – all in one stunningly choreographed second.

Flow typically accompanies these actions. It involves a Zen-like feeling of intense concentration, with time seeming to stop as you focus completely on the activity in hand. The experience crops up repeatedly when experts describe what it feels like to be at the top of their game, and with years of practice it becomes second nature to enter that state. Yet you don't have to be a professional to experience it – some people report the same

ability to focus at a far earlier stage in their training, suggesting they are more naturally predisposed to the flow state than others. This effortless concentration should speed up progress, while the joyful feelings that come with the flow state should help take the sting out of further practice, setting such people up for future success, says psychologist Mihaly Csikszentmihalyi at Claremont Graduate University in California. Conversely, his research into the flow state in children showed that, as he puts it, "young people who didn't enjoy the pursuit of the subject they were gifted in, whether it was mathematics or music, stopped developing their skills and reverted to mediocrity."

Despite its potentially crucial role in the development of talent, many researchers had deemed the flow state too slippery a concept to tackle – tainted as it was with mystical, meditative connotations. In the late 1970s, Csikszentmihalyi, then a psychologist at the University of Chicago, helped change that view by showing that the state could be defined and studied empirically. In one groundbreaking study, he interviewed a few hundred talented people, including athletes, artists, chess players, rock climbers and surgeons, enabling him to pin down

four key features that characterise flow.

The first is an intense and focused absorption that makes you lose all sense of time. The second is what is known as autotelicity, the sense that the activity you are engaged in is rewarding for its own sake. The third is finding the “sweet spot”, a feeling that your skills are perfectly matched to the task at hand, leaving you neither frustrated nor bored. And finally, flow is characterised by automaticity, the sense that “the piano is playing itself”, for example.

Exactly what happens in the brain during flow is of obvious interest, but has been tricky to measure. Csikszentmihalyi took an early stab at it, using electroencephalography (EEG) to measure the brainwaves of expert chess players during a game. He found that the most skilled players showed less activity in the prefrontal cortex, which is typically associated with higher cognitive processes such as working memory and verbalisation. That may seem counter-intuitive, but silencing self-critical thoughts might allow more automatic processes to take hold, which would in turn produce that effortless feeling of flow.

Later studies have confirmed these findings and revealed other neural signatures of flow. Chris Berka and her colleagues at Advanced Brain Monitoring in Carlsbad, California, for example, looked at the brainwaves of Olympic archers and professional golfers. A few seconds before the archers fired off an arrow or the golfers hit the ball, the team spotted a small increase in what’s known as the alpha

band, one of the frequencies that arises from the electrical noise of all the brain’s neurons. This surge in alpha waves, Berka says, is associated with reduced activation of the cortex, and is always more obvious in experts than in novices. “We think this represents focused attention on the target, while other sensory inputs are suppressed,” says Berka. She found that these mental changes are accompanied by slower breathing and a lower pulse rate – as you might expect from relaxed concentration.

Defining and characterising the flow state is all very well, but could a novice learn to turn off their critical faculties and focus their attention in this way, at will? If so, would it boost performance? Gabriele Wulf, a kinesiologist at the University of Nevada at Las Vegas, helped to answer this question in 1998, when she and her colleagues examined the way certain athletes move.

At the time, she had no particular interest in the flow state. But Wulf and her colleagues found that they could quickly improve a person’s abilities by asking them to focus their attention on an external point away from their body. Aspiring skiers who were asked to do slalom-type movements on a simulator, for example, learned faster if they focused on a marked spot ahead of them. Golfers who focused on the swing of the club were about 20 per cent more accurate than those who focused on their own arms.

Wulf and her colleagues later found that

A mental state called flow is crucial to sporting excellence



an expert’s physical actions require fewer muscle movements than those of a beginner – as seen in the tight, spare motions of top-flight athletes. They also experience less mental strain, a lower heart rate and shallower breathing – all characteristics of the flow state.

These findings were borne out in later studies of expert and novice swimmers. Novices who concentrated on an external focus – the water’s movement around their limbs – showed the same effortless grace as those with more experience, swimming faster and with a more efficient technique. Conversely, when the expert swimmers focused on their limbs, their performance declined.

Wulf’s findings fit well with the idea that flow – and better learning – comes when you turn off conscious thought. “When you have an external focus, you achieve a more automatic type of control,” she says. “You don’t think about what you are doing, you just focus on the outcome.”

Berka has been taking a different approach to evoke the flow state. Her group is training novice marksmen to use neurofeedback: each person is hooked up to electrodes that tease out and display specific brainwaves, along with a monitor that measures their heartbeat. By controlling their breathing and learning to deliberately manipulate the waveforms on the screen in front of them, the novices managed to produce the alpha waves characteristic of

DIY BRAIN ENHANCEMENT

Zapping your brain with a small current seems to improve everything from mathematical skills to marksmanship (see main story). Since the science is still immature, the safest way to experience this boost is probably to sign up for a lab experiment.

That hasn’t stopped a vibrant community of DIY tDCS enthusiasts from springing up. Their online forums are full of accounts of their home-made experiments, including hair-curling descriptions of blunders that, in one case, left someone temporarily blind.

What drives people to take such risks? Roy Hamilton, a neuroscientist at the University of Pennsylvania in Philadelphia, thinks it is part of a general trend he calls cosmetic neuroscience, in which people try to tailor their brains to the demands of an increasingly fast-paced world.

“In a society where both students and their professors take stimulant medications to meet their academic expectations,” he warns, “the potential pressure for the use of cognitive enhancing technologies of all types is very real”.



ASCENT X/MEDIA GMBH/RIC ROWAN/GETTY

the flow state. This, in turn, helped them improve their accuracy at hitting the targets. In fact, the time it took to shoot like a pro fell by more than half.

But as I found when I tried the method, even neurofeedback has a catch. It takes time and effort to produce really thrumming alpha waves. Just when I thought I had achieved them, they evaporated and I lost my concentration. Might there be a faster way to force my brain into flow? The good news is that there, too, the answer appears to be yes.

That is why I'm now allowing Michael Weisend, who works at the Wright State Research Institute in Dayton, Ohio, to hook my brain up to what's essentially a 9-volt battery. He sticks the anode – the positive pole of the battery – to my temple, and the cathode to my left arm. "You're going to feel a slight tingle," he says, and warns me that if I remove an electrode and break the connection, the voltage passing through my brain will blind me for a good few seconds.

Weisend, who is working on a US Defense Advanced Research Projects Agency programme to accelerate learning, has been using this form of transcranial direct current stimulation (tDCS) to cut the time it takes to train snipers. From the electrodes, a 2-milliamp current will run through the part of my brain associated with object recognition – an important skill when visually combing a scene for assailants.

The mild electrical shock is meant to depolarise the neuronal membranes in the region, making the cells more excitable and responsive to inputs. Like many other neuroscientists working with tDCS, Weisend thinks this accelerates formation of new neural pathways as someone practises a skill. The method he is using on me boosted the speed with which wannabe snipers could detect a threat by a factor of 2.3.

Mysteriously, however, these long-term changes also seem to be preceded by a feeling that emerges as soon as the current is switched on and is markedly similar to the flow state.

"If I break the connection, the voltage passing through my brain will blind me for a good few seconds"

"The number one thing I hear people say after tDCS is that time passed unduly fast," says Weisend. Their movements also seem to become more automatic; they report calm, focused concentration – and their performance improves immediately.

It's not yet clear why some forms of tDCS should bring about the flow state. After all, if tDCS were solely about writing new memories, it would be hard to explain the improvement that manifests itself as

soon as the current begins to flow.

One possibility is that the electrodes somehow reduce activity in the prefrontal cortex – the area used in critical thought, which Csikszentmihalyi had found to be muted during flow. Roy Hamilton, a neuroscientist at the University of Pennsylvania in Philadelphia, thinks this may happen as a side effect of some forms of tDCS. "tDCS might have much more broad effects than we think it does," he says. He points out that some neurons can mute the signals of other brain cells in their network, so it is possible that stimulating one area of the brain might reduce activity in another.

Uncertain effect

Others are more sceptical. Arne Dietrich of the American University of Beirut, Lebanon, suspects that learning will be impaired if the frontal cortex isn't initially engaged in the task. What's more, he thinks you would need a specialised type of tDCS to dampen activity in the prefrontal cortex. "But then again, it is not clear what sort of ripple effect tDCS has globally," he concedes, "regardless of which brain area is targeted."

In any case, it is clear that not all forms of tDCS bring about flow. Roi Cohen Kadosh at the University of Oxford certainly saw no signs of it when he placed an anode over the brain regions used in spatial reasoning.

This debate will only be resolved with much more research. For now, I'm intrigued about what I'll experience as I ask Weisend to turn on the current. Initially, there is a slight tingle, and suddenly my mouth tastes like I've just licked the inside of an aluminium can. I don't notice any other effect. I simply begin to take out attacker after attacker. As twenty of them run at me brandishing their guns, I calmly line up my rifle, take a moment to breathe deeply, and pick off the closest one, before tranquilly assessing my next target.

In what seems like next to no time, I hear a voice call out, "Okay, that's it." The lights come up in the simulation room and one of the assistants at Advanced Brain Monitoring, a young woman just out of university, tentatively enters the darkened room.

In the sudden quiet amid the bodies around me, I was really expecting more assailants, and I'm a bit disappointed when the team begins to remove my electrodes. I look up and wonder if someone wound the clocks forward. Inexplicably, 20 minutes have just passed. "How many did I get?" I ask the assistant.

She looks at me quizzically. "All of them." ■

Let yourself go

Concentration is overrated. A wandering mind is the best route to creativity, says **Richard Fisher**



BELIEVE me, I will try my hardest, but I cannot stop what is going to happen to you in the next 5 minutes. It might be a memory that takes you away... a place that you knew, or an idea you once had. It could be hunger. It could be sex. It could already be happening now.

As you read these sentences, your mind will almost certainly wander at least once – just as mine is drifting as I decide how best to phrase these words so that they hold your attention. In fact, according to some estimates, we may spend nearly 50 per cent of our lives drifting away from the present moment into the world inside our heads.

Sigmund Freud considered such zoning out “infantile”; others feared it could lead to psychosis. Today, we know it is instead the sign of a healthy mind, allowing us to plan for the future by imagining different events, for instance.

Drifting, it seems, is a sure sign that our creative juices are flowing. When it comes to arriving at brilliant ideas, the ability to concentrate is overrated. If a person’s mind is wandering, they outperform their peers in a range of tasks where flashes of insight are important, from imaginative word games to exercises in original thinking and invention.

The psychologists researching the benefits of daydreaming would never claim to have found a formula for all creative achievement. But their results suggest that learning how to tread the line between focusing in and zoning out could help you to arrive at a breakthrough you might otherwise have missed.

One of the first psychologists to turn their attention to mind wandering was Jonathan Schooler of the University of California in Santa Barbara. One day he was listening to a talk on consciousness when the speaker mentioned the wandering mind. Schooler was so intrigued that he found it tricky to focus. “My mind kept wondering about mind wandering,” he says. He found it peculiar that we should enter the state so frequently. “It’s the mind escaping from the present,” he says, “and we’re doing it all the time.”

His subsequent experiments helped to show just how often our minds stray off-piste. In one study, volunteers had to read extracts from Leo Tolstoy’s *War and Peace* in his lab. Besides asking them to report whenever they noticed themselves drifting, he would also ask them what they were thinking about at

random intervals, and at the end, he tested their comprehension of the text. These measures revealed that people’s minds wandered from the words for more than 20 per cent of the time, often without them realising. When faced with other tasks, our capacity for distraction seems even greater; when people were asked to report their state of mind at random intervals during the day – via a smartphone app – their attention was wandering from the task at hand a whopping 47 per cent of the time.

Flashes of inspiration

For a long time, this kind of mind wandering would have been considered a serious failing. Instead, the ability to filter out distractions and focus on a task – dubbed executive control – was considered to lie behind smart thinking. Since keeping your train of thought on track is necessary to remember information from moment to moment, short-term “working-memory” capacity is often used to gauge executive control. By this measure, a host of studies have shown that people who can focus well tend to ace analytical problems: they are whizzes at arithmetic and verbal reasoning tasks, and often have a higher IQ. If you wanted to be clever, it seemed that you would need to learn how to concentrate.

Yet there were hints that concentration wasn’t all it was cracked up to be. Although people with a high level of working memory are good at analytical problems, they tend to struggle on tasks that require flashes of inspiration. “Often the best way to solve a problem is to not focus,” says Jennifer Wiley at the University of Illinois in Chicago, who has reviewed the research.

Consider the following brain-teaser, which represents one of the types of puzzle used in these studies. What single word can be added to “High, book and sour” to make another word or phrase? To solve it, you can’t simply apply an analytical approach since that would involve crunching through every word in your vocabulary, says Wiley. Instead, the answer often comes out of the blue. Various studies show that people with high working-memory capacity, and therefore good executive control, can find it more difficult to solve these problems than people who are more easily distracted. (The answer, by the way, is “note”.)

The same goes for other established >

measures of flexible thinking in the lab (see puzzles, right). In one test, known as the unusual uses task, people are asked to spend a couple of minutes coming up with a range of creative uses for an object, such as a brick, and afterwards they are marked on the quantity and originality of their answers. One study by Holly White, then at the University of Memphis, Tennessee, showed that people with attention-deficit hyperactivity disorder – who have lower working-memory capacity and are prone to zoning out – did better at this test than those without ADHD.

All in all, the findings hinted at one answer to the question of why we zone out: it might lead us to think creatively, beyond the rigid limits imposed by our executive control. It would certainly make sense for moments of insight to come from daydreaming. After all, one important skill for creativity is the ability to link disparate concepts, which you might come across while wandering inside your head. What was missing, however, was a direct test to show that the insights really do come from a daydream, so a team in Schooler's lab, led by Benjamin Baird, set about gathering this crucial evidence.

The experiment took place in three stages. First, the volunteers spent 2 minutes dreaming up unusual uses for a brick. Next, some were given a mindless task to complete, such as watching for letters on a screen. Others were given a much trickier test that required their full attention. As you might expect, subsequent questionnaires revealed that people drifted off significantly more in the mindless task. Finally, unexpectedly, all participants were asked to take another crack at the unusual uses task. This time, those whose minds had been wandering came up with, on average, 40 per cent more answers than on their first go. Those who'd had to concentrate on their task barely improved at all.

Crucially, when questioned, the mind wanderers did not report that they had been thinking explicitly about the brick during their mindless task. "It seems to have allowed some sort of unconscious process," Schooler says. The message is that as you drift off into memories, thoughts of food or holiday plans, your brain is mulling over potential solutions for whatever problem you are trying to solve.

The findings tie neatly with brain scans of the non-focused mind. Malia Mason of Columbia University, New York, for instance, has used functional MRI to show that periods of mind wandering correlate with activity in a constellation of neural regions across the brain, known collectively as the default

network. This brain network has only recently been discovered, but was hiding in plain sight. For years, researchers had been placing people in brain scanners and failing to note a surge in activity during the supposed resting moments between experimental tasks.

Making connections

One of the default network's jobs could be to sort through our memories in order to preserve them. It is tempting to speculate that the pathways involved in these searching and sorting duties may also be involved in creativity, by helping us to assess and link those disparate concepts present in our minds.

Surprisingly, a subsequent study by Schooler in 2009 found that in addition to these regions, the drifting mind also activated some parts of the brain that tend to be associated with the executive functions, such as the dorsolateral prefrontal cortex, which lies behind the forehead.

This is curious, given that mind wandering seems to be the antithesis of the tight focus associated with executive control. But Schooler believes that the activity they observed would not represent concentration, as such. Instead, these regions might be

recruited to keep track of the important ideas in the fire hose of thoughts released during wandering. Since these regions are thought to be involved in self-awareness, he also wonders if the executive regions are recruited when we suddenly become aware we are daydreaming – which may be important if we are to keep a grasp on the task at hand.

It's worth noting that experiments like dreaming up uses for a brick might not match many people's ideas of creativity. Certainly, this kind of work could not explain the great works of Picasso or the insight of Einstein. It explores one aspect of the creative process – the moment of insight and inspiration when you hit upon a novel thought or solution to a problem. You would need to combine those flashes with great intelligence, hard graft and perhaps some intangible quality, to arrive at anything approaching genius. "The moment you study creativity in the laboratory you dilute it," says Joydeep Bhattacharya at Goldsmiths, University of London. "Have we seen hard evidence that daydreaming leads to creativity? Not yet."

Still, there are hints from outside the lab that a wandering mind can bring success in the real world – albeit from a small study. In 2003, Shelley Carson at Harvard University

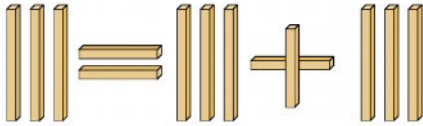


JASPER/JAMES/GETTY

Eureka!

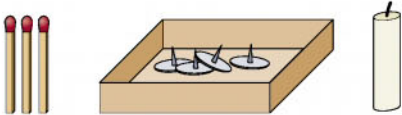
Creativity is very difficult to measure objectively. Nevertheless, psychologists have devised a range of problems that rely on flashes of inspiration, or test your ability to think flexibly - two important facets of the creative mind

- 1 Moving only one of the sticks can you make the sum work out correctly



- 2 In 2 minutes, how many uses can you think up for a bucket?

- 3 How would you fix a lit candle to a wall-mounted cork board in such a way that the candle wax won't drip onto a table below, using just these materials?



- 4 What word can be added to the following three to make a word or phrase?

high, book, sour

- 5 Move three coins to make the triangle point downwards



answers on the inside back cover

“People whose minds had been wandering came up with 40 per cent more answers to the problem”

and colleagues studied people who had written a published novel, patented an invention or had art shown at a gallery. In computer tests that required participants to screen out irrelevant information – latent inhibition tests – she found these high achievers were less likely to disregard inconsequential details and focus on the task, compared with an average person. In other words, their minds more frequently wandered from the task at hand, a tendency that may have left them open to novel or left-field ideas.

Even if the work won't help you to win a Pulitzer, it can nevertheless shed light on many of the familiar frustrations we face as we tackle more humdrum creative problems – be it writing a work report or designing a website. After all, we perform little acts of creative thinking just to get us through every day. Only the very biggest ideas come to be recognised by many others and by society – but these are the exception not the rule.

The limitations of a focused mind might explain why good ideas always seem to linger outside our reach when we feel under pressure. Numerous studies have shown that anxiety leads to the exact opposite of the freewheeling mindset you need to create

something original. “An anxious mood comes with a high degree of focus,” says Mark Jung-Beeman of Northwestern University in Evanston, Illinois, who has investigated the connection between mood and creativity with Karuna Subramaniam.

Instead of forcing yourself to concentrate, the best approach when a deadline looms may be to loosen your grip and take a quick break. By monitoring “alpha” brain waves associated with a chilled mindset, Bhattacharya found that people in a relaxed mood were more likely to find creative solutions to word puzzles. “If you consider attention as a spotlight,” he says, “it becomes diffuse and splayed out.”

Take it lying down

Even listening to jokes helps. Subramaniam and colleagues found that watching a Robin Williams stand-up routine helped people subsequently solve mental puzzles. By contrast, those who had just watched a horror movie clip struggled. In another experiment, simply lying down led some participants to feel more relaxed, and therefore solve more anagrams – another type of insight problem.

Since we find it difficult to concentrate when we are tired, you might want to flex your creativity when you feel most groggy. Early birds, for instance, find more original solutions late at night, while night owls do better early in the morning.

If all else fails, a stiff drink can lubricate the mind's cogs. We all know that alcohol can lead even the most focused minds astray, but just to make sure, Schooler and other psychologists decided to get some students drunk before tasting their concentration. Sure enough, the tipsy students found themselves drifting more often than sober participants. That may explain why students stoked up on a vodka-cranberry mix were better able to solve a series of tricky word puzzles that require creative, rather than analytical, solutions. They solved them faster, and in greater number, than those on soft drinks. By the same token, you should avoid coffee – since caffeine focuses your concentration, it's likely to keep a lid on your creative thinking.

Perhaps you are already in the blissful state of a daydream, though hopefully I managed to hold your attention for most of this article. Still, were you paying attention to the three typos in the previous paragraph? Well done if so. If your mind was somewhere else at that moment, however, I shall take heart in the fact that you were in a creative place. ■



SOPHIE CHIVET / AGENCE VU/CAMERA PRESS

Meditation isn't just for mystics - it can actually improve your mental and physical health, says Michael Bond

Everybody say *ommm*



Time spent meditating
is time well spent

It all sounds very rewarding, but what does science have to say on the subject?

Stories abound in the media about the transformative potential of meditative practice, but it is only in recent years that empirical evidence has emerged. In the past decade, researchers have used functional magnetic resonance imaging (fMRI) to look at the brains of experienced meditators such as Ricard as well as beginners, and tested the effects of different meditative practices on cognition, behaviour, physical and emotional health and brain plasticity. A scientific picture of meditation is now coming together. It suggests that meditation can indeed change aspects of your psychology, temperament and physical health in dramatic ways. The studies are even starting to throw light on how meditation works.

“Time spent earnestly investigating the nature of your mind is bound to be helpful,” says Clifford Saron at the Center for Mind and Brain at the University of California, Davis. And you don’t need a Buddhist or spiritualist world view to profit from meditation. “One can be an empiricist [in meditation], just by working with the nature of your experience.” Saron should know – he led the Shamatha project, one of the most comprehensive scientific studies of meditation ever.

In 2007, Saron and a team of neuroscientists and psychologists followed 60 experienced meditators over an intensive three-month retreat in the Colorado Rockies, watching for changes in their mental abilities, psychological health and physiology. The participants practised for at least five hours a day using a method known as focused attention meditation, which involves directing attention on the tactile sensation of breathing (see “How to meditate”, page 26).

The first paper from the project was published in June 2010. Headed by Katherine MacLean at Johns Hopkins University School of Medicine in Baltimore, the study measured the volunteers’ attention skills by showing them a succession of vertical lines flashed up on a computer screen. They then had to indicate, by clicking a mouse, whenever there was a line shorter than the rest. As the retreat progressed, MacLean and her colleagues found that the volunteers became progressively more accurate and found it increasingly easy to stay focused on the task for long periods.

Other researchers have also linked meditation with improved attention. In 2011 a team led by Antoine Lutz, now at the Lyon

Neuroscience Research Center at INSERM, the French national medical research agency, reported that after three months of training in focused attention meditation, volunteers were quicker at picking out different tones among a succession of similar ones, implying their powers of sustained concentration had improved. In 2007, Lutz’s colleague Heleen Slagter, now at the University of Amsterdam in the Netherlands, published results from a study involving a combination of focused attention and “open monitoring” or mindfulness meditation – which involves the constant monitoring of moment-by-moment experience. After three months of meditation for between 10 and 12 hours a day her subjects showed a decreased “attentional blink”, the cognitive processing delay, usually lasting about half a second, that causes people to miss a stimulus such as a number on a screen when it follows rapidly after another.

The suggestion that meditation can improve attention is worth considering, given that focus is crucial to so much in life, from the learning and application of skills to everyday judgement and decision-making, or simply concentrating on your computer screen at work without thinking about what you will be eating for dinner. But how does dwelling on your breath for a period each day

“Volunteers noticed a decreased sensitivity to pain after just a few sessions of meditation”

lead to such a pronounced cognitive change?

One possibility is that it involves working memory, the capacity to hold in mind information needed for short-term reasoning and comprehension. The link with meditation was established recently by Amishi Jha at the University of Miami in Coral Gables. She trained a group of American marines to focus their attention using mindfulness meditation and found that this increased their working memory. MacLean points out that meditation is partly about observing how our sensory experiences change from moment to moment, which requires us to hold information about decaying sensory traces in working memory.

MacLean and others also believe that meditation training enhances some central cognitive faculty – as yet unknown – that is used in all basic perception tasks. “It’s like a ➤

MANY people see meditation as an exotic form of daydreaming, or a quick fix for a stressed-out mind. My advice to them is, try it. It’s difficult, at least to begin with. On my first attempt, instead of concentrating on my breathing and letting go of anything that came to mind as instructed by my cheery Tibetan teacher, I got distracted by a string of troubled thoughts and then fell asleep. Apparently this is normal for first-timers.

Experienced meditators will assure you that it is worth persisting, however. “Training allows us to transform the mind, to overcome destructive emotions and to dispel suffering,” says Buddhist monk Matthieu Ricard. “The numerous and profound methods that Buddhism has developed over the centuries can be used and incorporated by anyone. What is needed is enthusiasm and perseverance.”

muscle that can be used in lots of different ways,” she says. Then, once perception becomes less effortful, the brain can direct more of its limited resources to concentration. Backing up this idea, Slagter’s measurements of electrical activity in the brain during the attentional blink task revealed that as meditation training progressed, volunteers used fewer resources when processing the first stimulus, meaning they were less likely to get “stuck” on it and miss the second stimulus.

Feeling better

Along with enhancing cognitive performance, meditation seems to have an effect on emotional well-being. A second study from researchers with the Shamatha project concluded that meditation improves general social and emotional functioning, making study participants less anxious, and more aware of and better able to manage their emotions.

A clue about how this might work comes from the finding that the volunteers also got better at a task in which they had to look at a screen and click a mouse whenever a long line appeared, but resist the urge to click at the appearance of shorter lines. This is harder than it sounds, especially as the shorter lines appear infrequently. Lead author Baljinder Sahdra, now at the Australian Catholic University in Strathfield, reasons that meditation training teaches people to “withhold impulsive reactions to a lot of internal stimuli, some of which can be emotionally intense in nature”, adding that



SAM DIEHLUS/CORBIS

Centuries of Buddhist insight are now available to everyone

this kind of restraint seems to be a key feature of healthy emotion regulation.

The notion that by practising meditation people become less emotionally reactive is also reinforced by brain imaging work. A team led by Julie Brefczynski-Lewis at West Virginia University in Morgantown used fMRI to study meditators “in action”. The researchers found that the amygdala – which plays a crucial role in processing emotions and emotional memories – was far less active

in expert meditators than in novices.

The ability to manage one’s emotions could also be key to why meditation can improve physical health. Studies have shown it to be an effective treatment for eating disorders, substance abuse, psoriasis and, in particular, for recurrent depression and chronic pain. In 2010, psychologist Fadel Zeidan, at Wake Forest University School of Medicine in Winston-Salem, North Carolina, reported that his volunteers noticed a

HOW TO MEDITATE

There are numerous styles of meditation, but the two most commonly studied by researchers are focused attention meditation, in which the aim is to stay focused on a chosen thing such as an icon, a mantra or the breath; and mindfulness or open monitoring meditation, where practitioners try to become aware of everything that comes into their moment-by-moment experience without reacting to it.

For focused attention

meditation, start by sitting on a cushion or chair with your back straight and your hands in your lap and eyes closed. Then concentrate your mind on your chosen object – say your breathing, or more particularly the sensation of your breath leaving your mouth or nostrils. Try to keep it there. Probably your mind will quickly wander away, to an itch on your leg, perhaps, or to thoughts of what you will be doing later. Keep bringing it back to the breath.

In time this will train the mind in three essential skills: to watch out for distractions, to “let go” of them once the mind has wandered, and to re-engage with the object of meditation. With practice, you should find it becomes increasingly easy to stay focused.

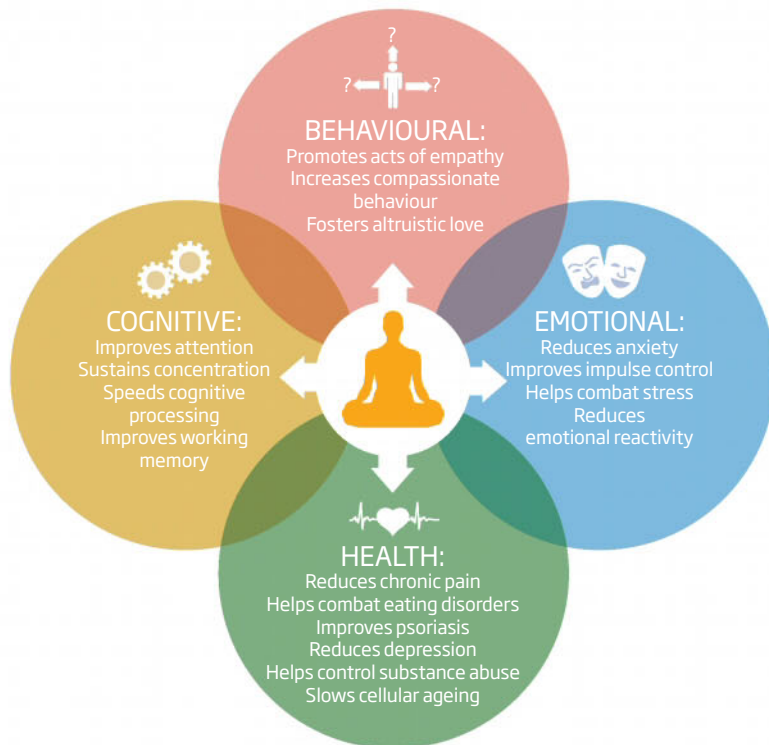
In mindfulness meditation the aim is to monitor all the various experiences of your mind – thoughts, emotions, bodily sensations – and simply observe them, rather than trying to focus

on any one of them. Instead of grasping at whatever comes to mind, which is what most of us do most of the time, the idea is to maintain a detached awareness. Those who develop this skill find it easier to manage emotions in day-to-day life.

The more you practise, the deeper the changes will be. As Buddhist teacher Alan Wallace puts it: “You have now set out on one of the greatest expeditions as you explore the hidden recesses of your mind.”

Transcending metaphysics

Scientific studies show that meditation has many measurable benefits



“One of the hottest areas in meditation research is whether it can enhance feelings towards others”

decreased sensitivity to pain after just a few sessions of mindfulness meditation. He believes meditation doesn't remove the sensation of pain so much as teach people to control their emotional reaction to it and reduce the stress response. “There's something very empowering about knowing you can alleviate some of these things yourself,” he says.

The positive effect of meditation on psychological well-being could also explain findings from the Shamatha project that regular meditation practice can lead to a significant increase in the activity of telomerase, an enzyme that protects against cellular ageing and which is suppressed in response to psychological stress.

Emotions may also be at the heart of another benefit of meditation. One of the hottest areas in meditation research is whether the practice can enhance feelings towards others. This arose partly because fMRI studies by Lutz and his team showed that brain circuits linked to empathy and the sharing of emotions – such as the insula and

the anterior cingulate cortex – are much more active in long-term meditators than in novices.

Compassion is a complicated construct that probably involves a host of emotional skills, according to Margaret Kemeny at the University of California, San Francisco. “To be compassionate with someone, first you have to recognise that they are experiencing a negative reaction. Then you have to consider what a beneficial response might be. Then you have to have the motivation to do something about it.” In other words, you are unlikely to increase someone's capacity for compassion without improving their emotional balance.

A gym for your mind

In 2009, an institute dedicated to studying the neurobiological roots of empathy and compassion opened at Stanford University in California. The Center for Compassion and Altruism Research and Education, which was set up with money from the Dalai Lama, among others, has already instigated a clutch of studies. They aim to discover how a special kind of meditation training – in which the practitioner focuses on enhancing their altruistic love for others – affects the brain and the extent to which it can cultivate empathic and compassionate feelings and behaviour.

The suggestion that people can become

more empathic and compassionate through meditation practice has prompted psychologist Paul Ekman and Alan Wallace, a Buddhist teacher and president of the Santa Barbara Institute for Consciousness Studies, to float the idea of mental training “gymnasiums”. Like physical exercise gyms, but for the mind, these would allow people to drop in and learn to improve their emotional balance, develop their capacity for compassion and even measure their stress levels.

Others have suggested that meditation could become an alternative to medication. Although this seems like a good idea, Saron is dubious. He worries that thinking of meditation as a quick fix will smother some of the subtleties that are integral to successful practice. “When you are returning your mind to the object in hand, you have to do it with a sense of gentleness and authority, rather than develop a sense of failure when your mind wanders.”

But the great thing about meditation is that anyone can practise it anywhere. What's more, you don't have to be an expert or spend five hours a day at it to reap the benefits. The novices in Zeidan's pain experiment reported improvements after meditating for just 20 minutes a day for three days. In a second experiment he found that similarly brief sessions can improve cognitive performance on tasks that demand continuous attention, such as remembering and reciting a series of digits. “It is possible to produce substantial changes in brain function through short-term practice of meditation,” says Richard Davidson, director of the Waisman Laboratory for Brain Imaging and Behavior at the University of Wisconsin-Madison. He says data from his lab shows “demonstrable changes in brain function” in novice meditators after just two weeks of training for 30 minutes a day. “Even small amounts of practice can make a discernible difference.”

That is good news for beginners like me. Still, it does seem that the more you meditate, the greater the impact on your brain. Research by Brefczynski-Lewis, for example, revealed changes in brain activity indicating that expert meditators require minimal cognitive effort to stay focused. But this particular effect was only evident in people who had spent around 44,000 hours meditating – the equivalent of working for 25 years at a full-time job. Most of us will probably never achieve that level of transcendence, but it's certainly something to aim for. ■

CHAPTER TWO
WHAT NOT TO EAT

Sickly sweet

It has been called toxic, addictive and deadly. Is sugar really that bad, asks Tiffany O'Callaghan



TIM GEORGE/SONGALLERY/STOCK



IMAGINE you are sitting at a table with a bag of sugar, a teaspoon and a glass of water. You open the bag and add a spoonful of sugar to the water. Then another, and another, and another, until you have added 20 teaspoons. Would you drink the water?

Even the most sweet-toothed kid would find it unpalatably sickly. And yet that is the amount of sugar you are likely to eat today, and every day – usually without realising it.

Sugar was once a luxury ingredient reserved for special occasions. But in recent years it has become a large and growing part of our diets. If you eat processed food of any kind, it probably contains added sugar. Three-quarters of the packaged food sold in US supermarkets has had sugar added to it during manufacturing. You can find it in sliced bread, breakfast cereals, salad dressings, soups, cooking sauces and many other staples. Low-fat products often contain a lot of added sugar.

It's hardly controversial to say that all this sugar is probably doing us no good. Now, though, sugar is being touted as public health enemy number one: as bad if not worse than fat, and the major driving force behind obesity, heart disease and type II diabetes. Some researchers even contend that sugar is toxic or addictive.

As a result, health bodies are gearing up for a "war on sugar". The World Health Organization wants us to cut consumption radically. In the US, doctors and scientists are pressing food companies to reduce sugar and be more open about how much they add; in the UK a group called Action on Sugar campaigns to ratchet down sugar. Politicians are mulling taxes on sugary drinks. But is sugar really that bad? Or is it all a storm in a teacup – with two sugars please?

When nutrition scientists talk about sugar they are not fretting about sugars found naturally in food such as fruit and vegetables, or the lactose in milk. Instead they are worried about added sugar, usually in the form of sucrose (table sugar) or high-fructose corn syrup (see "Sugar basics", page 30).

Our early ancestors would have been totally unfamiliar with these refined forms of sugar, and until relatively recently sugar was a rare and precious commodity. Only in the 1700s, after Europeans had introduced sugar cane ➤

Sugar basics

■ “Sugar” refers to a large class of sweet-tasting, energy-dense carbohydrates. The simple sugars glucose, fructose and galactose, and the more complex sucrose and lactose, are the most familiar.

■ The sugar added to food by manufacturers is usually either table sugar, which is sucrose, or high-fructose corn syrup. Sucrose is made up of a molecule of glucose and a molecule of fructose bonded together; they are split during digestion. High-fructose corn syrup, a mixture of glucose and fructose, is often portrayed as healthier than sucrose, but most researchers now agree that they are largely the same.

■ Calculating how much added sugar is in your diet is difficult. Food labels don’t distinguish between natural and added sugar – a loophole the food industry is in no hurry to close.

■ Nutrition scientists also talk about “free sugar” in food, which includes added sugar plus any sugars found in fruit juices, honey, maple syrup and so on.

to the New World and shackled its cultivation to slavery, did it become a regular feature of the Western diet. In 1700, the average English household consumed less than 2 kilograms of table sugar a year. By the end of the century that amount had quadrupled.

The upward trend has continued largely unbroken ever since. Between the early 1970s and the early 2000s, adults in the US increased their average daily calorie intake by 13 per cent, largely by eating more carbohydrates, including sugar. In 1996, the average US adult swallowed 83 more calories per day from added sugar than in 1977. Today, yearly sugar consumption in the US is close to 40 kilograms per person – more than 20 teaspoons a day.

The sugar rush has many causes, but one of the most important was the invention of high-fructose corn syrup in 1957. HFCS is a gloopy solution of glucose and fructose that is as sweet as table sugar but has typically been about 30 per cent cheaper.

Once this source of sweetness was available, food manufacturers added it liberally to their products (see charts, page 32). “Because hunger is no longer an important factor in most developed countries, what can make people eat more?” asks Serge Ahmed, a neuroscientist at the University of Bordeaux, France. “Food pleasure. And what creates food pleasure? Sugar.”

Unfortunately, it is a guilty pleasure. Not all scientists see eye to eye on the health effects of sugar, but there is one point on which most

agree: we don’t actually need it. Luc Tappy, a physiologist at the University of Lausanne in Switzerland, sums it up: “You cannot live without essential fats. You cannot live without protein. It’s going to be difficult to have enough energy if you don’t have some carbohydrate. But without sugar, there is no problem. It’s an entirely dispensable food.”

All that unnecessary sugar adds calories to our diet, so it is no surprise that the rise in consumption coincided with the rise of obesity and related problems such as type II diabetes. In 1960, around 1 in 8 US adults was obese; today more than a third are. Since 1980, obesity levels have quadrupled in the developing world to nearly 1 billion people. One recent study found that for every additional 150 calories’ worth of sugar available per day in a country there is an associated 1.1 per cent rise in diabetes.

So far so simple. But some researchers see something more sinister going on. To them, sugar isn’t just a source of excess calories: it is a poison.

The most outspoken is Robert Lustig, an endocrinologist at the University of California, San Francisco. Described by some of his peers as an anti-sugar evangelist, Lustig’s main beef is with fructose, a simple sugar found naturally in fruit but which is also a component of sucrose and HFCS.

The case against fructose is built on the fact that, unlike glucose, it doesn’t play an essential role in human metabolism (that is



Half a can of
baked beans

2.5

teaspoons
of sugar

Sickly sweet:
The dark side
of our sugar

not to say we need to eat glucose; complex forms of carbohydrate such as starch supply all the glucose our metabolisms need). Our ancestors would have encountered fructose in fruit but in nothing like the quantities we eat today, so part of the argument is that our bodies are simply not adapted to deal with it.

To begin with, fructose is almost exclusively metabolised by the liver. When we eat a lot of it, Lustig and others say, much of it is converted into fat. Fat build-up in the liver can lead to inflammation and scarring and progress to cirrhosis. Fatty liver has also been linked to insulin resistance, a precursor to diabetes.

Toxic attack

Fructose is converted into energy, but Lustig claims that, unlike glucose breakdown, this produces lots of oxygen radicals, dangerously reactive chemicals that attack our bodies and cause ageing. To mop these up requires antioxidants, but how many you get often depends on the quality of your diet. "People who can't afford better food don't get the antioxidants. That's one of the reasons why people in the lower socio-economic strata get sicker on the same dose of sugar," Lustig says.

What's more, unlike glucose, fructose isn't regulated by insulin. This hormone keeps blood glucose levels stable and spurs the production of leptin, the hormone that lets you know when you are full. Fructose doesn't affect leptin production; one small study even suggests it ups the level of its counterpart, ghrelin, the hormone that makes you feel hungry. In other words, fructose encourages overeating.

Finally, eating lots of fructose has been shown in both animal and human studies to boost levels of triglycerides in the blood, which increase the risk of hardened arteries and heart disease.

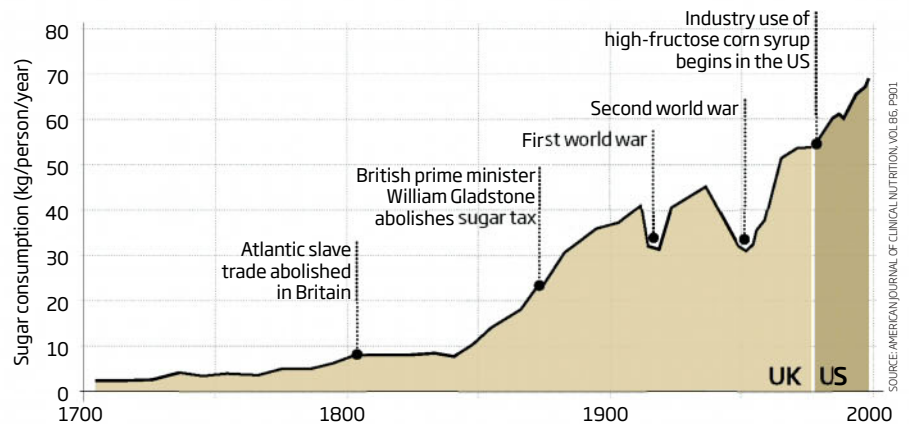
It's a compelling argument that has captured imaginations: a lecture Lustig gave in 2009 has been viewed more than 4 million times on YouTube. Still, many nutrition scientists remain unconvinced. A number of studies have failed to find evidence that fructose is uniquely harmful – though these have been criticised because their authors received funding from food and beverage companies.

More credibly, in 2012 Tappy reviewed all of the evidence against fructose. He concluded that although there is cause for concern in people who already have a metabolic disease or are at risk of developing one, there is no evidence that fructose is the sole, or even the main, cause of these diseases. But the case remains open. "There are many unanswered questions," he says.

Another sinister claim against sugar is that it warps eating habits by altering brain

The taste for sugar

Sugar consumption per person in the UK and US has been steadily rising



chemistry to make us want more. For several years neuroscientists have found it useful to compare energy-dense foods to addictive substances such as cocaine – at least in a metaphorical sense – because it equips them with the language to discuss their habit-forming properties. But is this anything more than a metaphor?

Several studies in rats have shown that a burst of sweetness affects the reward system in the brain in a similar way to cocaine. One study even gave cocaine-addicted rats the option between cocaine and sugar water. "Most turned away from the drug for the sweet reward," says Ahmed, who ran the study.

That sounds damning, but is it also true in humans? Foods high in fat and sugar – called "hyperpalatable" foods – are known to trigger our reward systems by boosting dopamine levels much as addictive drugs do. And there is research suggesting that most people with conditions such as binge-eating disorder display similar psychological characteristics

to people with substance abuse problems. But is that enough to condemn sugar as addictive? And how can you distinguish the allure of sugar from that of fat and salt in these foods?

Although some doctors find the evidence compelling enough that they treat obesity using techniques for treating addiction, the scientific case for food addiction is far from ironclad. In 2013, for example, NeuroFAST, an independent, European Union-funded collaboration between 13 universities that produces "consensus statements" on controversial issues in nutrition science, reviewed all the relevant evidence from human studies. Its conclusion: there is "no evidence" that food can be addictive.

Unsurprisingly, the sugar lobby agrees. "There is little evidence available from human studies, performed in a way that is representative of how food is consumed as part of everyday life," says Glenys Jones from Sugar Nutrition UK, which is mainly funded by UK sugar manufacturers.

So if we can't conclude that fructose is the culprit or that sugar is addictive, where does that leave us? Is it simply that too much sugar equals too many calories? Or has the entire case against sugar been overstated?

This question is now in the hands of the World Health Organization. Alarmed by reports of sugar's dangers, its Nutrition Guidance Expert Advisory Group carried out a review of the evidence with a view to making some recommendations.

As part of that process, in 2013 Lisa Te Morenga, a researcher in human nutrition at the University of Otago in New Zealand, reviewed the research on the relationship between sugar and body weight. She concluded that it wasn't necessarily eating too much sugar that was making us fat, but eating too much of everything. "There was no difference between higher and lower sugars when the energy people were consuming was exactly the same," says Te Morenga. In other words, ➤

"YOU CANNOT LIVE WITHOUT ESSENTIAL FATS. YOU CANNOT LIVE WITHOUT PROTEIN. BUT SUGAR IS AN ENTIRELY DISPENSABLE FOOD"



Reduce or replace?

One obvious way to cut down on sugar is to switch to artificial sweeteners. Unfortunately, recent research casts doubt on their effectiveness.

Instead of helping us skimp on calories while getting the same hit of sweetness, artificial sweeteners may prompt us to eat more. That's because real sugar gives you two hits of sweetness. First, it activates sweet receptors on your tongue, boosting dopamine in the brain. Later, as glucose is absorbed during digestion, the reward system gets a second hit. With artificial sweeteners, you only get the first hit. So by decoupling sweetness from satisfaction, people may be left unsatisfied, and compensate by eating more.

if total calorie count was controlled for, people didn't get any fatter when more of those calories came from sugar. These findings, too, were welcomed by the sugar industry.

So is the white stuff off the hook? Not so fast. When Te Morenga looked at studies that more closely replicate food choices in real life – that is, when participants weren't held to precise calorie counts – those who ate a lot of sugar tended to consume more calories overall and gained more weight. And the most important source of sugar was one that has been high on the list of obesity campaigners' concerns for years: sugary drinks. This was yet more evidence that sweetened drinks really do cause weight gain – which is the strongest reason to point the finger at sugar.

Why does it matter if we consume calories in liquid rather than solid form? Think of it this way. It takes about 2.5 oranges to make a glass of juice. But drinking a glass doesn't make you feel as full as eating two-and-a-half oranges. That's because the fibre in the fruit makes you feel fuller for longer.

As Te Morenga puts it, "all sugar-sweetened drinks really do contribute calories to the diet" – but without making you full. This is partly because fructose, which can make up 65 per cent of the sugar in drinks from soda fountains, doesn't activate the fullness hormone leptin.

This lack of satiety from sugary drinks makes it possible to consume many more calories at a sitting than you would otherwise. Having a sugary drink with a meal, for example, doesn't make you eat less (and replacing it with a diet drink might not help – see "Reduce or replace?", left).

This lack of satiety in exchange for calories seems to have long-term consequences. Several epidemiological studies have linked the consumption of sugary drinks with increased risk of obesity, type II diabetes and

heart disease. That's why soda is a prime target for public health officials: so far legislators in over half the US states have tried and failed to restrict sales in some way, the most famous being New York City's thwarted attempt to ban supersized sodas in 2013.

The failure, in part, can be put down to campaigns by the food industry, which has a long history of waging war against threats to its profits – as the WHO knows only too well.

The WHO's new sugar advice isn't the first of its kind. Ten years ago it tried something similar. After reviewing the evidence it concluded that people should get no more than 10 per cent of their calories from "free sugars" (see "Sugar basics", page 30), otherwise they wouldn't be getting a balanced diet. That was about half of what people were actually consuming.

Industry threats

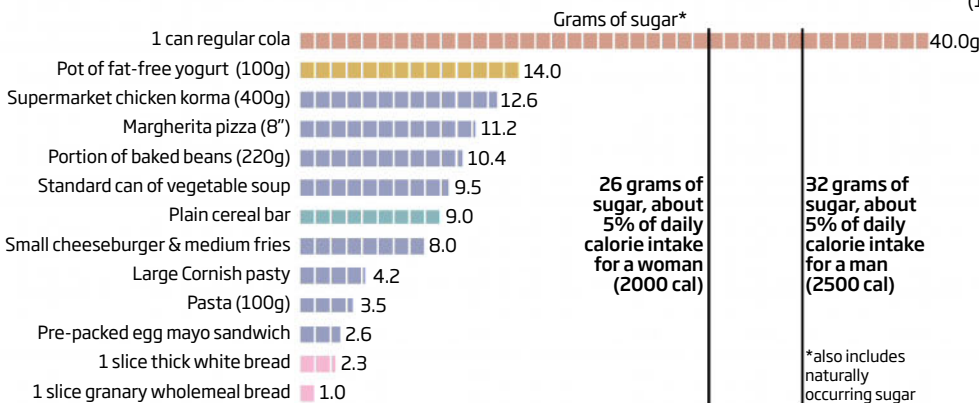
The sugar industry went ballistic. The US Sugar Association wrote to the director general of the WHO, pointing to a report from the US Institute of Medicine suggesting that 25 per cent of daily calories was an acceptable sugar intake, and threatening to put US funding for the WHO in peril if the report was widely circulated. It sent a similar letter to then-US Health Secretary Tommy Thomson.

The report and its 10 per cent figure were still published, but with little fanfare – and almost no impact. Many researchers contacted by *New Scientist* were unsure whether it had ever been released or, if it had, if the 10 per cent figure was included.

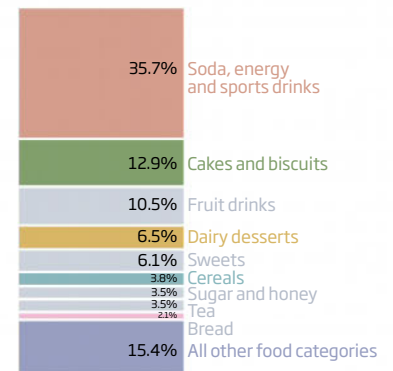
The new WHO guidelines were released for consultation in March 2014. They went further than before, recommending that just 5 per cent of daily calories come from free sugars. That would mean cutting current consumption by two-thirds, to about 8 teaspoons a day for

Stealth sugar

The World Health Organization is now recommending that no more than 5% of calories should come from added sugar. Large quantities are hidden in processed foods...



...meaning the average US adult eats more than 100 grams a day, with most coming from soft drinks (100g sucrose: ~400 calories)





Margherita pizza

2.8

**teaspoons
of sugar**

CORBIS

men and 6 for women. By way of comparison, a standard can of cola contains 10 teaspoons.

This figure won't go down well with the industry. Marion Nestle, professor of nutrition, food studies and public health at New York University, expects them to play dirty again, citing parallels between their tactics and those used by the tobacco industry of yesteryear.

"This is about marketing," she says. "They lobby behind the scenes to make sure that no government agency makes regulations they don't like, they fund election campaigns to do the same thing, they attack critics." They also try to influence the science: "In general the food companies sponsor research to give them the answer they want." WHO director general Margaret Chan has echoed Nestle's concerns.

So what can be done? There are signs that the WHO has learned lessons from 2003. The 5 per cent consumption figure is based less on evidence about sugar's purported link to obesity, and more on a less controversial condition: tooth decay.

One of the WHO's analyses looked at the relationship between sugar and dental cavities. Led by Paula Moynihan at Newcastle University in the UK, the review concluded that there was evidence – albeit of very low quality – to justify reducing intake to 5 per cent to minimise risk of tooth decay.

That looks like smart tactics by the WHO. It will be harder to attack this recommendation as everybody knows that sugar rots your teeth. But the poor quality of evidence leaves plenty

of room for the industry to manoeuvre.

Not all anti-sugar campaigners, though, see the industry as the enemy. For the past two decades, Graham MacGregor of the Wolfson Institute of Preventive Medicine in London has been spearheading a global campaign against dietary salt. He and his colleagues have persuaded the food industry to reduce added salt by about 30 per cent. Now they are trying to do the same with sugar. "There's no point screaming at the industry, it doesn't do any good," he says. "You have to work with them."

"COMPANIES LOBBY BEHIND THE SCENES, ATTACK CRITICS AND SPONSOR RESEARCH TO GIVE THEM THE ANSWER THEY WANT"



GALLERYSTOCK

That, however, is a long-term project, which is why many public-health researchers advocate more aggressive tactics. In October 2013, for example, the *British Medical Journal* published projections that a 20 per cent tax on sugary drinks could reduce the number of obese people in the UK by 180,000.

Of course, taxes drop the debate squarely into familiar political territory: the nanny state versus individual responsibility. Do governments have a duty to intervene or is it down to people to look after themselves?

Te Morenga isn't convinced that sugar is the uber-villain of our health woes, but is confident that the way sugary foods are marketed makes us eat more than we need. "Maybe people should take more personal responsibility," she says. "But we're letting food companies spend millions of dollars to convince people to buy their products – or that soft drinks are a perfectly normal thing to have with a meal."

While politicians weigh up their options, for individuals, the advice is quite simple: try to reduce how much sugar you are consuming. Above all, avoid sugary drinks. "It's the easiest thing to do," says Tappy.

Of course, critics of efforts to curb sugar intake will counter that if you simply eat well and exercise, sugary drinks and snacks can be reasonable indulgences. That's true, so far as it goes. But there is also another simple truth about sugar: however much you might want it, you really don't need it. ■

Friend or foe?

Salt's reputation as a health hazard has recently taken a pounding. **Graham Lawton** sifts through the evidence

ON MY dining table at home sits a container of small, white crystals. One of my daily rituals is to grind some of these crystals on to food; occasionally I dab a finger on to one and pop it into my mouth. They taste metallic and mineral, like the ocean.

Like many people, salt is a routine part of my diet. And yet this mineral that I so casually sprinkle on to my food could kill me. Not immediately, but if I carry on like this, it may well get me in the end.

The World Health Organization says the world is in the grip of a "crisis" of non-infectious diseases. Salt is one of the main culprits because of its effect on blood pressure. Only one substance gives the WHO greater cause for concern, and that is tobacco.

For the past 40 years, doctors around the world have been waging a war on salt. In some places they have been very successful. "All politicians and public health people say we've got to do something about it," says Graham MacGregor, professor of cardiovascular medicine at the Wolfson Institute of Preventive Medicine in London and director of World Action on Salt and Health.

And yet in recent years something has shifted. You might call it a sea change. Headlines have appeared questioning the benefits of eating less salt. Some have claimed salt reduction is positively harmful; even *Scientific American* declared: "It's time to end the war on salt." What is going on? Can four decades of health advice really be wrong?

Salt – or more accurately its constituent ions sodium and chloride – is a vital nutrient.

Sodium and chloride help maintain fluid balance and sodium is one of the ions nerve cells use to create electrical impulses.

The typical food available to our hunter-gatherer ancestors would have been low in salt so we have evolved an exquisite system for detecting it in our diet. One of our five types of taste bud is dedicated to salt, the only one tuned to a single chemical. Unlike energy, our bodies cannot readily store salt and so we are experts at hanging on to it, largely through a recycling unit in the kidneys. It is possible to survive perfectly well on very little salt.

Until recently most humans ate no salt other than what was naturally in their food, amounting to less than half a gram a day. Pure salt only entered the food chain around 5000 years ago when the Chinese discovered it could be used to preserve food.

Salt has since played a leading role in human history. It assisted the transition to settled communities and became one of the world's most valued commodities.

We no longer have to rely on salt to keep food from spoiling, but our appetite for it is undiminished. Most people eat much more salt than they need. Although US dietary guidelines set an adequate intake of 3.75 grams a day, the average Westerner eats about 8 grams; in some parts of Asia, 12 is the norm.

Despite a widespread belief that we have an innate liking for salt, this appetite appears to be learned. People living in traditional societies, such as the highlanders of Papua New Guinea, have no access to pure salt and find it repulsive, but if they move to the city





they quickly take to it. As with chilli and caffeine, it seems we can learn to love the intrinsically aversive flavour of salt.

And like an addictive drug, the more you eat the more you crave, as salt receptors on the tongue become desensitised by overuse. Once they are in this habituated state, unsalted foods taste bland and uninteresting. It can take several weeks of salt withdrawal for taste preferences to return to normal.

It doesn't help that today's diet is full of salt. Around three-quarters of the salt we eat is added to food before it even reaches our plates, not only in the obvious culprits like cured meat and smoked fish but also concealed in breakfast cereal, biscuits, cheese, yogurts, cake, soup and sauces. Even bread is surprisingly salty.

There is a multitude of reasons why processed food is so laden with salt. As well as prolonging shelf life, it makes cheap ingredients taste better and masks the bitter flavours that often result from industrial cooking processes. It can be injected into meat to make it hold more water, thus allowing water to be sold for the price of meat. It improves the appearance, texture and even the smell of the final products. And it makes you thirsty, boosting sales of drinks.

This effortless consumption of salt horrifies doctors. Our kidneys can excrete some excess salt but even so, people who consistently eat more than about half a gram a day – that is, practically all of us – build up excess sodium. To keep fluid concentrations stable, our bodies retain extra water. “We’re all sloshing ➤

around with a litre or a litre and a half compared with what we would be if we were on our evolutionary salt intake,” says MacGregor.

An inevitable consequence of this excess fluid is a rise in blood pressure. Exactly how is not clear. Nor is the reason why some people are more prone than others. But the fact that it does is uncontroversial.

It is the effect on blood pressure that causes problems. High blood pressure is one of the main risk factors for cardiovascular disease; even small increases raise your risk of having a stroke. “Everything that lowers blood pressure works. There’s no argument,” says MacGregor.

For this reason, salt reduction has become one of the most important public health targets in the West. Dietary guidelines vary, but generally recommend eating no more than 5 to 6 grams of salt a day. And these levels are far from ideal – they are merely what is considered realistic in a world awash with salt.

Try calculating your own salt intake and you’ll soon learn how hard it is to meet even this modest target. I worked out my daily total and found that I eat around 8 grams a day.

In theory, salt is an easy target for action. If food manufacturers slowly reduced the salt content of their products, everyone would eat less salt and nobody would even notice as their taste buds gradually resensitised.

Staunch defender

In the UK, this kind of salt reduction was first mooted in 1994 but hastily shelved after protests from food manufacturers. In the intervening years lobbying by scientists, public health groups and bodies such as the Food Standards Agency gradually turned the tide – not least by raising public awareness – and now the industry is broadly reconciled to modest salt reductions. Elsewhere the picture is more mixed, with US manufacturers especially truculent. The most vigorous defender of the status quo is the Salt Institute,

a trade body based in Alexandria, Virginia, representing 37 producers and sellers of sodium chloride. The institute has a long history of trumpeting any research that goes against the orthodoxy and picking holes in the evidence against salt.

So what is the evidence? Over the years dozens of studies have been done and while the findings are far from uniform, the general direction of travel is clear.

One approach is to look for a link between how much salt people eat when left to their own devices and their rates of heart attacks and strokes. Over the years many such studies have been done. In 2009, cardiologist Francesco Cappuccio of the University of Warwick, UK, pooled all the data and found a strong relationship between a salty diet and cardiovascular disease.

Another way is to intervene directly in people’s diets – take two groups of people, get

one of them to eat less salt for a while and see what the outcome is. These trials take more work than observational studies but several have been done. The biggest managed to get thousands of people to cut down on salt by about 2 grams a day for up to four years and saw a 25 per cent fall in cardiovascular disease.

Or you can look at whole countries, taking the before-and-after approach. Fifty years ago northern Japan had one of the world’s biggest appetites for salt – an average of 18 grams a day per person – and shockingly high numbers of strokes. The government implemented a salt reduction programme, and by the late 1960s average salt consumption had fallen by 4 grams a day and stroke deaths were down by 80 per cent. Finland, another salt-guzzling nation, achieved similar gains in the 1970s.

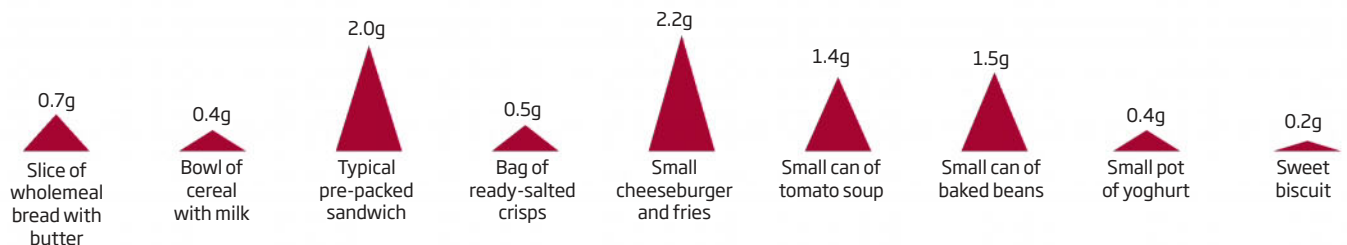
However, the evidence is not always so clear. In July 2011 the Salt Institute was presented



POWER AND SYRED/SCIENCE PHOTO LIBRARY

Well seasoned

Typical salt content of some common processed foods. Recommended upper level per day is 5.0 - 6.0 grams





One of the world's most controversial crystals

epidemiology”, but even in the original analysis the link between salt and death rates only just slipped below statistical significance. Far from casting doubt on salt reduction, some argued that the findings supported it.

The Cochrane report wasn't the end of it. In 2012 Alderman's journal published a further meta-analysis purporting to show that salt reduction could actually be harmful. It concluded that while cutting salt lowered blood pressure, blood levels of certain hormones and lipids were increased, which could theoretically raise cardiovascular risk.

But many of the studies included in the analysis lasted just a few days and involved big salt reductions. MacGregor accepts that sudden and steep salt reduction can lead to counterproductive hormonal changes, but says that modest reductions, say from 8 to 6 grams, do not. “There's no evidence whatsoever that a modest reduction does any harm,” he says.

One lesson from these latest studies is that headlines can be misleading; the devil is in the detail. That is why the salt reducers talk about the “totality of the evidence”. Nutrition science is notoriously hard. You need large numbers of people to detect the outcome of small dietary changes and there are so many confounding factors that sometimes paradoxical results pop up.

“Nutrition is not black and white,” says Susan Jebb of the University of Oxford. “It's not about one definitive trial; it's about the totality of the evidence. In this case the balance of evidence strongly supports

“Try calculating your own salt intake and you'll soon learn how hard it is to meet even modest targets”

reductions in salt.”

There is one way of settling the debate. Take 30,000 people, put half of them on a high-salt diet and half on a low-salt diet for at least five years and see what happens.

Unfortunately, this trial will probably never be done. According to Cappuccino it would be impractically big, prohibitively expensive and ethically questionable – not to mention hard to achieve in today's salt-saturated world. The salt lobby disagrees. “To say it is too expensive and takes too many people is a bogus argument,” says Alderman. “It can be done and it should be done.” As for ethics, he asks which is worse: to do the experiment, or to

with its biggest PR coup for years when the Cochrane Collaboration, an internationally renowned body dedicated to assessing medical evidence, published a long-awaited study on salt and cardiovascular disease.

As is usual for Cochrane, the study was a “meta-analysis”, pooling the results of all the best-designed randomised controlled trials that have been done, the highest standard of proof in medicine. Seven trials met the quality criteria, with over 6000 subjects in total.

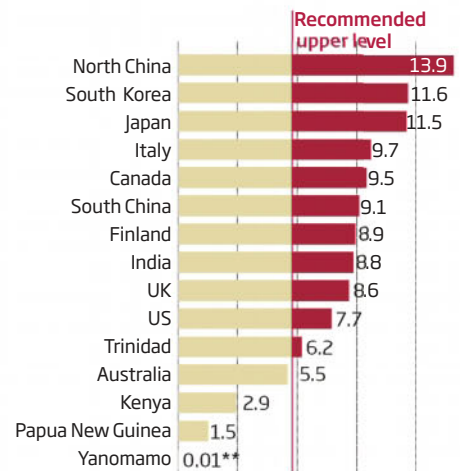
The analysis did show that people who cut back on salt have slightly lower blood pressure and are less likely to die from heart attacks and strokes. But, crucially, the effect on deaths wasn't big enough to be statistically significant. The Cochrane team could not rule out the possibility that the reductions had happened by chance.

The research was published simultaneously by Cochrane and the *American Journal of Hypertension*, whose editor-in-chief Michael Alderman is a long-time critic of salt reduction. In an accompanying editorial, Alderman, who was once a paid consultant for the Salt Institute, repeated his oft-stated claims that there is not enough evidence for salt reduction. Sensing a story, many newspapers ran with his line.

Is Alderman correct? Not surprisingly, MacGregor thinks not. For one thing, he claims the Cochrane study is flawed. When he reanalysed the same data in a slightly different way, he found a reduction that was statistically significant. Alderman criticises this as “salami

An appetite for salt

National average salt intake (grams of salt per day)



** an indigenous people of the Amazon, Brazil/Venezuela border who have the lowest recorded salt intake in the world

SOURCE: BMJ, VOL 326 (FOR AUSTRALIA, WORLD ACTION ON SALT AND HEALTH)

foist salt reduction on everyone without being sure it won't do any harm?

But perhaps the salt lobby will be quite happy for the trial never to happen. Demanding definitive proof before taking action sounds reasonable, but if you know that proof will never arrive then all you are doing is defending the status quo.

Like the tobacco industry before it, the salt industry inevitably feels threatened by public health campaigns aimed at reducing consumption of its one and only product. And as with tobacco, its best tactic is to spread doubt. “What the Salt Institute wants is the idea that there is disagreement among the experts,” says MacGregor. In fact, there are very few independent experts who are against salt reduction.

Even the chief author of the Cochrane study, statistician Rod Taylor at the University of Exeter Medical School, UK, agrees with MacGregor that the findings lend further support to salt reduction. “Our results do not mean that asking people to reduce their intake of salt is not a good thing,” he says.

“We have much stronger evidence for salt than we do for fat, for the benefits of eating fruit and vegetables or losing weight,” argues MacGregor. “There has never been a randomised controlled trial of cigarette reduction. Should we not have done anything about cigarettes?”

Of course it would be nice to wipe salt off the list of things you need to worry about. But you may not live to regret it. ■



HERE'S TO A DRY JANUARY

Andy Coghlan and nine colleagues find that a month of alcohol abstinence made a difference to their livers

“DRY January”, for many a welcome period of abstinence after the excesses of the holiday season, could be more than a rest for body and soul. A recent experiment involving *New Scientist* staff generated the first evidence that giving up alcohol for a month might actually be good for you, at least in the short term.

Many people who drink alcohol choose to give up for short periods, but there is no scientific evidence that this

has any health benefits. So we teamed up with Rajiv Jalan at the Institute for Liver and Digestive Health at University College London Medical School (UCLMS) to investigate.

The liver plays a role in over 500 processes vital for functions as diverse as digesting food, detoxification and hormone balance. In 2009, of the 11,575 deaths from liver disease in the UK, more than a third were attributed to alcohol consumption.

Mine's an orange juice: *New Scientist* staff forswore alcohol for a month and reduced their liver fat by 15 per cent

Most of what we know about liver health comes from studies of people with chronic disease, many of whom are alcoholics. Very few studies have focused on liver function in apparently healthy people.

Our project was on a small scale, but Jalan felt it could yield some useful preliminary information about the effects of short-term abstinence. On 5 October 2013, 14 members of the *New Scientist* staff – all of whom consider themselves to be “normal” drinkers – went to the Royal Free Hospital in London. We answered questionnaires about our health and drinking habits, then had ultrasound scans to measure the amount of fat on the liver. Finally, we gave blood samples, used to analyse levels of metabolic chemicals linked with the liver and overall health.

For the next five weeks, 10 of us drank no alcohol while four continued as normal. On 9 November, we returned to the hospital to repeat the tests.

“You’re going to be very excited,” said Jalan, when the results were in.

First off, he revealed that there had been no significant changes in any of the parameters measured for the four people who didn't give up alcohol.

But the changes were dramatic and consistent across all 10 abstainers (see charts, right).

Liver fat fell on average by 15 per cent, and by almost 20 per cent in some individuals. Jalan says this is highly significant, because fat accumulation on the liver is a known prelude to liver damage. It can cause inflammation, resulting in liver disease. "This transition is the harbinger first for temporary scarring called fibrosis and ultimately a non-reversible type of scarring that destroys liver structure, called cirrhosis," says Jalan. Although our livers were all judged to be generally healthy, the fat reductions would almost certainly help to retard liver deterioration, he says.

Then came another surprise. The blood glucose levels of the abstainers dropped by 16 per cent on average, from 5.1 to 4.3 millimoles per litre. The normal range for blood glucose is between 3.9 and 5.6 mmol/l. "I was staggered," says Kevin Moore, consultant in liver health services at UCLMS. "I don't think anyone has ever observed that before."

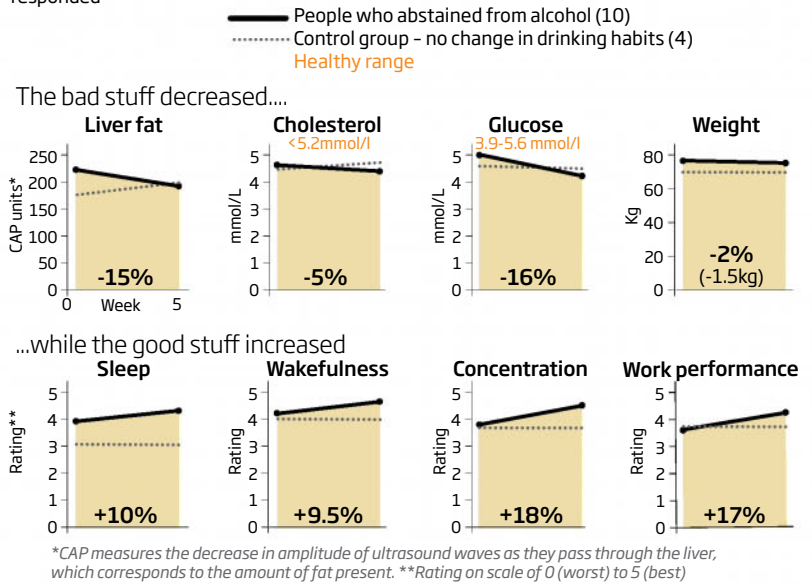
Glucose was measured using a fasting blood glucose test taken after participants had refrained from eating or drinking anything but water for 8 hours. This stimulates production of the hormone glucagon, which releases glucose from body stores into the blood. In a healthy person, a rise in glucose triggers the production of insulin, which tells certain cells to take up glucose from the blood to maintain a safe blood sugar level.

Type 2 diabetes results when cells no longer respond to insulin, leading to high blood sugar. A drop in circulating glucose in our tests could mean that our bodies had become more sensitive to insulin, removing more glucose from the blood – a sign of improved blood sugar control. We also lost weight, by 1.5 kilograms on average.

Total blood cholesterol, a risk factor for heart disease, dropped by almost 5 per cent, from 4.6 to 4.4 mmol/l. A healthy amount is considered anything below 5.2 mmol/l. "Basically, you're getting improved glucose and

Cutting out the booze

A small group of *New Scientist* staff gave up alcohol for 5 weeks. Here's how their bodies responded



cholesterol management," says Moore.

The benefits weren't just physical. Ratings of sleep quality on a scale from 1 to 5 rose by just over 10 per cent, improving from 3.9 to 4.3. Ratings of how well we could concentrate soared 18 per cent from 3.8 to 4.5. "It represents a significant effect on quality of life and work performance," says Jalan, although he acknowledges that self-reported experiences are open to bias.

The only negative was that people reported less social contact.

Our experiment gives no indication of how long the improvements persist. "Whether it's 15 days or six months, we don't know," says Jalan. However, it lays

the ground for larger studies, he says.

"What you have is a pretty average group of British people who would not consider themselves heavy drinkers, yet stopping drinking for a month alters liver fat, cholesterol and blood sugar, and helps them lose weight," says Moore. "If someone had a health product that did all that in one month, they would be raking it in."

Still, that doesn't mean it is OK to indulge for the other 11 months. "That's absolutely the wrong message to give out," says liver specialist Scott Friedman of the Mount Sinai Hospital in New York. "What's surprising is how quickly the benefits were evident, but think about how much you could gain from more prolonged abstinence."

"These results show that even a relatively short period of abstinence impacts on the liver," says Nick Sheron at the University of Southampton, UK. He says that liver disease can develop over the course of 30 years, so a short period of abstinence needs to translate into long-term behaviour change. "But what a hugely encouraging start this is," he says. "And if you can persuade a bunch of journalists to have a month off the booze there is really no excuse for anyone not to be able to do the same thing, is there?" ■

Ultrasound scans measured how "fatty" our livers were





ANTHONY PETERS



Deprive yourself

Going without food could improve your health and brain functioning and perhaps even help you live longer. **Emma Young** gives it a try

THERE'S a fuzz in my brain and an ache in my gut. My legs are leaden and my eyesight is blurry. But I have only myself to blame. Besides, I have been assured that these symptoms will pass. Between 10 days and three weeks from now, my body will adjust to the new regime, which entails fasting for two days each week. In the meantime, I just need to keep my eyes on the prize. Forget breakfast and second breakfast, ignore the call of multiple afternoon snacks, because the pay-offs of doing without could be enormous.

Fasting is most commonly associated with religious observation. It is the fourth of the Five Pillars of Islam. Buddhists consider it a means to practise self-control and advocate abstaining from food after the noon meal. For some Christians, temporary fasts are seen as a way of getting closer to God. But the benefits I am hoping for are more corporeal.

The idea that fasting might be good for your health has a long, if questionable, history. Back in 1908, "Dr" Linda Hazzard, an American with some training as a nurse, published a book called *Fasting for the Cure of Disease*, which claimed that minimal food was the route to recovery from a variety of illnesses including cancer. Hazzard was jailed after one of her patients died of starvation. But what if she was, at least partly, right?

A recent surge of interest in fasting suggests that it might indeed help people with cancer. It could also reduce the risk of developing cancer, guard against diabetes and heart disease, help control asthma and even stave off Parkinson's disease and dementia. Many of the scientists who study fasting practise what they research, and advocate starting around the age of 40. One of them is Mark Mattson at the US National Institute on Aging. "We know from animal models that if we start an intermittent fasting diet at what would be the equivalent of middle age in people, we can delay the onset of Alzheimer's and Parkinson's," he says. Surely worth a try?

Until recently, most studies linking diet with health and longevity focused on calorie restriction. They have had some impressive results, with the lifespan of various lab animals lengthened by up to 50 per cent after their daily calorie intake was cut in half. But

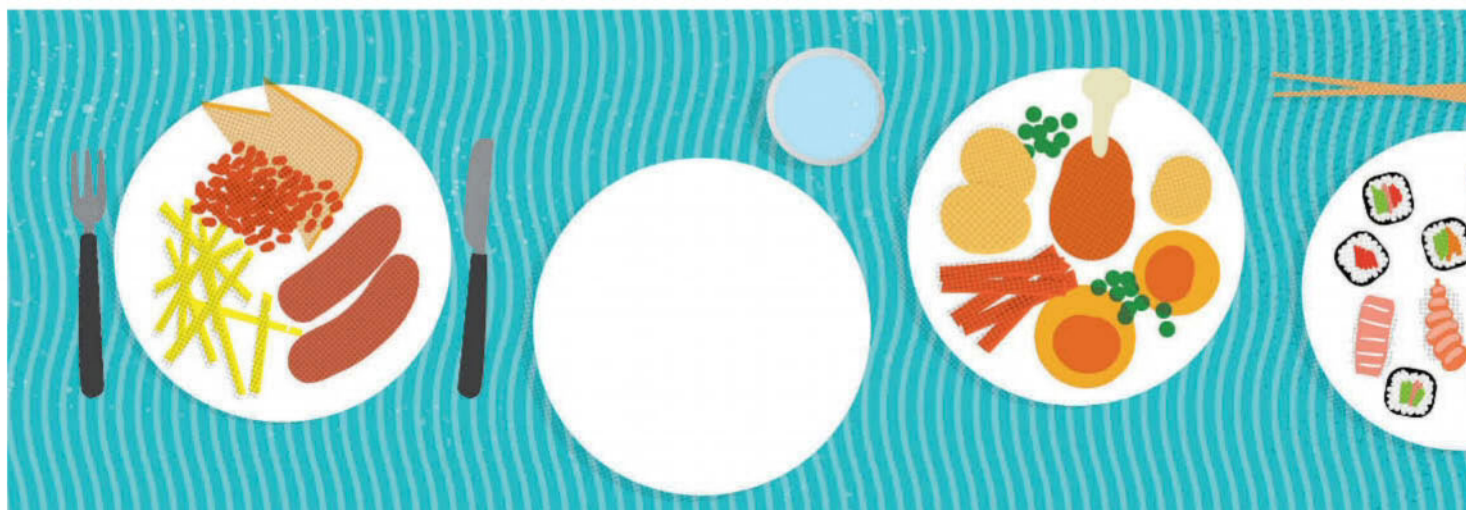
these effects do not seem to extend to primates. A 23-year-long study of macaques found that although calorie restriction delayed the onset of age-related diseases, it had no impact on lifespan. So other factors such as genetics may be more important for human longevity too.

That's bad news for anyone who has gone hungry for decades in the hope of living longer, but the finding has not deterred fasting researchers. They point out that although fasting obviously involves cutting calories – at least on the fast days – it brings about biochemical and physiological changes that daily dieting does not. Besides, calorie restriction may leave people susceptible to infections and biological stress, whereas fasting, done properly, should not. Some even argue that we are evolutionarily adapted to going without food intermittently. "The evidence is pretty strong that our ancestors did not eat three meals a day plus snacks," says Mattson. "Our genes are geared to being able to cope with periods of no food."

What's in a fast?

As I sit here, hungry, it certainly doesn't feel like that. But researchers do agree that fasting will leave you feeling crummy in the short term because it takes time for your body to break psychological and biological habits. Less reassuring is their lack of agreement on what fasting entails. I have opted for the "5:2" diet, which allows me 600 calories in a single meal on each of two weekly "fast" days. The normal recommended intake is about 2000 calories for a woman and 2500 for a man, and I am allowed to eat whatever I want on the five non-fast days, underlining the fact that fasting is not necessarily about losing weight. A more draconian regimen has similar restricted-calorie "fasts" every other day. Then there's total fasting, in which participants go without food for anything from one to five days – longer than about a week is considered potentially dangerous. Fasting might be a one-off, or repeated weekly or monthly.

Different regimens have different effects on the body. A fast is considered to start about 10 to 12 hours after a meal, when you have ➤



used up all the available glucose in your blood and start converting glycogen stored in liver and muscle cells into glucose to use for energy. If the fast continues, there is a gradual move towards breaking down stored body fat, and the liver produces “ketone bodies” – short molecules that are by-products of the breakdown of fatty acids. These can be used by the brain as fuel. This process is in full swing three to four days into a fast. Various

hormones are also affected. For example, production of insulin-like growth factor 1 (IGF-1) drops early and reaches very low levels by day three or four. It is similar in structure to insulin, which also becomes scarcer with fasting, and high levels of both have been linked to cancer.

When it comes to treating cancer, Valter Longo, director of the Longevity Institute at the University of Southern California, thinks

that short-term complete fasts maximise the benefits. He has found that a 48-hour total fast slowed the growth of five of eight types of cancer in mice, the effect tending to be more pronounced the more fasts the animals undertook. Fasting is harder on cancer cells than on normal cells, he says. That’s because the mutations that cause cancer lead to rapid growth under the physiological conditions in which they arose, but they can be at a disadvantage when conditions change. This could also explain why fasting combined with conventional cancer treatment provides a double whammy. Mice with gliomas – a very aggressive cancer and the most commonly diagnosed brain tumour in people – were more than twice as likely to survive the 28-day study if they underwent a 48-hour fast at the same time as radiation therapy than those without the fast.

Clinical trials assessing the impact of fasting in people with cancer are ongoing. Early results are promising, says Longo, and patients in the advanced stages of cancer, who cannot wait for the results, might find it worth discussing fasting with their oncologist.

HOLD THE PROTEIN

One key effect of fasting is that it lowers levels of a hormone called insulin-like growth factor 1. Low levels of IGF-1 are associated with a decreased risk of cancer and increased lifespan. So if you could reduce it by, say, 70 per cent, wouldn’t you? The only catch is that it takes five days without food to do this. But what if you could get the same result simply by altering your diet? Luigi Fontana of Washington University in St Louis, Missouri, thinks it may be possible.

Suspecting that fasting per se is not what matters, Fontana compared the IGF-1 levels of members of the Calorie Restriction Society of Newport, North Carolina, with people who ate a typical Western diet. There was no difference, despite the calorie restriction group having severely reduced their food intake for an average of six years. However, IGF-1 levels among a group of strict vegans were significantly lower.

The key, Fontana believes, is protein, which accounted for just 10 per cent of calories for the vegans but about 25 per cent for the calorie-restricted group.

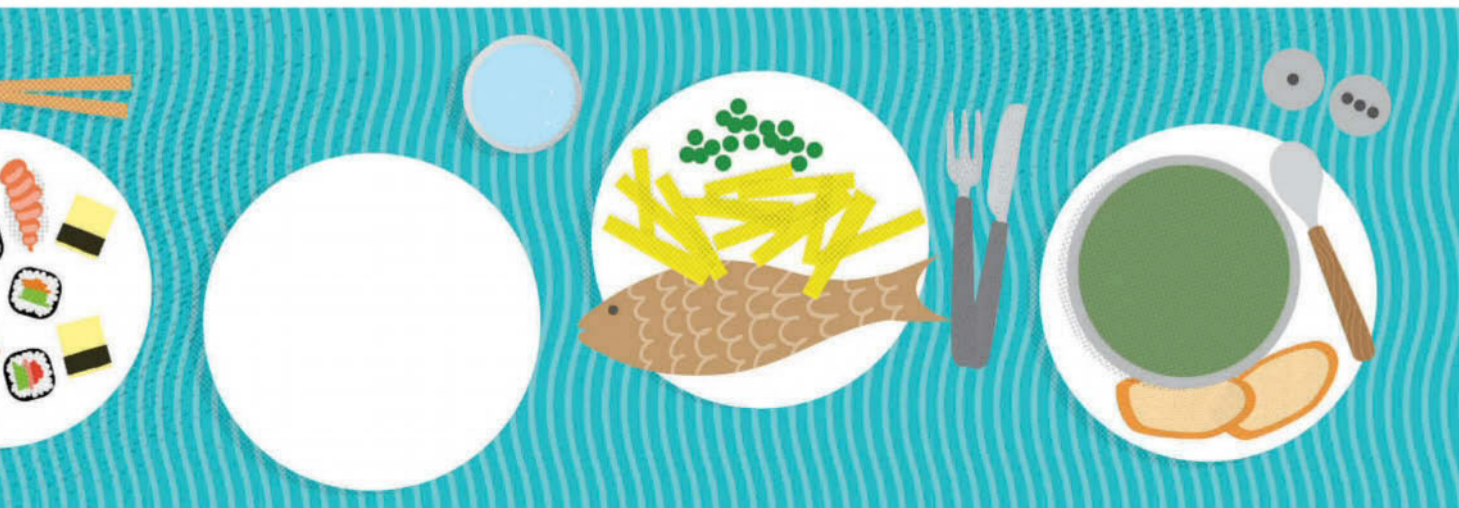
There is strong evidence linking high protein intake with cancer, says Fontana. For example, cancer rates increase for people who move from a low-protein Japanese diet to a relatively high-protein US diet. He has also found that middle-aged people who eat a diet high in animal protein are at greater risk of cancer, diabetes and death.

Fontana doesn’t advocate cutting out protein altogether, just consuming the US recommended daily allowance of 0.8 grams per kilogram of body weight. For an average adult that equates to roughly the same amount of protein as in two chicken breasts – a third less than a typical western diet.

The medical orthodoxy is that lots of protein is good for you, Fontana says. “But I think it’s wrong.”

Less is more

Could fasting prevent cancers developing in the first place? Evidence is scant but there are “very good reasons” why it should, says Longo. He points out that high levels of IGF-1 and glucose in the blood, and being overweight, are all risk factors for cancer, and they can all be improved by fasting. Another risk factor is insulin, says Michelle Harvie at the University of Manchester, UK. Studying women whose family history puts them at high risk of developing breast cancer, she put half of them on a diet that involved cutting calories by about 25 per cent, and half on a 5:2 fast. After



six months, both groups showed a reduction in blood insulin levels, but this was greater in the fasting group. Harvie's team is now analysing breast biopsies to see whether this translates to fewer of the genetic changes associated with increased cancer risk.

High insulin is also associated with type 2 diabetes, so perhaps it is no surprise that fasting shows promise here too. At the Intermountain Heart Institute in Murray, Utah, Benjamin Horne has found that a 24-hour water-only fast, once a month, raises levels of human growth hormone, which triggers the breakdown of fat for energy use, reducing insulin levels and other metabolic markers of glucose metabolism. As a result, people lost weight and their risk of getting diabetes and coronary heart disease was reduced. Alternate day fasting (with a 500-calorie lunch for women and 600-calorie one for men on fast days) has similar benefits, says Krista Varady of the University of Illinois, Chicago. She has seen improvements in levels of low-density lipoprotein cholesterol, sometimes known as "bad cholesterol", and blood pressure, in volunteers eating either a low-fat or high-fat diet on "feeding" days.

For people who are overweight, any kind of intermittent fasting diet will probably help reduce the risk of diabetes and cardiovascular problems, says Mattson. In 2007, he found another benefit too. He put 10 overweight people with asthma on an alternate-day incomplete fast and found that after just a few weeks their asthma symptoms improved. Blood markers of inflammation, including C-reactive protein, also decreased, suggesting that the fast was helping to moderate their overactive immune system. Whether fasting would benefit people with asthma who are in the normal weight range or those with other conditions associated with an overactive

immune response remains to be seen. There is some evidence that alternate-day fasting can lower their levels of blood fat. However, Mattson suspects that when it comes to diabetes and cardiovascular disease, fasting may not be as beneficial for people of normal weight as it is for people who are overweight, simply because they are already likely to be in pretty good shape, metabolically speaking.

Mattson has, however, identified another

perhaps equivalent to 20 years in people.

So, what about the common advice to start the day with a good breakfast? Mattson believes it is flawed, pointing out that the studies were based on schoolchildren who usually ate breakfast, meaning their poor performance could simply be due to the ill effects that occur when people begin fasting. Mattson himself skips breakfast and lunch five days a week, then has dinner and normal

"So what about the common advice to start the day with a good breakfast? Mark Mattson believes it is flawed. He skips breakfast and lunch five days a week"

effect of fasting that he believes can benefit everyone – it is good for the brain. "If you look at an animal that's gone without food for an entire day, it becomes more active," he says. "Fasting is a mild stressor that motivates the animal to increase activity in the brain." From an evolutionary perspective, this makes sense because if you are deprived of food, your brain needs to begin working harder to help you find something to eat. His studies show that alternate-day fasting, with a single meal of about 600 calories on the fast day, can boost the production of a protein called brain-derived neurotrophic factor by 50 to 400 per cent, depending on the brain region. This protein is involved in the generation of new brain cells, and plays a role in learning and memory. It can also protect brain cells from the changes associated with Alzheimer's and Parkinson's. In mice engineered to develop Alzheimer's-like symptoms, alternate-day fasting begun in middle age delayed the onset of memory problems by about six months. "This is a large effect," Mattson says,

weekend meals with his family. Varady has tried alternate-day fasting, but she likes to eat dinner with her young child and husband, so now keeps her food intake to within an eight-hour period. Harvie, however, sounds a more cautious note for anyone thinking of giving fasting a go. "We still don't know exactly who should be fasting, how often or how many days a week," she says. Besides, it may not be without risks. One study in mice, for example, found that an alternate-day fast for six months reduced the heart's ability to pump blood.

There is also the fact that fasting is difficult. Varady finds that between 10 and 20 per cent of people who enrol in her studies drop out, unable to stick to the regime. This may be less of a problem in the future, though. Researchers are now investigating the possibility that you can get some of the health benefits of fasting without actually depriving yourself of food (see "Hold the protein", left).

As I count down the minutes to the end of my fast, I can't help wishing them success. ■



We are constantly being bombarded with health advice, but not all of it is based on rigorous evidence.

Caroline Williams debunks six common myths

Don't swallow them



It's the myth that just won't go away. Almost everyone thinks they don't drink enough water, but the idea that we all should drink lots of it – eight glasses per day – is based on no scientific data whatsoever.

No one really knows where the eight-glasses myth comes from. Some blame the bottled water industry but plenty of doctors and health organisations have also promoted it over the decades. The source might be a 1945 recommendation by the US National Research Council that adults consume 1 millilitre of water for each calorie of food, which adds up to about 2.5 litres per day for men and 2 litres for women.

According to Barbara Rolls, a nutrition researcher at Penn State University and author of the 1984 book *Thirst*, this amount is about right for people in a temperate climate who aren't exercising vigorously. And 1.9 litres is what you'll get from drinking eight 8-ounce glasses of water – the 8 x 8 rule – as per the US version of the myth.

What most people don't realise, though, is that we get a lot of that water from food, as the National Research Council pointed out at the time. Foods contain water and are broken down chemically into carbon dioxide and

DRINK EIGHT GLASSES OF WATER PER DAY

more water. So if you are not sweating buckets you need only about a litre a day – and 1.2 litres is what you will get from the eight 150-millilitre glasses (about a quarter of a pint) recommended by the UK's health service.

But even this is misleading because there is no need to drink pure water. The fluids that people drink anyway, including tea and coffee, can provide all the water we need, says Heinz Valtin, a kidney specialist at Dartmouth Medical School in Hanover, New Hampshire, who has reviewed the evidence.

According to the myth, however, caffeinated drinks don't count because they are diuretic, stimulating the body to urinate and hence lose more water than it gets from the drink. Not true. A comparison of healthy adults in 2000 found no difference in hydration

whether they got their water from caffeinated drinks or not. Even one or two mildly alcoholic drinks – a regular beer or a wine spritzer with a lot of soda, say – will hydrate rather than dehydrate you.

Hydrophilics respond by saying that pure water is better than other drinks. Even this claim is arguable, but the crucial point is that if you are a healthy individual already drinking enough tea, milk, juice or whatever, there is no evidence that swigging down water as well will achieve anything other than making you go to the bathroom all the time.

The final aspect of this myth is that we need to force ourselves to drink because by the time we are thirsty we are already seriously dehydrated. Not so. Rolls showed 30 years ago that we get thirsty long before there is any significant danger to health. It takes less than a 2 per cent rise in the concentration of the blood to make us want to drink, while the body isn't officially regarded as dehydrated until a rise of 5 per cent or more.

So relax and trust your body. Don't force yourself to gulp down gallons of water if you don't want to (that can be dangerous); just drink the drink of your choice whenever you're thirsty. ➤

2

SUGAR MAKES CHILDREN HYPERACTIVE

Every parent has seen it happen: take a group of young children, add sugar, then stand back and watch them bounce off the walls. But although many parents will find it hard to believe, sugar does not cause hyperactivity.

A 1996 review of 12 blinded studies, where no one at the time knew which kids had received sugar and which a placebo, found no evidence to support this notion. This is true even for children with ADHD or whose parents consider them sensitive to sugar.

In fact, one of these studies concluded that the sugar effect is all in parents' minds. Parents and their 5 to 7-year-old "sugar-sensitive" children were split into two groups. The parents of one group were told their children had been given a large dose of sugar, while the others believed their kids were in the placebo group. In reality, all the children had

been given sugar-free food. But when the parents watched their offspring at play afterwards, those who thought their kids were in the sugar group were more likely to rate their behaviour as hyperactive.

Having said all that, sugar does affect kids' brains, although in a surprising way. In one study, David Benton, a psychologist at Swansea University in the UK, found that in the half hour or so after having a glucose drink, 9 to 11-year-old schoolchildren were better able to concentrate on tasks and scored higher in memory tests. That's the opposite of hyperactivity, one characteristic of which is an inability to concentrate.

But don't start plying your kids with sugary drinks – as the study notes, the performance boost may not last long. Non-sugary meals that help the body maintain a constant supply of glucose to the brain are better.

So perhaps what parents mistake for hyperactivity at parties is just sugar-fuelled kids focusing hard on having fun. "Provision of energy is clearly going to increase the possibility of energy expenditure," says Andrew Scholey, who studies glucose and cognitive enhancement at Swinburne University in Melbourne, Australia.



A doughnut can contain eight teaspoons of sugar

We live in a toxic world. You're breathing in lead as you read this. Your next meal will contain everything from natural poisons to pesticides and pollutants. As a result, the human body is a veritable cesspit of suspect chemicals. The last US National Report on Human Exposure to Environmental Chemicals found potentially concerning levels of dozens of undesirable substances, including heavy metals, dioxins, PCBs and phthalate plasticisers, in the blood and urine of Americans.

The question is, what can we do about it? According to popular wisdom, we need to "detox" to get rid of these poisons in our body, and there is no shortage of advice on the best way to accomplish this. But do any of these detox plans actually work? And is detoxing really good for us?

For a start, we are already doing it all the time, with the help of our livers, kidneys and digestive systems. Most of the toxic chemicals we consume are broken down or excreted, or both, within hours.

However, it can take weeks, months or even years to get rid of some substances, especially fat-soluble chemicals such as dioxins and PCBs.

3

OUR BODIES CAN AND SHOULD BE DETOXED

If we take these in faster than our bodies can get rid of them, levels build up in our bodies.

Many detox programmes promote a period of consuming only fluids and no solid food, but this will make virtually no difference to levels of chemicals that have built up over years. "For many of these it will take between six and 10 years of zero exposure

to get rid of one-half of the amount stored in our fat tissues," says Andreas Kortenkamp, a toxicologist at Brunel University in London. "That is not achievable, because, unfortunately, there is no zero exposure."

What's more, fasting or dieting releases fat-soluble chemicals into the blood, rather than eliminating them from the body. One study found the level of organochlorines and pesticides in blood shot up by 25 to 50 per cent after people lost a lot of weight quickly. Animal studies show that this increases the level of compounds in tissues like the muscles and brain, where they can do more harm than in fat.

This sudden flood of chemicals could even cause the kind of problems detoxers are trying to avoid, says Margaret Sears, an environmental health researcher at the CHEO Research Institute in Ottawa, Canada. "These chemicals have toxic effects as endocrine disrupters that paradoxically affect energy levels and appetite, potentially contributing to yo-yo weight loss and gain," she says. Plus there's no guarantee that chemicals released from fat will actually leave



the body - some will end up back in storage.

With chemicals that the body does eliminate rapidly, such as phthalates, a short fast will lower levels. It's not clear that this does you any good, though. As soon as you start eating again, says Kortenkamp, levels go back to where they were.

For these reasons, Sears recommends what she calls a "lifelong detox", which involves eating healthily and avoiding undesirable chemicals as much as you can - although knowing what you are exposed to and how to avoid them is far from easy. And Kortenkamp isn't convinced that even that will help much. "Only regulatory action that reduces exposures will work. Individual avoidance strategies are but a drop in the ocean," he says.

That said, you can greatly reduce your exposure to toxic chemicals like nicotine and alcohol. There is also one way of speeding up the removal of many fat-soluble toxic chemicals that is supported by scientific evidence: producing milk. Although it is possible for women to induce lactation without giving birth - and even for men to lactate - the milk-yourself detox method is unlikely to catch on.

The human body is a veritable cesspit of suspect chemicals

4

ANTIOXIDANT PILLS HELP YOU LIVE LONGER

It seems blindingly obvious. As our cells metabolise the food we eat, they produce rogue molecules called free radicals that wreak havoc. Over a lifetime, the damage they do slowly builds up and may cause all kinds of degenerative diseases. Luckily, though, many chemicals can act as antioxidants that mop up free radicals. Plus, eating vegetables rich in antioxidants seems to reduce the risk of degenerative diseases. So popping pills packed with antioxidants must surely help stave off these diseases too?

That's what some scientists started thinking from the 1970s onwards. The Nobel prizewinning chemist Linus Pauling enthusiastically promoted high doses of vitamins without waiting for the evidence, the public lapped it up and a whole new industry sprang up to meet demand.

Then, in the 1990s, the results of rigorous clinical trials of some of the most popular supplements, including beta-carotene, vitamin E and vitamin C, started to come in. Study after study found that while these substances do work as antioxidants in the test tube, popping them in pill form does not provide any health benefit.

On the contrary: some studies suggest that they are harmful. A 2007 review of nearly 70 trials involving 230,000 people concluded not only that antioxidant supplements do not increase lifespan, but that supplements of beta-carotene and vitamins A and E actually seem to increase mortality.

Why? Perhaps because high levels of free radicals tell cells to ramp up their own built-in antioxidant defences, says Barry Halliwell, a biochemist at the National University of Singapore. He thinks these internal defences are far more effective than the antioxidants we get from food. So by taking supplements, we may be deactivating a first-rate defence mechanism and replacing it with a poorer one. "Free radicals in low amounts also play useful roles," Halliwell says.

If this is right, the benefits of vegetables may have nothing to do with antioxidants. One suggestion is that vegetables are beneficial because they are mildly poisonous - a little poison may activate protective mechanisms that ward off disease.

In the meantime, the antioxidant juggernaut rolls on. No one seems keen to abandon the idea that antioxidant supplements are good for you. ➤

PETER DAZEL/GETTY

5

BEING A BIT OVERWEIGHT MEANS YOU WILL DIE SOONER

Let's be clear: being seriously obese is bad for your health. A body mass index of over 40 increases the risk of type 2 diabetes, heart disease and certain cancers and increases the risk of dying from any cause by up to 29 per cent. This is not a health myth.

But carrying just a few extra pounds, far from being a one-way ticket to an early grave, seems to deter the grim reaper, according to a 2013 review of nearly a hundred studies involving nearly 3 million people. The review, led by Katherine Flegal of the US Centers for Disease Control in Hyattsville, Maryland, and published in *The Journal of the American Medical Association*, reported that being "overweight" - defined as having a body mass index (BMI) of 25 to 29 - seems to have a protective effect, with a 6 per

cent reduction in death risk compared with people with a BMI of between 18.5 and 25. Those with BMIs over 35, however, have a higher risk.

It isn't clear why being overweight might protect against an early death. Perhaps carrying a few extra pounds in reserve helps the body fight off illness or infection. Perhaps overweight people are more likely to receive medical attention. Or perhaps some of those counted as "normal" had lost weight due to serious illnesses.

Whatever the reason, Flegal says her finding is not a green light to eat all the pies. Overweight people might be more likely to develop diseases that affect the quality of life, for instance. Even so, it seems that a little bit of flab may not be the crime against health it has always been made out to be.

6

WE SHOULD LIVE AND EAT LIKE CAVEMEN

Some aspects of the diet, such as eating less highly-processed grains and sugars, agree with the latest evidence. But others, such as ditching grains, legumes and dairy, do not. And in any case the underlying rationale is flawed.

The idea that there was some evolutionary sweet spot 50,000 years ago just isn't true, says Marlene Zuk, an evolutionary biologist at the University of Minnesota in St Paul, who has written a book criticising the paleo lifestyle. Our ancestors were not perfectly adapted to their lifestyles, and we have adapted somewhat to our agricultural diet.

For instance, many people have extra copies of genes for digesting the starch found in grains. The ability to digest milk as an adult - lactose tolerance - has also evolved independently in several populations.

Another criticism is that we don't know for sure what our ancestors ate, and their diets probably varied from place to place. Even if we did know, replicating it in the modern world would not be easy. The animals and plants we eat have been transformed beyond recognition by selective breeding.

Last but not least, it's not clear that ancient hunter-gatherers really were that much healthier than us.

The original proponents of the discordance hypothesis stand by their idea, but they have revised it in light of the latest evidence. Eaton and Konner now include low-fat dairy products and whole grains in their recommended foods. ■

Aspects of the paleo diet do not agree with the evidence

Our bodies didn't evolve for lying on a sofa watching TV and eating processed food. They evolved for running around hunting game and gathering fruit and vegetables. So, the myth goes, we'd all be a lot healthier if we lived and ate more like our ancestors.

This "evolutionary discordance hypothesis" was first put forward in 1985 by medic S. Boyd Eaton and anthropologist Melvin Konner, both of Emory University in Atlanta, Georgia. In it they claimed that while our genes haven't changed for at least 50,000 years, our diets and lifestyles have changed greatly since the

advent of agriculture 10,000 years ago, and it has all happened too quickly for us to evolve to deal with it. This, they argued, is the reason why diabetes, heart disease and cancers are rife. If we could only exercise more and eat like hunter-gatherers, we'd be much healthier.

In recent years, diets based on these ideas have become very popular. These Stone Age or "paleo" diets involve eating game, fish, fruit, non-starchy vegetables and nuts, and avoiding grains, dairy, legumes, oils, salt and refined sugars. Some do not allow food to be cooked; most require abstinence from alcohol.





How to live to **100** ...and enjoy it

Perhaps you think you stand no chance of clocking up a century. You know that longevity depends in large part on having the right genes, and one glance at the family tree may reveal that yours just won't pass muster. If so, think on this: centenarians are the fastest-growing demographic group across much of the developed world. Assuming there hasn't been a miraculous Methuselah mutation in the human genome in the past hundred-odd years, we can draw only one conclusion: the way we live is stretching our lifespans. So, what are the secrets of a long and happy life? The science of longevity can help you find out how to maximise your tally at the final checkout, without compromising any urges you might have to dance in the aisles on the way there

COLIN HAWKINS/TAXI



GRANSEK/LAIF/CAMERA PRESS

1 Go for the burn

How's this for an elixir of youth: an X-ray, a mild case of sunburn, a couple of beers and a sauna. If you think all that would leave you feeling anything but youthful, think again. Many researchers believe that small doses of "stressors" such as poisons, radiation and heat can actually be good for you – so good that they can even reverse the ageing process.

This counter-intuitive effect, called "hormesis", was once considered flaky, but over the past decade it has been shown to extend longevity in yeast, fruit flies, protozoans, worms and rodents. If the findings extend to people, it could stretch the average healthy human lifespan to 90, says biologist Joan Smith-Sonneborn of the University of Wyoming in Laramie.

How so? Stressors seem to kick-start natural repair mechanisms, including heat-shock proteins and DNA-repair enzymes, to fix the damage they have caused. If this damage is not too severe, the repair systems may overcompensate, building up enough oomph

to repair unrelated damage as well. And if you accept the idea that damage equals ageing, this is nothing less than rejuvenation.

There is already some indirect evidence that hormesis has positive effects on human longevity. Between 1980 and 1988, researchers at Johns Hopkins University in Baltimore, Maryland, tracked 28,000 nuclear shipyard workers to study the effects of low doses of radiation. To their surprise, they found that the mortality rate of these workers was 24 per cent lower than in a control group of 32,500 shipyard workers of similar ages who were not exposed to radiation.

An earlier study by the legendary epidemiologist Richard Doll found similar low death rates among radiologists compared with other doctors. One explanation for this is that the radiologists received low doses of X-rays on a regular basis.

You may not even have to expose yourself to poisonous chemicals or radiation to see the benefits of hormesis. Some compounds with supposed anti-ageing properties, notably



vitamin E and melatonin, seem to act hormetically in protozoans: increasing longevity when given in small amounts but not large ones.

Meanwhile, a number of researchers think caloric restriction – one of the most widely studied and reliable methods of increasing lifespan in animals – works because it is a mild stressor. Unfortunately (or perhaps fortunately, if you like your food), the latest research suggests it does not work in primates (for more on caloric restriction see “Watch what you eat”, page 56).

In any case, there may be a more reliable and slightly less onerous way to trick your body’s repair mechanisms into overdrive. Smith-Sonneborn and others suspect that the life-extending effects of exercise are also down to hormesis. She proudly practises what she preaches with an exercise regime that she says stresses her body to just the right level to get the optimum response. It seems to be working: at the age of 70 she had the bone density of a 35-year-old. **Graham Lawton**

“I hope this marriage will last”

Wook Kundor, a 104-year-old Malaysian, after getting hitched in 2005 for the 22nd time, to a man of 33

Don't be a loner

2

Being sociable looks like one of the best ways to add years to your life. Relationships with family, friends, neighbours, even pets, will all do the trick, but the biggest longevity boost seems to come from marriage or an equivalent significant-other relationship. The effect was first noted in 1858 by William Farr, the British founding father of demography, when he penned (with a quill) that widows and widowers were at a much higher risk of dying than their married peers. Large statistical studies carried out since then suggest that marriage could add as much as seven years to a man’s life and two years to a woman’s – although one study suggests that your partner’s age might have some influence on this.

Even if the odds are stacked against you, marriage can more than compensate. Linda Waite of the University of Chicago has found that a married older man with heart disease can expect to live nearly four years longer than an unmarried man with a healthy heart. Likewise, a married man who smokes more than a pack a day is likely to live as long as a divorced man who does not smoke. There is a flip side, however, as partners are more likely to become ill or die in the couple of years following their spouse’s death or hospitalisation, and caring for a spouse with dementia can leave you with some of the same severe cognitive problems, largely because of disturbed sleep patterns. Even so, the odds favour marriage. What’s more, in a 30-year study of more than 10,000 people, Nicholas Christakis, now at the Yale Institute for Network Science, describes how all kinds of social networks have similar effects.

So how does it work? The effects are complex, affected by socio-economic factors, health-service provision, information distribution, emotional support and other more physiological mechanisms. For example, social contact can boost development of the brain and immune system, leading to more robust health and less chance of depression later in life. People in supportive relationships may handle stress better. Then there are the psychological benefits of a supportive, kindly partner. Elderly people who hear loving positive words are more sprightly in step and less likely to request a “do not resuscitate” instruction when admitted to hospital than those who hear negative comments.

A life partner, children and good friends are all recommended if you aim to live to 100. The ultimate social network is still being mapped out, but as Christakis says: “people are interconnected so their health is interconnected”. **Helen Phillips**

The world is dotted with longevity hotspots where the number of centenarians exceeds 10 in 100,000. But why? Perhaps the locals are genetically primed for longevity. It could be something in the water. Or it may simply be that these are statistical flukes – places where oldies outnumber youngsters, so increasing the proportion likely to pass the 100 mark. Whatever the reason, the very existence of hotspots raises the question of what sort of environment is most conducive to a long life.

Although small doses of radiation and toxins can be beneficial, a neighbourhood humming with either is an obvious no-no. There are also some more subtle environmental influences you should avoid if you want to live long and prosper. A study of elderly residents from a poor area of St Louis, Missouri, found that factors such as low air quality and dirty streets tripled the likelihood of their suffering from disabilities in later life. Likewise, data from the UK Office for National Statistics found that men living in the poorest suburbs of Glasgow have a life expectancy of less than 71 – almost 14 years shorter than people in wealthier areas of the UK.

Still, teasing out the various factors at play here is tricky to say the least, and there are wildly differing views about whether it is our physical environment or our genetic

make-up that contributes most to longevity. S. Jay Olshansky of the University of Illinois in Chicago is among those who put the emphasis on genes, but even this camp accepts that environment can affect the potential lifespan we are born with. We eat the wrong foods, drink, smoke, expose ourselves to the sun, Olshansky says. “All of that shortens our lifespan.”

Tom Perls, who heads the New England Centenarian Study at Boston University, represents the other end of the spectrum. He believes that although longevity may seem to run in families, environment accounts for up to 70 per cent of this effect. “Just because it’s familial doesn’t mean it’s all down to genes,” he says, because family members often share many environmental factors. He points to a

group of Seventh Day Adventists in California whose lifespan averages 88, a decade more than the US average. They are genetically quite diverse, but share a lifestyle that includes vegetarianism, no smoking, no drinking, and with strong emphasis on family and religion, all of which can contribute to longevity.

There is general agreement, however, that your location is less important than the personal environment you create through your behaviour. You could move to the Japanese island of Okinawa, considered to be the world’s number one longevity hotspot, but a better bet might be to live life the Okinawa way. “We boil it all down to four factors: diet, exercise, psycho-spiritual and social,” says Bradley Willcox, a researcher with the Okinawa Centenarian Study. **Caroline Williams**

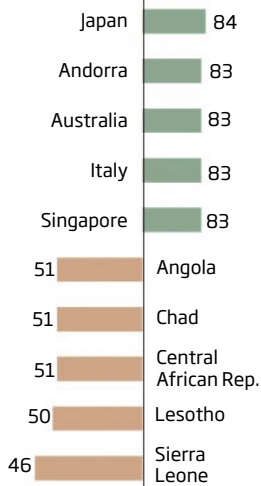
3 Consider relocation

LIVE LONG AND PROSPER

Several countries appear to be centenarian hotspots – with Japan topping the list

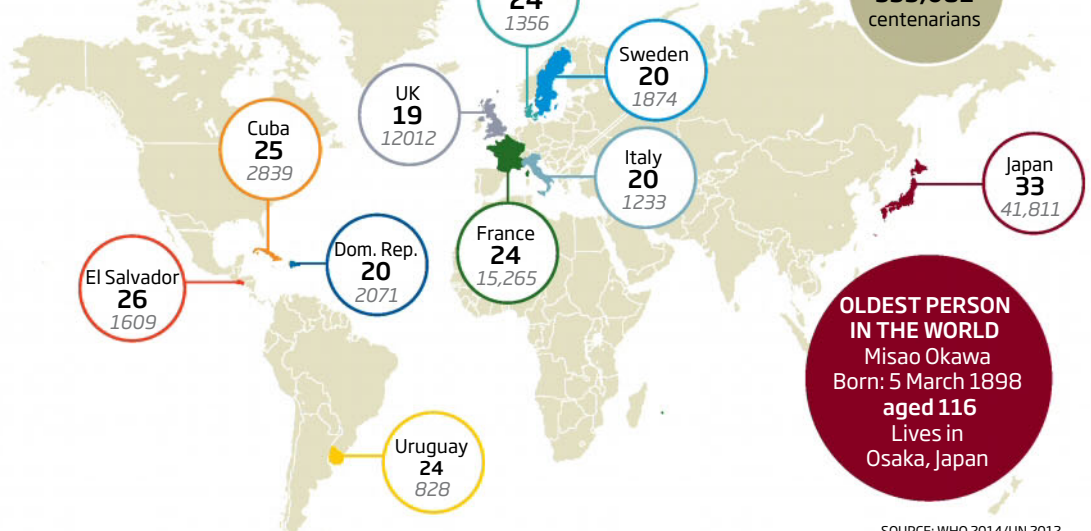
Highest and lowest life expectancies around the world

World average: 70



Number of centenarians per 100,000 population

Actual number of centenarians



SOURCE: WHO 2014/UN 2012

4

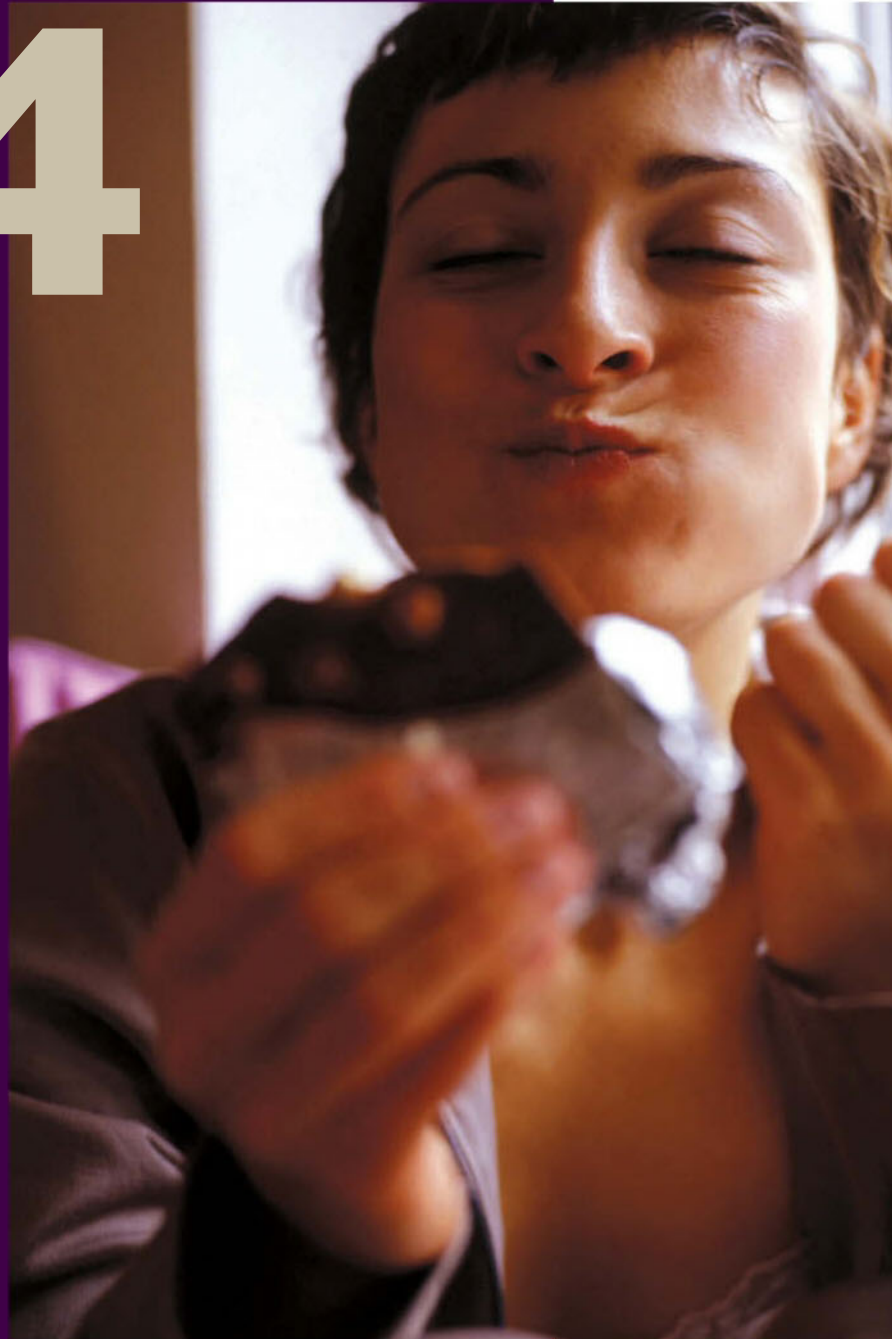
Make a virtue out of a vice

One of the most informative studies of healthy ageing to date has been conducted at the convent of the School Sisters of Notre Dame in Mankato, Minnesota. The nuns there, around 1 in 10 of whom have reached their hundredth birthday, teach us that a healthy old age is often a virtuous one - which means no drinking or smoking, eating healthily and in moderation, and living quietly, harmoniously and spiritually. But clean living is not to everyone's taste. Besides, what is the point of living to 100 if you can't enjoy a few wicked indulgences? Assuming you will have some vices, the trick is to choose them wisely.

The idea that one glass of wine a day is actually good for you is now ingrained in the popular consciousness. Some say that wine is what underlies the "French paradox", the unexpectedly low rate of heart disease in the Mediterranean population. Wine does contain fruit antioxidants, but many of these chemicals are also found in the raw fruit. Beer too has its health lobby. The research literature is rather at a loss to explain these effects, or even to agree that they exist. While the issue is still in doubt, however, is it worth the risk of not drinking?

Another vice that you probably shouldn't fight too hard is sleep. If you love your duvet, sleep easier knowing the findings of Till Roenneberg of the University of Munich, Germany. He showed that unless you can reset your body clock with lots of bright light and good discipline, fighting your natural lark or owl tendencies can be bad for your health.

Then there's chocolate. It contains compounds called flavonoids that have been found to lower blood pressure and possibly even reduce your risk of suffering a stroke. The latest research suggests they do this by enhancing the body's production of nitric oxide, which dilates blood vessels, relaxes arteries and lowers blood pressure. Chocoholics should be aware that not all candy bars are



chock-full of flavonoids. Your best bet is dark chocolate, but the choice is set to expand as the big confectionery manufacturers capitalise on the life-enhancing qualities of their products and start to produce special flavonoid-rich bars.

Whatever your pleasure, the great news is that pleasure itself is good for you. Really good. Not only does it counteract stress, it also causes our cells to release a natural antibiotic called enkelytin. Whether it's chocolate, coffee, having a tippale or a flutter, a spot of sunbathing (with suncream), a romantic (or more carnal) encounter, or another form of sinful pleasure, think of it as self-medication. Just make sure that if you have a vice, you enjoy it. Helen Phillips

"If you live to be 100, you've got it made. Very few people die past that age"

Actor George Burns, who died aged 100 in 1996

Your best shot at living out a century with an active enough mind to know about it is probably to become a nun.

Not only are there many centenarians among the Minnesota nuns studied by David Snowdon of the Sanders-Brown Center on Aging at the University of Kentucky in Lexington, but some of them also seem very resilient to the effects of Alzheimer's disease and other forms of dementia.

Not prepared to take holy orders for the sake of your continuing mental health? Then you had better be smart in the first place. By our mid-20s, many of our mental faculties have already reached their peak. After that, things start to decline. The best way to get around this is to start with some excess

capacity. Study after study has shown that intelligence, good education, literacy and high-status jobs all seem to protect people from the mental ravages of old age and provide some resistance to the symptoms, if not the brain damage, of dementia. Brain researchers and doctors are starting to refer to it as cognitive reserve (for more on this see "Use it don't lose it", page 58).

Some think the effect is simply about having a long way to fall. Others suspect it is more about greater mental efficiency or having alternative options and back-up plans for solving any given problem. Either way, cognitive reserve is a hot research area. It seems that boosting your mental capacity might have as potent an effect as the drugs

that are already available for dementia.

Better yet, it is never too late to begin your cognitive workout regime. Mental gymnastics are definitely on the agenda—everything from reading to learning new things to interacting with people rather than being a couch potato. But don't stop with mental exercises. Several recent studies have shown that regular physical exercise can improve memory and problem-solving skills in the elderly by up to 20 per cent.

All this helps explain the remarkable mental health of those centenarian nuns, who fill their advancing years with both physical and mental activity, from gardening and crosswords to reading, walking, conversation and knitting. **Helen Phillips**

Exercise the little grey cells

5

"If I had known I was going to live this long I would have taken better care of myself"

Hermann Doernemann, who at the age of 110 was the oldest man in Germany, speaking in 2003



KAREN KASKAUSKI/CORBIS RIGHT/ALAMY

“I’ve only ever had one wrinkle, and I’m sitting on it”

Jeanne Calment speaking on her 110th birthday. She died in 1997 age 122, making her officially the oldest person ever

6

Centenarians have surprisingly little in common, but one thing most do share is their love of a laugh. “These people are gregarious and fun to be with,” says Tom Perls from the New England Centenarian Study. He reckons the key is how they respond to stress. Although a little stress may be good for you, sustained and severe stress can cut your life expectancy. Perls suspects that people born with a sunny disposition cope better with stress, which increases their chances of reaching a ripe old age.

Evidence is mounting in his favour. The study of nuns in Minnesota reveals that those who had the most positive outlook on life during adolescence and young adulthood are also the healthiest in old age. Optimism improves the prospects of patients with heart conditions, and it increases your chances of recovering from infectious diseases. A positive attitude can also help stave off the ravages of time. Researchers from the Institute of Mental Health in Delft, the Netherlands, report that older men with an optimistic outlook on life were only half as likely to suffer from cardiovascular disease over a 15-year period (from 1985 to 2000) as those whose world view was more negative, regardless of their initial state of health. In another study researchers from Yale University found that over-70s who held negative stereotypes of the elderly were more likely to suffer hearing loss over a three-year period than those who saw oldies in a more positive light. Hearing loss, which can be very isolating, is thought to affect 71 per cent of over-70s in the UK.

What seems to be happening, explains Janet Lord of the University of Birmingham, UK, is that positive thinking lowers levels of the stress hormone cortisol, which dampens the immune system. Its effects are offset by another hormone called DHEA, but levels of DHEA start to decline from around the age of 30, dropping to less than 20 per cent of their



maximum value by the time we reach 70. That, she says, is why we gradually become less able to fight off diseases as we age. In addition, cortisol has adverse effects on the cardiovascular system and the brain. A study from the University of Edinburgh, UK, for example, reveals that older men with high levels of cortisol have smaller anterior cingulate cortices. Shrinkage of this brain region is linked with Alzheimer’s disease and depression in older people, and the researchers think it may be caused by stress.

Some people are born laid-back, but even if you are a natural stress bunny, there are things you can do to reduce your cortisol levels. “These include t’ai chi, exercise, having faith, meditation and yoga,” says Perls. “Even a deep breath can reboot you.” He cites the “relaxation response”, devised four decades ago by Herbert Benson of Harvard

Medical School and founder of the Mind/Body Medical Institute in Chestnut Hill, Massachusetts. It couldn’t be simpler. Just sit comfortably, close your eyes and listen to your breathing. On each outward breath, repeat a calming word, sound or phrase and gently rid your mind of any intrusive thoughts. For best results, repeat each morning for 10 to 20 minutes. Benson describes the effect as “the physiological opposite of stress”, and uses it to treat a variety of conditions, including depression, high blood pressure and insomnia.

Relaxation is all well and good, but there is an even more enjoyable way to achieve similar results. Those happy centenarians have it sussed. It turns out that laughing and smiling also reduce cortisol levels. A happier life is likely to be a longer one – and that’s surely something to smile about. **Kate Douglas**

RONNIE KAUFMAN/GETTY

7 Nurture your inner hypochondriac

One obvious piece of advice for anyone wishing to become a healthy centenarian is this: if you're sick, go see a doctor. But what if you are ill and don't know it? Lots of life-threatening diseases have innocuous beginnings, and some remain symptom-free until it is too late. Clearly, it can pay to anticipate the worst. So, what are the most effective preventive measures to take, and when should you take them?

Those searching for an early warning system will find a bewildering range of options. A few hundred dollars buys you a full-body CT scan, capable of spotting silent tumours or early signs of heart disease. Numerous cancers and diseases such as diabetes can be picked up early with other simple tests. Meanwhile, genetic screens can tell you whether you have an elevated risk of developing, say, breast cancer, so that you can be extra vigilant.

At first glance these all look like must-haves. The tests either tell you you're as fit as a fiddle, or alert you to a problem you

didn't know was there. Win-win. Unfortunately, it is not as simple as that.

Take prostate cancer. Across the world, millions of middle-aged men have had blood tests for high levels of an antibody called PSA, which can indicate prostate cancer. The test used to be offered routinely, but is now widely considered to be more trouble than it is worth. Many men with prostate cancer do not have high PSA, and three out of four who have a biopsy after an elevated score do not have cancer. What's more, even if the test does find cancer, treating it can do more harm than good, as most prostate cancers are so slow-growing that they wouldn't be fatal even to a man who lived to 150.

The PSA test is notoriously problematic, but most screening techniques have similar cost-benefit issues. First, there is always a risk of false positives, leading to psychological stress and unnecessary medical intervention. And if the false positives don't get you, the false negatives might: a clean test

result might mean you rest too easy and ignore real symptoms. Sometimes the screens themselves are bad for you. A full-body CT scan, for example, delivers a dose of radiation equivalent to 500 chest X-rays. A single scan won't do any significant damage, but if you go for one every couple of years you may be taking an undue risk. Perhaps worst of all, there may be times when the tests find something, yet there is nothing that can be done for you.

Which prophylactic measures are worth it, then? There is no easy answer. In England, the National Health Service only routinely offers screens that have passed a strict test of risk versus benefit. That has narrowed the field to just a few types: bowel cancer for all 60 to 74-year-olds, mammograms for women aged 50 to 70, cervical screening for women aged 25 to 64 and abdominal aortic aneurysm screening for men over 65.

The NHS also offers guidance and advice for men who want a PSA test, cardiovascular health checks for anybody over 40, and chlamydia tests for the under-25s.

Beyond that, it's a case of you pays your money and you takes your pick – but do seek professional advice. In other words, go see a doctor. **Graham Lawton**



Watch what you eat

8



There's good news and bad news for anyone who wants to eat their way to 100. The good news is that you may be able to do it. The bad news is that there won't be much eating involved, and there's no guarantee that it will work.

One of the few proven strategies to extend lifespan in animals is caloric restriction – deliberately feeding them just enough to keep them alive. This indisputably extends the lives of mice by about 30 per cent, and also works in worms, flies and dogs. Other studies have shown that animals eating less than normal have a lower metabolic rate and fewer damaging free radicals – chemicals that have been linked to several diseases of ageing.

But despite many people choosing to go hungry in the name of living longer, it is doubtful whether caloric restriction works in humans. While there are studies that show that people on restricted diets have lower insulin levels and less DNA damage, both of which are associated with good health, there

FOODPIX/JUPITER



9 Get a life

So, you're well on your way to reaching the big one-zero-zero. How are you going to make the most of those extra years? What you need is a bit of excitement along the way. Take some risks. Not only will new experiences bring you pleasure, they might also have added benefits.

For a start, a novel intellectual challenge will keep your mind sharp and could also ward off diseases. Marian Diamond of the University of California, Berkeley, has found that playing bridge boosts the immune system. Her studies with lab rats even suggest that intellectual novelty promotes longevity: rodents given mazes to solve and toys to play with lived 50 per cent longer. There is also evidence to indicate that the kind of buzz you get from travelling, learning a new language, completing a sudoku puzzle or creating your own work of art helps delay the onset of neurodegenerative diseases, including Alzheimer's.

If that seems a bit tame, what about the excitement of a high-adrenaline sport – after all, you know that exercise is good for you. Admittedly, mountaineering, cave diving or base jumping are not entirely compatible with longevity, but maybe you can justify the risk by making a trade-off. If you smoke, quit now. Or cut down on some other bad habit such as binge drinking or burgers. Alternatively, if you want a thrill but cannot justify the risk, go for safer kicks such as fairground rides, amateur dramatics, a new lover or bungee jumping.

Unfortunately, there is no evidence to suggest that getting your pulse racing extends longevity, but regular thrills will help to make your life feel longer. One of the more tiresome aspects of ageing is that while the days seem to drag, the years rush by. This paradox is not simply subjective: researchers are finding that our brains actually oscillate with a tick-tock that marks the passage of time, and this winds down as we grow older, making time seem to fly. As yet, scientists have not come up with a way to speed the clock back up, but building temporal landmarks with memorable experiences can create the opposite illusion, so the years seem to pass more slowly.

Longevity is surely not an end in itself. So, live a little! As T.S. Eliot said: "Only those who risk going too far can possibly find out how far they can go." Kate Douglas

are none that show this actually leads to a longer lifespan. And two recent studies on monkeys which were supposed to produce more human-relevant information have not really clarified things.

One, run by the US National Institute on Aging (NIA) in Bethesda, Maryland, found that rhesus macaques on a restricted diet did not outlive those given standard feed. The other, run by the Wisconsin National Primate Research Center in Madison, found the opposite: calorie-restricted macaques were almost half as likely to die at any age than well-fed ones.

The differing results may be down to the different protocols. The NIA macaques were fed a diet consisting of whole grains and sugar, measured to provide a normal diet for their age and weight. The calorie-restricted monkeys received 30 per cent less than this for life. The Wisconsin monkeys, on the other hand, were all allowed to eat as much as they wanted, before half were steadily given 30 per

cent fewer calories. It may be that the Wisconsin results merely reflect the benefits of calorie restriction in overweight individuals.

So for now, it's not clear whether skipping meals will make you live longer – although constant hunger will probably make it feel that way.

If that doesn't appeal, perhaps the best advice is to eat lots of fruit and vegetables. Research carried out on behalf of the UK's National Health Service found that eating five portions a day increases longevity by three years. There is also strong evidence that fresh fruit and vegetables – especially greens – help keep ageing brains sharp.

If five-a-day sounds too much like hard work, consider two facts: studies of centenarians make it clear that a healthy diet is an extremely important factor in longevity, and eating high-calorie, fat-laden foods is one of the surest ways to an early grave. **Bob Holmes and Helen Thomson**

Why are well-educated, active people more able to fend off the symptoms of dementia and brain damage? Lisa Melton investigates

Use it don't lose it

RICHARD WETHERILL was intolerably good at chess. Hardly surprising, for the retired university lecturer could think a mind-boggling eight moves ahead. But in recent months, his razor-sharp mind had started to dull. When he found he could no longer think five moves ahead, he was sure something was seriously wrong and arranged to meet a neurologist. Though his wife dismissed his complaints, Wetherill was adamant that he needed help. Yet a battery of tests revealed nothing amiss: he sailed through every test designed to spot early dementia. Under a brain imager, his brain looked normal.

Two years later, in 2003, Wetherill died suddenly. Imagine his neurologist's amazement when the autopsy revealed a brain riddled with plaques and tangles, the hallmark of Alzheimer's disease. The anatomical evidence indicated advanced disease, with a level of physical damage that would have reduced most people to a state of confusion. Yet for Wetherill the only impact was that he could no longer play chess to high standards. What on earth was he doing differently? What was cushioning the blow?

Wetherill's experience is a perfect example of an observation that has long interested scientists: people who are more intelligent,



MILAN HORACEK/BILDERBERG/NETWORK

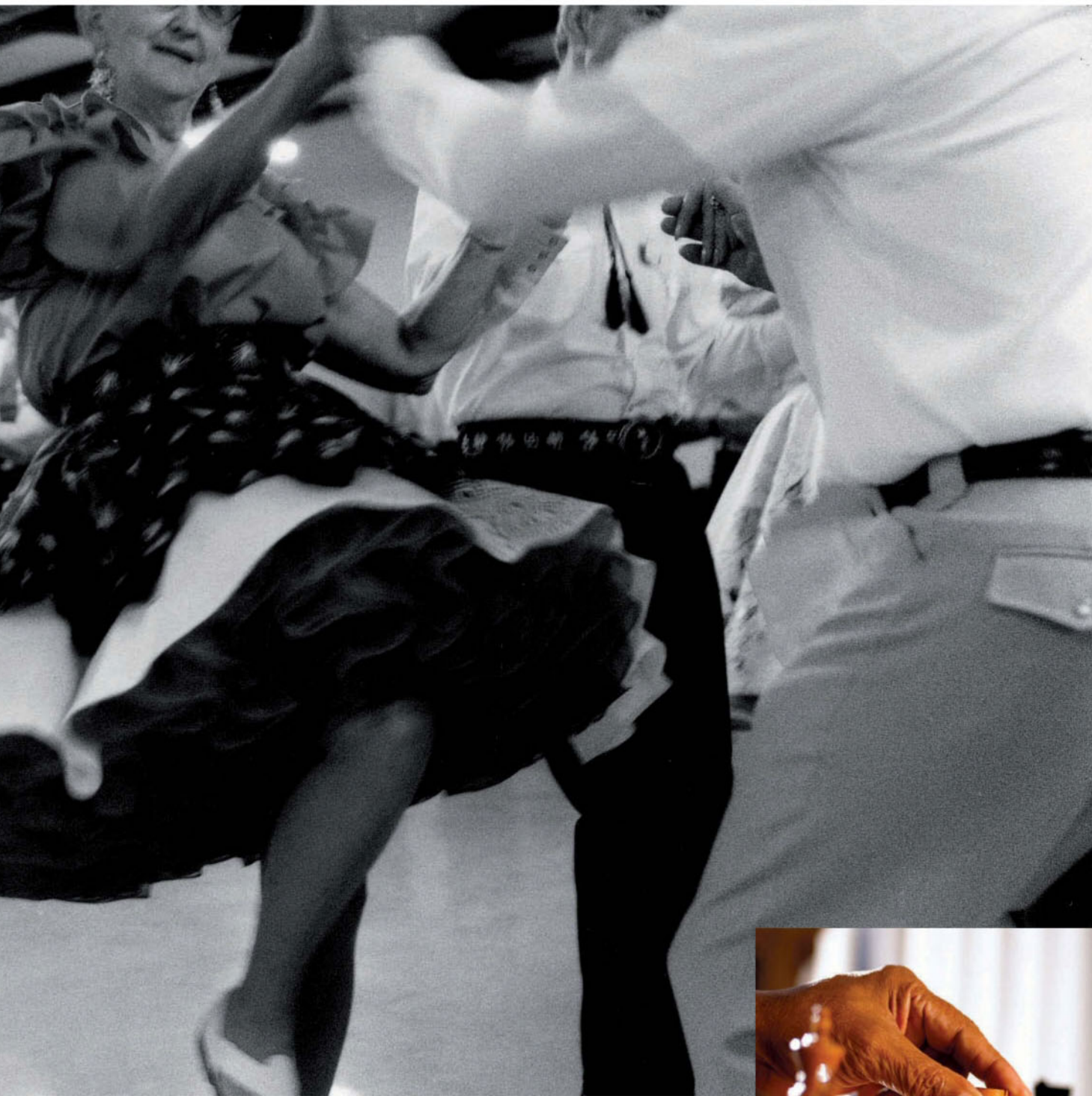
who lead more intellectually stimulating lives, who are better educated and have high-status occupations, somehow seem protected from the mental decline that comes with age. And not just age, but other insults too, from head injuries and alcohol intoxication to stroke, HIV, Alzheimer's and Parkinson's disease.

Around 20 years ago psychologists and neuroscientists dubbed this mental padding "cognitive reserve". And the more you've got, they argued, the more brain damage you

could sustain without showing signs of mental decline.

At first the idea of cognitive reserve was controversial. Some dismissed it as nothing more than common sense – people who start off smarter have further to fall. Others said it was because intelligence is correlated with socio-economic status, which tends to be associated with better health overall. But there is now a large body of evidence that cognitive reserve is real.





SIMON ROBERTS/INSPICURES

For example, epidemiologists have confirmed that high literacy and IQ protects people from the declines of normal ageing and slows the progress of degenerative brain diseases such as Alzheimer's, Parkinson's and multiple sclerosis. Such people also recover from stroke, head injury, intoxication and poisoning with neurotoxins more rapidly than the average person. Meanwhile, neuroscientists have used brain scans to discover the biological underpinnings of



Staying mentally and physically active can build an emergency stash of brainpower



PHOTOLIBRARY/IMAGESTATE

cognitive reserve. For anyone hoping to enjoy a ripe and active old age, the implications are enormous.

Like it or not, after the age of 25 or so, our mental abilities start to fade. The speed at which we process information, our reasoning powers and our spatial abilities are all at their best in our early 20s, and it's all downhill from there (though our ability to learn new things does not fade as fast as once thought: see "Old dog, new tricks", page 63).

One of the first inklings that some people have an emergency stash of brainpower came in 1992 when Yaakov Stern, a neurobiologist at Columbia University in New York, looked at the blood flow in the brains of Alzheimer's patients. All showed symptoms of equal severity, though they had varying levels of education. But despite all the subjects being outwardly equally

Soon afterwards, evidence started to pile up in favour of cognitive reserve. In 2001, a team led by Lawrence Whalley of the University of Aberdeen, UK, found that better-educated people suffer less cognitive impairment for a given level of damage to their white matter, which is known to be linked to mental decline in old age. And in 2003 Shelli Kesler of Stanford University School of Medicine in California found that highly educated people were less likely to experience a pronounced dip in IQ after a head injury.

If cognitive reserve does exist, then what is it? One obvious possibility is that it's simply a function of brain size: the larger your brain, or the more neurons it contains, the more able you are to cope with losses.

Brain size does correlate with reserve to some extent, but it does not explain all the

educated are better at recruiting alternative neuronal networks to compensate for the deterioration of their cortical areas, which deal with complex behaviour and thought. This, Fabrigoule believes, is cognitive reserve in action. "Once you have a lesion or an insult, from a neurochemical point of view the network won't work normally," she explains. "Better-educated, intelligent people are better at recruiting compensatory mechanisms."

What is more, her results suggest that cognitive reserve resides in a specific area of the brain: the dorsolateral prefrontal cortex, which is critical in controlling learning, short-term memory, attention and language. These compensating areas light up even in early Alzheimer's disease, indicating that the brain is starting to tap into its reserve capacity.

Stern agrees that cognitive reserve is in part down to the brain's ability to switch to plan B. "What gives people with high reserve the upper hand is the ability to summon that compensatory response," he says. "They are used to engaging these networks and can do it more easily."

Powerful engine

But it appears there is another ingredient to cognitive reserve: information-processing efficiency. Stern scanned the brains of volunteers, young and old, as they performed increasingly difficult memory tests, to see how the activity levels in their brains changed as they moved from easy tasks to more difficult ones. He found that the higher a person's IQ, the less effort their brains had to make to complete the tests. Rather like a car with a more powerful engine, their brains found it easier to accelerate.

Stern speculates that this mental efficiency could also play a role in cognitive reserve, by allowing people with a higher IQ to cope when confronted with brain damage or disease.

"Having more efficient networks keeps these people in higher stead when faced with ageing or lesions," he says.

So it looks as though there are two ways in which people with a large cognitive reserve compensate for the effects of ageing or brain damage: they either recruit alternative networks or increase the efficiency of their existing ones.

It seems paradoxical, then, that once people with high IQ, good education or occupational achievement are diagnosed with dementia, they tend to go downhill unusually fast. Stern,



EDKASHI/CORBIS

"Exercise seems to protect people in their 60s and 70s against dementia"

affected, Stern found that in terms of damage to the brain there were clear differences: those who had received more education also had more severe brain pathology.

The findings suggested that some kind of "padding" was shielding the more educated patients from the full force of clinical symptoms that would be expected from the physical condition of their brains. This made sense of long-reported findings that some people who had all the features of Alzheimer's disease at autopsy had remained lucid right up to their deaths.

findings. Psychologists now know that there's another extremely important factor; cognitive reserve is found not just in the brain's hardware but also in its software.

In the mid-2000s a team led by psychologist Colette Fabrigoule of Bordeaux Segalen University in France used magnetic resonance imaging to watch what was going on in the brains of people with Alzheimer's while they performed a cognitive task. The researchers were interested in what circuits their subjects engaged, and how the circuits worked together.

They found that people who are highly

Don't underestimate the lifelong power of a good education

for example, has looked at the impact of Alzheimer's disease on well-educated people and found that they seem to die sooner after diagnosis than people without a good education.

But psychologist Michael Rutter from the Institute of Psychiatry in London points out that this is compatible with the idea of cognitive reserve. "It's not that people with high education and with Alzheimer's disease deteriorate faster." What is happening, he says, is that by the time symptoms appear, these people are at a relatively late stage of the disease. If you measure the progress of the disease by plaques and tangles, they are already far gone. As long as they have cognitive reserve in the bank, outward signs are not apparent. Yet the disease progresses regardless, and once that extra cushioning goes, the outward decline is dramatic. Wetherill's story is a case in point. He was relatively unaffected until he was on death's door, at which point he declined dramatically.

With all this evidence that cognitive reserve is something we want – and as much of it as possible – the next question is how to get it. Is it just a matter of luck, or is it possible to boost your cognitive reserve?

According to Marcus Richards at the UK Medical Research Council's Unit for Lifelong Health and Ageing in London, building cognitive reserve is a lifetime enterprise. "There are a massive number of factors that shape and develop cognitive function throughout our lifetimes," he says.

Not surprisingly, one of the most important is intelligence. The best predictor of cognitive ability in middle age is your IQ score at 8. Of course, intelligence is to a large extent inherited. But this does not necessarily mean we are stuck with whatever cognitive reserve our genetic cards dealt us.

It is possible to rack up brainpower beyond your childhood potential. When Richards analysed the findings of the Scottish Mental Survey, which followed a group of several hundred people born in 1921 who took an IQ test aged 11 and then again at 80, he found that, although IQ scores at 11 were a strong predictor of scores at 80, some people managed to significantly increase their IQ over and above where you'd expect them to be based on their childhood ability. That something is likely to be education.

Richards also analysed data from the 1946 British Cohort, a large study of people born just after the second world war. He found that educational attainment at age 26 was one of



SAMUEL BOLLENDORFF/DOEL PUBLIC

the strongest predictors of cognitive ability at age 53. The upbeat conclusion is that early education makes a difference to cognitive performance later in life, and this probably equates to having a higher cognitive reserve. "Education works," Richards says.

Stern would agree: he thinks that education may be critical in training people to recruit the alternative mental networks that enable them to compensate for damage or disease. "Cognitive reserve is not something you are born with," he says. "It's something that changes, and can be modified over time."

Education isn't the only factor. Cognitive reserve is also built up by performing mentally demanding tasks throughout life. Richards's study of the British Cohort, for example, found that cognitive ability at 53 was also influenced by occupation at 26. And when researchers at the University of South Florida in Tampa looked at data from the Swedish Twin Registry, they found that people engaged in complex, mentally stimulating occupations were to some extent protected against the risk of dementia and Alzheimer's.

Even if you missed out on education and a stimulating job, it's never too late to start. Fighting senility with mental gymnastics such as crosswords and logic puzzles has become part of the anti-ageing folklore, and there is evidence that mental activity really does cushion people who have begun to suffer age-related decline. As long as a decade ago, for

example, Stern and colleagues found that intellectual activities such as reading could reduce the severity of Alzheimer's symptoms. "Cognitive function is modifiable right across the life course," says Richards. "It's never too late to take control."

Physical fitness also appears to be beneficial. People who are physically active tend to perform better than couch potatoes on cognitive tests, and exercise seems to protect people in their 60s and 70s against dementia (see "Faster body, faster mind", page 76).

Despite all the evidence, however, it has yet to be firmly established in clinical trials which activities work best at building cognitive reserve. Some neuroscientists maintain that anything that stimulates mental processing – even something as ordinary as meeting friends or gardening – may help. Others, though, say that the evidence still isn't strong enough to make specific recommendations.

Nonetheless, what almost everyone agrees on is that cognitive reserve has huge potential to alleviate suffering and save healthcare costs. Beyond 65, a person's risk of dementia roughly doubles every five years; nearly 25 per cent of people over the age of 85 have it. In the US, the prevalence of dementia is predicted to triple by 2050 unless interventions can be found. Any way of lessening the impact will therefore have enormous benefits. "This is as powerful as any drug we will ever have to stop Alzheimer's progression," Stern says. ■



JONATHAN BURTON

Old dog, new tricks

Learning like a child is easy if you know how, says David Robson



Some people approaching their fifth decade choose to collect vintage wine, vinyl records or sports memorabilia. For Richard Simcott, it is languages. His itch to learn has led him to study more than 30 foreign tongues – and he’s not ready to give up.

During our conversation in a London restaurant, he reels off sentences in Spanish, Turkish and Icelandic as easily as I can name the pizza and pasta on our menu. He has learned Dutch on the streets of Rotterdam, Czech in Prague and Polish during a house share with some architects. At home, he talks to his wife in fluent Macedonian.

What’s remarkable about Simcott isn’t just the number and diversity of languages he has mastered. It’s his age. Long before grey hairs appear and waistlines expand, the mind’s cogs are meant to seize up, making it difficult to pick up any new skill, be it a language, the flute or archery. Even if Simcott had primed his mind for new languages while at school, he should have faced a steep decline in his abilities as the years went by, yet he still devours unfamiliar grammars and strange vocabularies to a high level. “My linguistic landscape is always changing,” he says. “If you’re school-aged, or middle-aged – I don’t think there’s a big difference.”

A decade ago, few neuroscientists would have agreed that adults can rival the learning talents of children. But we needn’t be so defeatist. The mature brain, it turns out, is more supple than anyone thought. “The idea

that there’s a critical period for learning in childhood is overrated,” says Gary Marcus, a psychologist at New York University. What’s more, we now understand the best techniques to accelerate knowledge and skill acquisition in adults, so can perhaps unveil a few tricks of the trade of super-learners like Simcott. Whatever you want to learn, it’s never too late to charge those grey cells.

The idea that the mind fossilises as it ages is culturally entrenched. The phrase “an old dog will learn no tricks” is recorded in an 18th century book of proverbs and

“The idea that the mind fossilises is entrenched, but old dogs are better learners than we thought”

is probably hundreds of years older.

When researchers finally began to investigate the adult brain’s malleability in the 1960s, their results appeared to agree with the saying. Most insights came indirectly from studies of perception, which suggested that an individual’s visual abilities were capped at a young age. For example, restricting young animals’ vision for a few weeks after birth means they will never manage to see normally. The same is true for people born with cataracts or a lazy eye – repair too late, and the brain fails to use the eye properly

for life. “For a very long time, it seemed that those constraints were set in stone after that critical period,” says Daphne Bavelier at the University of Rochester, New York.

These are extreme circumstances, of course, but the evidence suggested that the same neural fossilisation would stifle other kinds of learning. Many of the studies looked at language development, particularly in families of immigrants. While the children picked up new tongues with ease, their parents were still stuttering broken sentences. But if there is a critical period for foreign language learning, everyone should be affected equally; Simcott’s ability to master a host of languages should be as impossible as a dog playing the piano.

Bearing this in mind, Ellen Bialystok at York University in Toronto, Canada, turned to the US census records, which detailed the linguistic skills of more than 2 million Hispanic and Chinese immigrants. A “critical period” for learning a second language in infancy should have created a sharp difference between those who had moved country in early childhood and those who were uprooted in adolescence. In reality? “There was absolutely no discontinuity,” Bialystok says. Instead, she saw a very gradual decline with age among immigrants – which could reflect differences in environment as much as the adults’ rusty brain circuits. “People talk more slowly and clearly to children in short, simple sentences,” she says. “And the child’s entire social and





Adults often agonise over how to do a task rather than throwing themselves into it

During a more challenging test of hand-eye coordination, nearly 1000 volunteers of all age groups learned to juggle over a series of six training sessions. As you might expect, the senior citizens aged 60 to 80 began with some hesitation, but they soon caught up with the 30-year-olds and by the end of the trials all the adults were juggling more confidently than the 5 to 10-year-olds.

Old dogs, then, are much more adaptable than folklore would have it – and if we do have deficits, they aren't insurmountable. The reason that children appear to be better learners may have more to do with their environment, and factors such as physical fitness (see "Stay fit to stay sharp", left).

Indeed, many researchers believe that an adult's lifestyle may be the biggest obstacle. "A child's sole occupation is learning to speak and move around," says Ed Cooke, a cognitive scientist who has won many memory contests. "If an adult had that kind of time to spend on attentive learning, I'd be very disappointed if they didn't do a good job."

A glut of free time and a carefree existence are out of reach for most of us, but there are other behaviours that boost children's learning, and these habits can be easily integrated into even an adult's schedule. For example, children are continually quizzed on what they know – and for good reason: countless studies have shown that testing doubles long-term recall, outperforming all other memory tactics. Yet most adults attempting to learn new skills will rely more on self-testing which, let's be honest, happens less often.

That's why Cooke developed a website, called Memrise, which helps take some of the pain out of testing and, crucially, can integrate learning into the adult day. It is designed to track your learning curve with cunningly

educational network is organised around that language."

Yet while Bialystok's study suggested that adult brains are more pliable than had once been imagined, there was still the suspicion that children might have the edge in certain skills. Adult learners sometimes find it harder to learn to sing in tune, hit a home run or mimic an accent convincingly. At first glance, the problem might seem to lie in adults' perception and motor skills. Learning involving these abilities differs from the acquisition of factual knowledge, because it needs us to rewire the eyes, ears and muscles.

It's something that Marcus can identify with. At the age of 38, he devoted himself to learning the guitar, an experience he detailed in his book *Guitar Zero*. "My family's initial response was laughter – but they soon saw I was making progress," he says. Still, during his research, he attended a musical summer camp for 8 to 15-year-olds. He says he was quicker to catch on to the structure of songs, but his younger bandmates had better coordination and sense of pitch.

Yet the available evidence hints that children may not always be inherently better at such tasks. One study by Yang Zhang at the University of Minnesota in Minneapolis that focused on the acquisition of foreign accents in adults suggests we may simply be suffering from poor tuition. When the researchers gave them recordings that mimicked the exaggerated baby talk of cooing mothers, the adult learners progressed rapidly.

Nor do adults necessarily fumble the intricate movements that are crucial for music or sport. When volunteers visiting Virginia Penhune's lab at Concordia University in Montreal, Canada, learned to press keys in a certain sequence, at certain times – essentially a boiled-down version of keyboard practice – the adults tended to outshine the younger volunteers.

STAY FIT TO STAY SHARP

The key to a spry mind in old age may be as simple as a walk in the park.

Over the past few years, it has become clear that poor physical fitness – including factors such as obesity and cardiovascular health – can be as damaging to our brains as they are to our sex appeal, reducing the long-distance connections between neurons and shrinking the hippocampus, which is involved in learning and memory. For this reason, the general decline in health as we age may also contribute to the gradual decrease in mental skills – including our capacity to learn new skills, fuelling the idea that you can't teach an old dog new tricks (see main story).

Thankfully, the changes are reversible, according to Arthur Kramer, who has worked with senior citizens in his lab at the University of Illinois at Urbana-Champaign. Typically, the studies demanded a mild exercise regime, asking volunteers to walk for 40-minute periods, three days a week for a year, for example. "I wouldn't say these old folks would win any races, but they could certainly go further and faster by the end," he says.

Imaging their brains before and after training, he found that hippocampi had expanded, perhaps through the growth of new brain cells or an increase in synaptic connections between neurons. Just as importantly, much of the long-distance communication across the brain was restored to its former glory. "The senior citizens' connectivity was equivalent to a 30-year-old's," says Kramer. The result is a general cognitive boost, including improved attention, which should aid learning of any new skill.

"An adult's lifestyle may be the biggest obstacle, but it needn't be if we use the right techniques"

timed tests that force you to retrieve the information just as you are about to forget it.

"Memrise engages your brain to the greatest possible extent," says Cooke, who has himself used the site to learn thousands of words of foreign vocabulary. Users can create their own courses – the topics range from art to zoology – and importantly, it is easy to load the site in the few spare minutes of your lunch break or while you are waiting for a train. Cooke

has also launched a smartphone app.

What about tasks that involve perceptual learning or motor skills – like battling against a lifetime of tone deafness, or perfecting that golf swing? Here too, there are guiding principles that can help you rediscover the seemingly effortless learning of youth.

Adults can hamper progress with their own perfectionism: whereas children throw themselves into tasks, adults often agonise over the mechanics of the movements, trying to conceptualise exactly what is required. This could be one of our biggest downfalls. “Adults think so much more about what they are doing,” says Gabriele Wulf at the University of Nevada, Las Vegas. “Children just copy what they see.”

Wulf’s work over the past decade shows that you should focus on the outcome of your actions rather than the intricacies of the movements. She applies this finding in her own life: as a keen golfer, she has found it is better to think about the swing of the club, for instance, rather than the position of her hands. “I’m always trying to find where best to focus

my attention,” she says. Similarly, if you are learning to sing, then you should concentrate on the tone of the voice, rather than on the larynx or the placement of the tongue. Study after study shows that simply shifting your mindset in this way accelerates your learning, perhaps by encouraging the subconscious, automatic movements that mark proficiency.

“Study after study shows that simply shifting your mindset a certain way can accelerate learning”

Misplaced conscientiousness may also lead adults to rely on overly rigid practice regimes that stifle long-term learning. The adult talent for perseverance, it seems, is not always a virtue. Left to their own devices, most people segment their sessions into separate blocks – when learning basketball, for instance, they may work on each shot in turn, perhaps because they feel a desire to master it.



The approach may bring rapid improvements at first, but a host of studies have found that the refined technique is soon forgotten.

Instead, you’d do better to take a carousel approach, quickly rotating through the different skills to be practised without lingering too long on each one. Although the reason is still unclear, it seems that jumping between skills makes your mind work a little harder when applying what you’ve learned, helping you to retain the knowledge in the long term – a finding that has helped people improve in activities ranging from tennis and kayaking to pistol shooting.

Such an approach might not be to everyone’s taste. With intricate skills, it might feel like you are making no progress. But even if you do revert to stints of lengthy practice, you can still reap some of the same benefits by occasionally trying out your skills in an unfamiliar situation. In tennis, you might move to a different part of the court for a couple of serves before returning to the regular position; while playing scales on a musical instrument, you might switch hands temporarily. According to work by Arnaud Boutin at the Leibniz Research Centre for Working Environment and Human Factors in Dortmund, Germany, venturing out of your comfort zone in this way helps to ensure that you improve your overall performance rather than confining your progress to the single task at hand. “Otherwise, the longer you practise, the harder it becomes to transfer the skills that you’ve learned to new situations,” says Boutin.

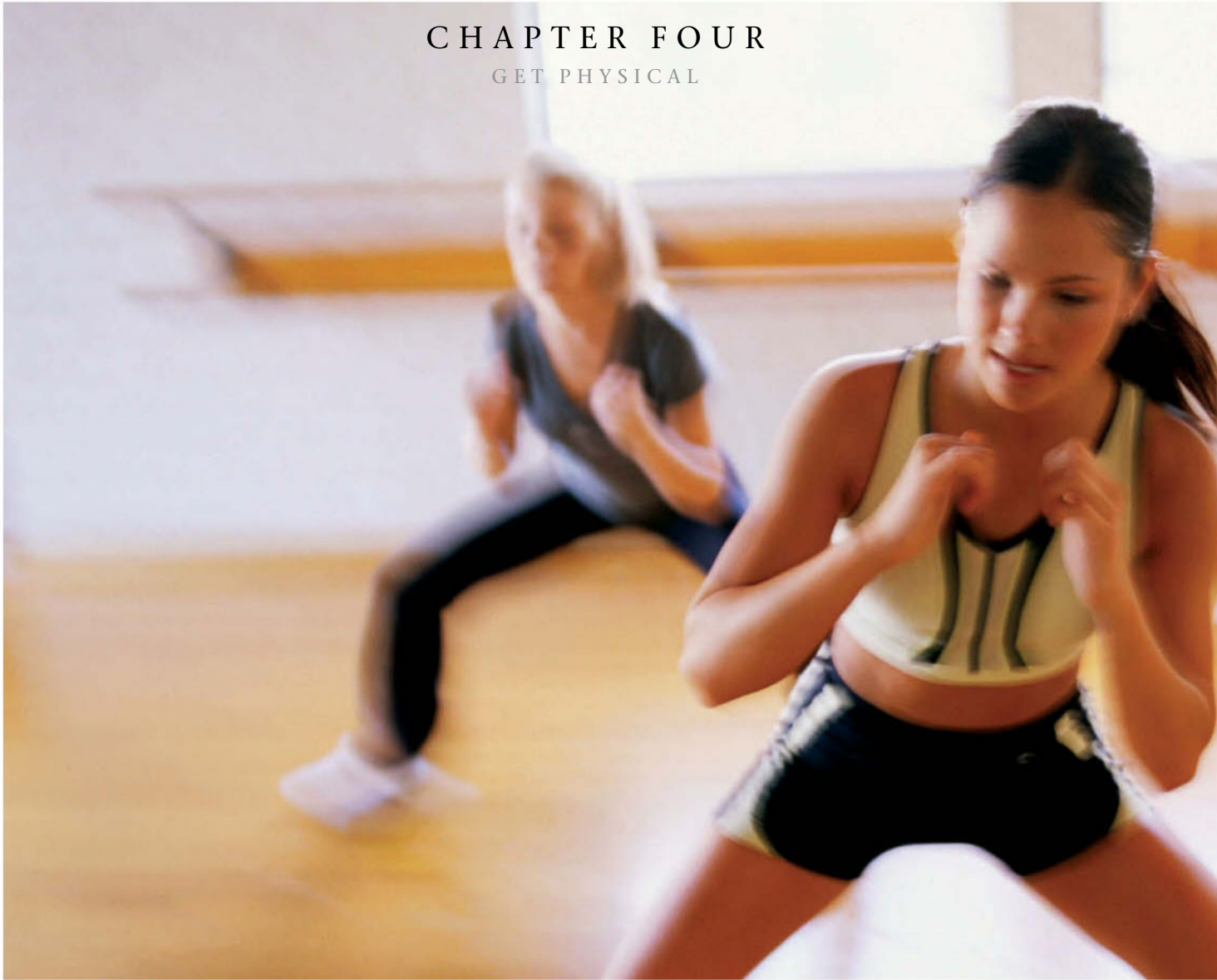
If none of that helps you learn like a child, simply adopting the arrogance of youth may do no harm. “As we get older, we lose our confidence, and I’m convinced that has a big impact on performance,” says Wulf. To test the assumption, she recently trained a small group of people to pitch a ball. While half were given no encouragement, she offered the others a sham test, rigged to demonstrate that their abilities were above average. They learned to pitch on target with much greater accuracy than those who didn’t get an ego boost.

Whether your itch to learn will ever match Simcott’s appetite for foreign languages is another matter. “What I do – it’s like an extreme sport. There’s no need to learn that many languages,” he says. He recently took up Chinese, and has no plans to stop after that. “I’m like a linguistic butterfly. There’s always another that suddenly feels appealing.”

Still, embrace the idea that your mind is as capable as Simcott’s, and the lure of extreme learning might take hold of you too. ■

CHAPTER FOUR

GET PHYSICAL



If you want to stay healthy you need to stay fit - but how, asks Clare Wilson

Exercise is good for you

DOES an activity have to get you out of breath to count as exercise? Do you really have to do half-an-hour a day? Is pumping iron a good way to keep your heart healthy? These are just some of the dilemmas many of us face when working out the best way to get fit or stay fit. The good news is that scientists do broadly agree on the best ways to do both. They just haven't been very good at telling us what they've discovered.

"We haven't done a great job of distilling down a large number of studies and say what this means for the average person who's trying to get in shape," acknowledges Simon Marshall, a specialist in exercise and sports psychology at the University of California in San Diego.

Whether because of a lack of information, or because some of us are just plain lazy, most people don't do enough exercise. One recent survey in the UK found that only a third of



What counts as exercise?

The standard advice is to do a session of muscle-strengthening exercises on two or more days per week (see page 69) plus a minimum of 150 minutes a week of moderate-intensity cardiovascular exercise. The tricky question here is what “moderate” means.

Gauging the intensity of an activity by measuring how fast it makes your heart beat is old hat. These days, metabolic rate is the preferred measure. It is usually represented in units known as the metabolic equivalent of task, or MET. This is the metabolic rate during the activity in question divided by the rate when sitting doing nothing. Moderate exercise is defined as anything that clocks up between 3 and 6 METs (see chart, page 68).

Gauging your metabolic rate precisely requires having your oxygen uptake measured in a lab, but you can just look up the average MET for your chosen activity in *The Compendium of Physical Activities*. It even answers the hoary old question about golf: yes, it does count as exercise, notching up 4.5 METs if you walk round the course.

Unsurprisingly, higher-intensity exercise is more efficient way to notch up the minutes. An hour a week of, say, swimming or cycling is roughly equivalent to 150 minutes of moderate exercise.

For those not inclined to put in the hard yards, walking offers a relatively easy way to clock up those 150 minutes of moderate intensity exercise. It scores anywhere from 2 to 12 METs, depending mainly on speed and terrain. Fiona Bull, joint head of the National Centre for Physical Activity and Health at Loughborough University in the UK, says moderate intensity means “walking purposefully”. “There should be a slight elevation in your heart rate but you should be able to talk easily,” she says.

People tend to underestimate how fast they have to walk to achieve this. A good rule of thumb is that 3 METs equates to about 100 steps a minute, so all you need to measure your performance is a pedometer and a watch.

Marshall suggests that you select a walk you often take and use the pedometer to gauge how many steps it takes. From this you can easily calculate a target time to hit 3 METs or more. “You can give time-based goals and weave it into your lifestyle,” he says.

adults meet the recommended goals for physical activity.

Though we all know that exercise is a good thing, only recently has the extent of its influence on health been established. In the early 20th century, heart attacks were growing steadily more common in the West, and they were seen as a sinister new epidemic. It is now thought there are several explanations for this, ranging from a fall in infectious diseases enabling heart attacks to overtake them as a cause of death, to various changes in society that made lifestyles less healthy.

A key insight into the importance of physical activity came from a study of London buses in the early 1950s. At the time, the buses not only had a driver but also a conductor, who sold tickets to passengers after they had boarded. Most of the buses were double-deckers, so the conductors spent a lot of their day dashing up and down the stairs.

The landmark study was published in the medical journal *The Lancet* in 1953. It showed that conductors suffered half as many heart attacks as their driver colleagues. Jerry Morris, the epidemiologist at the UK’s Medical Research Council who led the work, said at the time: “It was the first hint that this new frightening epidemic could be linked to the way we live.”

Since Morris’s study, hundreds of other investigations have confirmed the benefits of exercise on the heart and circulation, as well as on almost every other system of the body. Diseases that are prevented by exercise include stroke, cancer, diabetes, liver and kidney disease, osteoporosis and even brain diseases such as dementia and depression.

So how should you go about getting fit and staying fit? How do you distinguish facts from myths? Evidence is the key. Read on, and you can use it for yourself. ➤

MARK GAMBAY/CORBIS

How much, and how often?

Half an hour of moderate-intensity exercise at least five days a week used to be the required regime to keep fit. Now the consensus is that exercise doesn't have to be portioned out in daily doses. If you aim for 150 minutes per week you can divide it up however you like.

That is good news for those who find it difficult to exercise daily. If you can manage two hours at the weekend – by walking or gardening, for example – you only have to do another half hour during the week. “There’s not compelling evidence that 150 minutes across five days is any better than across three or four,” says Simon Marshall the University of California, San Diego.

Another hot question in sports science is what is the shortest period of exercise that is worth doing. The latest evidence suggests that three lots of 10 minutes, for example, are just as good as one continuous 30-minute bout.

But if you really push yourself, you can boost your fitness in less time. High intensity interval training (HIIT) involves a series of 30-second all-out sprints with rests in between. One recent study suggested that intense bursts of cycling separated by rests burned the same amount of energy as cycling continuously for twice as long.

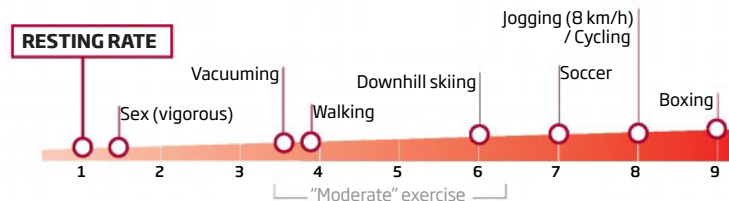
What's the best way to get fit: one long run, or several short ones?



LUCAS JACKSON/REUTERS

Energy to burn

Exercise raises your metabolic rate. A common way of measuring the intensity of exercise is by the ratio of the metabolic rate during exercise to the rate at rest, dubbed a metabolic equivalent (MET)



How do I know if I'm getting fit?

“Fitness” can refer to a number of attributes, including muscle strength and flexibility, but is usually used to refer to aerobic fitness, also known as cardiorespiratory or cardiovascular fitness. This boils down to how effective the body is at delivering oxygen to muscle cells.

If you become more active, your body undergoes numerous changes that boost aerobic fitness. Muscle fibres grow and are better supplied with blood vessels. Within the

muscle cells, the mitochondria, which release energy from glucose, increase in size and number.

The heart also undergoes significant changes. Ultrasound scans show that the heart of an athlete looks quite different from that of someone sedentary. The left ventricle – the chamber that does most of the work of pumping blood around the body – is likely to be much larger, and the walls more muscular.

The best way of assessing

someone's aerobic fitness is to measure their VO_2max , the maximum consumption of oxygen they can achieve during a session of exercise that gradually increases in intensity. Typically, the subject runs on an accelerating treadmill while breathing through a face mask to gauge the oxygen level of the air they breathe out. The higher your VO_2max , the fitter you are.

There are also ways to estimate VO_2max that don't require a sports

science lab. The only equipment needed for the Rockport Fitness Walking Test, for example, is a watch. Time how long it takes you to walk a mile as quickly as possible, then measure your heart rate. Plug the time and heart rate, along with your age, gender and weight into the appropriate equation or find a website that will do it for you – try the Brian Mac Sports Coach site – and you'll get a ballpark value for your VO_2max .



Is pumping iron really necessary?

Look around most gyms and you'll probably conclude that if you don't pump iron you're not doing a complete workout. But is that really true?

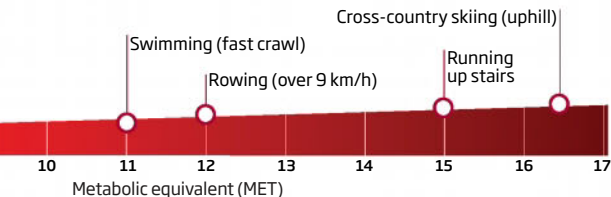
Several studies have suggested a link between muscle strength and living longer, but for a long time it was unclear whether other factors were confusing the picture. People who are muscular are more likely to be thin, aerobically fit and generally healthy – all features known to extend lifespan.

Recently, however, some large, well-designed studies have settled the question. One study, published in 2008, measured the muscle strength of almost 9000 American men and followed their health for 20 years. The death rates among those whose muscle strength was in the bottom third for their age group was around

30 per cent higher than for the other two-thirds.

That link remained even after the results had been adjusted to take account of the effects of aerobic fitness. "The bottom line is that both strength and aerobic fitness make independent contributions to health," says Steve Blair, one of the study's co-authors, based at the University of South Carolina's Arnold School of Public Health, who helped write the US national guidelines on exercise.

The most recent guidelines issued by the American College of Sports Medicine recommend 150 minutes of moderate exercise, plus two to three episodes of strength training per week, consisting of around three sets of 10 repetitions of strengthening exercises of all the major muscle groups.



SOURCE: UNIVERSITY OF SOUTH CAROLINA

"Risk of a heart attack during jogging does rise, but pales into insignificance beside its overall lifetime benefits"

Jogging can kill you

"Look at Jim Fixx!" cry the couch potatoes, citing the celebrity runner credited with kick-starting the jogging craze in the 1970s. At the age of 52, Fixx famously dropped dead from a heart attack midway through a run. Could exercise be a killer lying in wait for the unwary?

The risk of a heart attack does rise during vigorous exercise like jogging or shovelling snow. But the extent of the rise depends heavily on how accustomed you are to that exercise. For someone who is completely unfit, the risk can rise as much as 100-fold, relative to when they are resting. For someone who regularly runs five times a week, their risk while exercising roughly doubles. The lesson, says David Stensel, an exercise physiologist at Loughborough University in the UK, is to be careful when you take up exercise. He advises gradually building up the intensity and duration of your exercise sessions, and that you have a medical check-up if you are over 35 and are not used to regular physical activity.



Stensel points out that the raised risk, which lasts for the duration of the exercise and up to half an hour after it, pales into insignificance beside the overall lifetime benefits of regular exercise. Study after study has shown that keeping active lowers an individual's risk of suffering a heart attack by 50 to 80 per cent.

That protective effect stays with you day and night – whether you are running a marathon or asleep in bed. There are a myriad other health benefits too. "You're far better off exercising than worrying about your risk of heart attack during exercise," says Stensel.

Is getting fit easier for some people?

Although physical activity is an essential part of getting fit, it's not the whole story. An individual's fitness level also depends on how they respond to that activity, which is largely determined by their genes.

The landmark research in this field is the Heritage family study, begun in the 1990s. US and Canadian researchers recruited 481 sedentary people from 98 families, and subjected them to a rigorous 20-week training programme. They then put them through a battery of tests.

Many people's aerobic fitness improved dramatically, but others showed a less marked response and a few did not appear to improve at all. The disheartening news is that about 1 in 10 showed no change whatsoever in their aerobic fitness, despite doing

45 minutes of vigorous exercise three times a week for the final six weeks of the programme.

The degree of response turned out to be largely down to the participants' genes. If your parents find it hard to get fit, there's a good chance you will too. "We had families where all of them were low responders and other families where they were all high responders," says Claude Bouchard, now director of the Pennington Biomedical Research Center at Baton Rouge, Louisiana, who led the study.

Happily, even those whose aerobic fitness did not change had lower blood pressure and cholesterol, more normal insulin levels, and less abdominal fat. "You're never a complete non-responder," says Bouchard.

You can't be fat and fit

Whether being overweight is an absolute bar to fitness has become one of the most hotly debated questions in exercise science. Steven Blair at the University of South Carolina is one of those who doesn't accept what might at first sight seems plain common sense - that being fat means you must be unfit.

No one denies that there is a negative correlation between weight and aerobic fitness: overweight people tend, as a group, to be less fit. This is partly because a sedentary lifestyle contributes to weight gain, and partly because fat people may feel discouraged from taking exercise. It can be a vicious circle.

In a study published in 2007 Blair recruited 2600 people of varying weight and timed how long they could run on a treadmill before becoming exhausted, a proxy for fitness. Among those who were mildly obese, only a third met a common definition of being physically unfit, and only half of those who were moderately



obese were unfit. Blair points out that measures of aerobic fitness - the body's ability to deliver oxygen to the muscles - have nothing to do with the amount of fat tissue present.

In the 12 years during which the subjects were followed, Blair's study found that the risk of dying was more closely linked to fitness than fatness. People who were fit but obese had a lower risk of dying than people who were unfit but of normal weight. That's important, says Blair, because while many overweight people find it hard to get slim, they could still become healthier with more exercise. It's a point he would like doctors to bear in mind when advising overweight patients.



"While overweight people find it hard to get slim, they could still become healthier with exercise"



ERIK A. LARSEN/REDDUX/EVERETT

You need to 'push fluids'

Everyone knows the importance of keeping hydrated. Whether it's a water bottle or a sports drink, athletes and gym bunnies are rarely seen without a source of fluid close at hand. Common advice is to deliberately drink beyond what thirst dictates, or "push fluids", to combat dehydration and keep performance up to scratch.

Usually that's a waste of time, and just occasionally it can be fatal. Exercise-associated hyponatraemia (EAH) is a dangerous condition that occurs when people have drunk so much that the concentration of sodium in their blood falls too low. This leads to excess water moving into the tissues of the brain, causing brain swelling. Symptoms include nausea, vomiting and confusion. In rare cases - at least 12 have been recorded worldwide - the victim has died.

Slower marathon runners, who tend to drink more over the several hours it takes them to complete the course, are one group more likely to develop EAH, and women seem

to be more at risk than men. The condition can even be caused by sports drinks claimed to be "isotonic" - meaning that they contain the same concentration of dissolved substances as normal body fluids - as they tend to contain sugar but very little salt.

Cases of EAH rose in the US in the 1990s. Tim Noakes, director of the exercise science and sports medicine unit at the University of Cape Town, South Africa, who was the first to describe the condition, blames the rise on marketing by the makers of sports drinks, which he says promote overdrinking. He also claims that guidelines by the American College of Sports Medicine and other bodies have been influenced by sponsorship from the manufacturers of Gatorade, formerly Quaker Oats, now PepsiCo.

Since awareness of EAH has grown, most guidelines now warn athletes not to overdrink; rather to drink only when thirsty, Noakes says. Although some examples



of advice to drink "as much as possible" remain, most advice now sets lower and upper limits on how much to drink.

Ron Maughan, emeritus professor of sports nutrition at Loughborough University in the UK, says blanket guidelines are flawed because people vary in how much they sweat. He recommends that people weigh themselves before and after exercise to find out how much they sweat, and drink enough to maintain their body weight.

But this is overdoing it, says Noakes. Drinking to satisfy your thirst is all that is needed. "The easiest way to lower your performance is to overdrink, not underdrink."

What if I get injured?

Pulled muscles and twisted ankles are the downside of sports and exercise. Sometimes it's hard to know whether to rest an injury, see a doctor or push on through the pain.

If you are starting a new activity, don't be put off by some aches and stiffness during the first couple of days. "There's discomfort which you get just from using parts you're not used to using," says John Tanner, a musculoskeletal physician at the Oving Clinic in West Sussex, UK. "If it becomes a pain and intrusive, either stop and give it a break, or get some advice on technique." Around half of regular runners and players of team sports like football get some kind of musculoskeletal injury every year.

When returning to exercise after an injury, transient warm-up pain need not be a sign to stop, as long as it eases off after 5 to 10 minutes. Pain

may return on finishing the exercise, or the next morning. "But that's no bad thing if after 10 minutes it's gone again," says Martyn Speight, a musculoskeletal physician at the Wharfedale Clinic in Leeds, UK.

In many sports the most common injury is a sprained ankle. It's a problem that often recurs: in the first year after an injury, the risk of suffering a repeat sprain roughly doubles compared with that for previously uninjured people.

The risk can be reduced, however, by some simple home exercises using a wobbly platform known as a balance board. In July 2009, a team from the Free University of Amsterdam in the Netherlands showed that using the board for half an hour three times a week for eight weeks halves the risk of a repeat ankle sprain in the first year after injury.

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The best medicine

There's one simple thing you can take to protect against a host of life-threatening diseases, as **Andy Coghlan** discovers

IT'S 9 am in the office – time for my daily medication. As usual, I slink off to the fire escape for my fix. Twenty minutes later, I'm back at my desk, brimming with vitality and raring to go.

I've taken this medicine regularly now for about 10 years, after developing elevated blood pressure in my mid-40s. I'd heard it could help reduce blood pressure and improve circulation. Sure enough, the high blood pressure vanished long ago.

Amazingly, this drug is freely available to everyone on the planet. It's completely up to you when you take it, and how much. And, as research is now revealing, the more of it you take, the healthier you will be.

What is this wonder drug? It is plain old physical activity of all sorts – from running marathons to simply walking around your sofa while watching television. We've all heard that exercise is good for us, but what is becoming increasingly clear is the sheer extent of its benefits and why it works.

A plethora of recent studies shows that exercise protects us from heart attacks, strokes, diabetes, obesity, cancer, Alzheimer's disease and depression. It even boosts memory. And it has the potential to prevent more premature deaths than any other single treatment, with none of the side effects of actual medication. "It's a wonder drug," says Erik Richter, a diabetes researcher at the University of Copenhagen, Denmark. "There's probably not a single

organ in the body that's unaffected by it."

Throughout evolution, humans have been active. Our ancestors chased prey as hunter-gatherers and fled from predators. More recently, they laboured on farms and in factories. But the decline of agricultural and industrial labour, plus the invention of the car, a multitude of labour-saving devices and – most perniciously – TV, computers and video games, mean we've all ground to a sudden and catastrophic standstill.

"We were built to be active, but the way our environment has changed and the way we live our lives has led us to become inactive," says Christopher Hughes, senior lecturer in sport and exercise medicine at Queen Mary, University of London.

Now we're paying the price. In 2009 Steven Blair, an exercise researcher at the University of South Carolina in Columbia, published a study of more than 50,000 men and women showing that a lack of cardiorespiratory fitness was the most important risk factor for early death. It accounted for about 16 per cent of all deaths in men and women over the period of study, more than the combined contributions of obesity, diabetes and high cholesterol, and double the contribution of smoking (see graph, page 75).

In other words, physical inactivity is killing us. "Everyone knows too much booze or tobacco is bad for you, but if physical inactivity was packaged and sold as a product, it would need

to carry a health warning label," says Hughes.

As we have become inactive, so once-rare diseases have mushroomed. A report from the organisation Diabetes UK reveals that in 1935, when the world's population was just over 2 billion, an estimated 15 million people globally had type 2 diabetes. By 2010 the world's population had more than trebled and the number with diabetes had shot up to 220 million, with 300 million predicted for 2025. Likewise, results published in 2012 in the *Journal of the American Medical Association* showed that over a third of US men and women are obese, as are about 17 per cent of US children.

Weekly dose

The good news is that we can do something about it. I started running up and down the fire escape for a few minutes each day in the hope of not having to take cholesterol-lowering statins or drugs for high blood pressure. Now I'm eager to know what my daily routine is doing to my body and, more importantly, how it might be protecting me from disease.

The most robust evidence so far comes from the Exercise is Medicine initiative pioneered by the American College of Sports Medicine in Indianapolis, Indiana. Researchers there have collated studies over the past decade or so of people who follow the US government's advice on physical activity. This prescribes ➤

150 minutes per week of moderate-intensity aerobic activity, such as brisk walking, ballroom dancing or gardening, or 75 minutes of more vigorous activity such as cycling, running or swimming.

What the Exercise is Medicine findings show is that this weekly dose of moderate exercise reduces the risk of premature death through heart disease by 40 per cent, approximately the same as taking statins.

Flush out the fat

Chi Pang Wen of the National Health Research Institutes in Zhunan, Taiwan, offers some insights into precisely how physical activity prevents cardiovascular diseases. "Exercise can stimulate circulation, flush out fatty deposits in the walls of blood vessels and dilate small vessels that could otherwise be the cause of a heart attack or stroke," he says. In 2012 he presented results from a study of over 430,000 Taiwanese men and women, showing that exercise reduced the risk of heart attacks by 30 to 50 per cent.

Exercise also keeps blood vessels clear by helping to destroy the most dangerous fats. Recent research reveals that it alters the structure of fatty triglyceride particles in the bloodstream, making it easier for enzymes to destroy them before they can gum up the works. Many risks to circulatory health come from such fatty particles, in the form of chylomicrons produced in the gut, or very low density lipoproteins (VLDLs) pumped out by

the liver. The bigger the VLDL particles are, the easier they are for enzymes to break down, and the findings show exercise causes the particles to enlarge by about a quarter.

"A single 2-hour bout of exercise reduced triglyceride concentrations in the circulation by 25 per cent compared with no exercise," says Jason Gill, who led the study at the University of Glasgow, UK. His team found a decrease in both types of fat, but it was twice as large for the more insidious VLDL particles.

One of the most startling findings of the Exercise is Medicine initiative is that a modest weekly dose of exercise lowers the chances of developing type 2 diabetes by 58 per cent, twice the preventive power of the most widely prescribed anti-diabetes medication, metformin.

Type 2 diabetes affects adults when they stop responding efficiently to the hormone insulin, which orders muscle and fat cells to absorb surplus glucose from the bloodstream. When insulin loses its punch, glucose continues circulating and creates the potentially fatal sugar imbalances that are the hallmark of diabetes.

How does exercise reverse this? The story dates back to 1982, when Richter found that insulin activity is enhanced by physical activity – at least, in rats. Experiments showed that after the rats ran around for a couple of hours, their cells became up to 50 per cent more responsive to insulin compared with the cells of non-exercising rats. "We confirmed it later in humans," Richter says.



As cells reawaken to insulin, it seems that surplus glucose gets sponged from the circulation. Richter found that the effects lasted for a couple of hours after exercise in rats, and up to two days in humans.

He and colleagues have since unravelled more details about how exercise brings this about. They have discovered that both insulin and muscle contractions during exercise activate a molecule in muscle and fat cells called AS160, which helps them absorb glucose. Once activated, AS160 orders the cell to send molecules to the cell's surface to collect glucose and bring it inside. Without these transporter molecules, glucose cannot get through the fatty cell membrane.

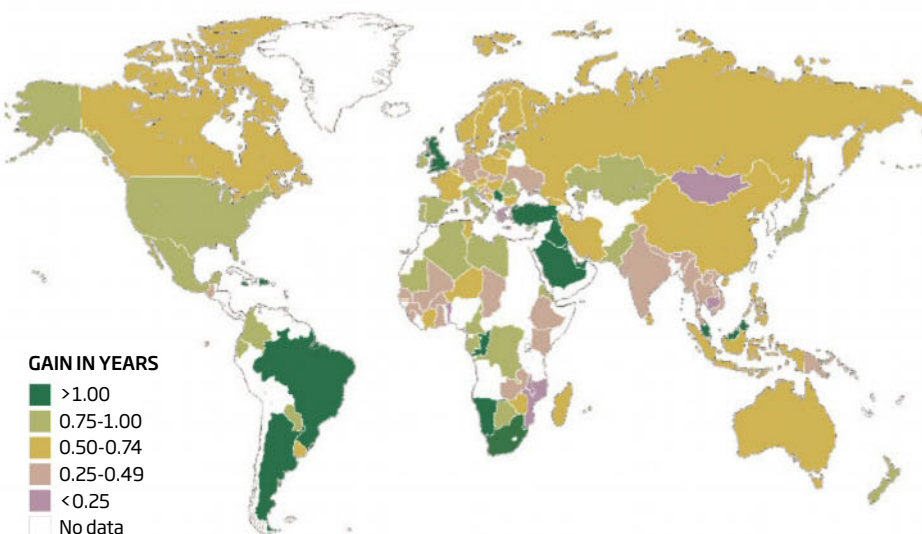
That's not the only way exercise also helps cells burn off excess sugar. Muscle cells absorb glucose and fatty acids from the bloodstream to replenish adenosine triphosphate (ATP), the molecular fuel found in most living cells. As ATP is used up, it produces waste products that are sensed by another molecule, AMPK. AMPK then orders cells to recharge by absorbing and burning yet more fat and sugar. In the mid-1990s, Grahame Hardie at the University of Dundee, UK, found exercise accelerates this process because muscle contraction activates AMPK.

Hardie says exercise has the potential to reverse obesity and diabetes and prevent cancer. The findings of the Exercise is Medicine initiative show that taking the US government's recommended weekly dose of exercise halves the risk of breast cancer in women and lowers the risk of bowel cancer by around 60 per cent. This is about the same reduction seen with low daily doses of aspirin.

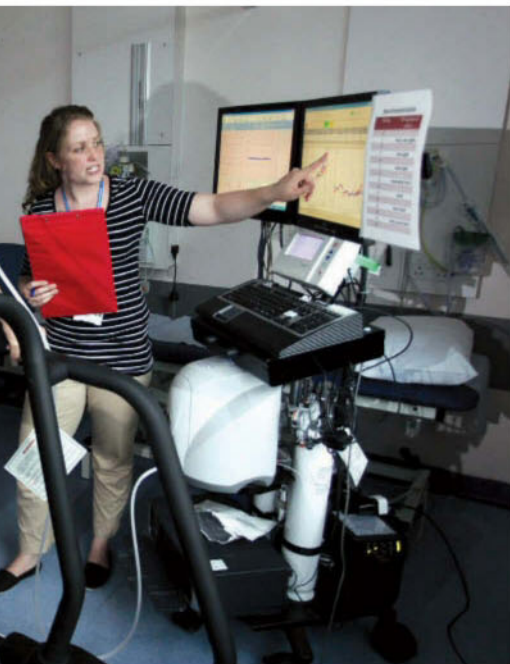
How exercise does this is not yet clear – not least because so many factors are involved in

Get active, live longer

Estimated gains in life expectancy if people get off the couch



SOURCE: HAN LEE ET AL/THE LANCET (DOI:10.1016/S0140-6736(12)61311-9)



Visits to the doctor should include a treadmill test

including faulty or mutated DNA that could trigger cancer if it hangs around. More recently, Levine has discovered the same processes in brain cells, suggesting that exercise might play a role in staving off dementias and neurodegeneration.

As well as potentially staving off dementia, pounding the stairs might even help boost my brainpower and memory. Back in 1999, Henriette van Praag of the US National Institute on Aging in Baltimore, Maryland, found that mice using a running wheel developed new neurons in the hippocampus, a part of the brain vital for memory. “We had a doubling or tripling of neurons after they’d been running daily for about a month,” she says.

Subsequently, van Praag and other groups found the most likely reason: a doubling in the level of a substance in the hippocampus called brain-derived neurotrophic factor, or BDNF, which may support growth of new neurons.

More than a decade on, a team led by Art Kramer of the University of Illinois at Urbana-Champaign demonstrated through a brain-imaging study of 120 older adults that exercise increased hippocampus volume by around 2 per cent. It also improved their memory, as measured by standard tests.

“The volume increase we saw can make up for approximately two years of normal age-related decrease,” says Kramer. “We found that even modest increases in fitness can lead to moderate, 15 to 20 per cent improvements in memory.”

cancer’s appearance and progression, including sex hormone imbalances, the ability of the immune system to clear cancer cells, and damage to genes and DNA generally. However, some clues are beginning to emerge. “Exercise reduces body weight, which is a known risk factor for postmenopausal breast cancer,” says Lauren McCullough of the University of North Carolina at Chapel Hill.

She also thinks that reducing fat deposits in the body results in less exposure to circulating hormones, growth factors and inflammatory substances. “All have all been shown to raise breast cancer risk,” she says.

Another clue comes from work by Anne McTiernan of the Fred Hutchinson Cancer

“Everyone knows booze and tobacco are bad for us. But if physical inactivity was packaged and sold as a product, it would need to carry a health warning”

Research Center in Seattle, who studies bowel cancer. Biopsies from 200 healthy volunteers showed that, compared with exercisers, non-exercisers had more telltale signs of abnormalities in colonic crypts – recesses in the lining of the colon that absorb water and nutrients. Crypts in idle participants had an increased number of dividing cells, and these also climbed higher up the crypt walls, where they had the potential to form pre-cancerous polyps.

Another potential protection against cancer might come back to the ability of exercise to stimulate AMPK. Recent research by Beth Levine of the University of Texas Southwestern Medical Center in Dallas showed that exercise stimulates cells craving extra energy to burn unwanted rubbish,

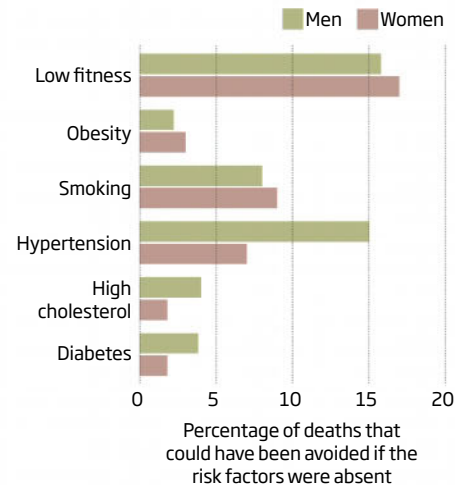
The benefits aren’t just restricted to adults. Kramer and his colleagues have also found that pre-adolescent children who exercise develop larger hippocampuses.

So if exercise is so beneficial, why won’t people take it? At least 56 per cent of US adults don’t meet the government’s exercise guidelines. “The most common excuse people give in polls is that they don’t have time,” says Blair. That is unlikely to be true: according to a 2008 study, US citizens spend, on average, almost 8 hours a day watching TV.

For those, like me, who don’t want the fuss of joining a gym, there is plenty people can do at home or the workplace in their own time and at their own pace. Blair cites a study in which researchers asked half of a group of couch potatoes to walk round their sofa

Exercise or die

Based on a study of 54,000 people in the US



SOURCE: BRITISH JOURNAL OF SPORTS MEDICINE, VOL. 43, P.1

during each TV commercial break. “They burned 65 calories more per hour, and that is 260 calories in 4 hours,” he says. Over a week, their exertions met the US government recommendations for exercise.

And overweight people can benefit massively from exercise even if they don’t lose weight, Blair points out. One of his studies has shown that for fit fat people, the risk of dying prematurely is half that for unfit lean people.

Once a marathon runner, Blair now walks for an hour a day, and now in his 70s, he has set himself the goal of walking 5 million steps each year, tracking his progress with a pedometer.

Blair is concerned that not enough doctors recognise that lack of fitness is effectively a disease. He wants them to use fitness as a gauge of health, perhaps making their patients do a treadmill test as a matter of routine, rather than considering it as an afterthought.

Figures published in *The Lancet* in 2012 back up his assertion that no action other than abstaining from smoking is as good for health as being physically active. The study also revealed that physical inactivity effectively leads to 5 million premature deaths a year worldwide, as many as are caused by smoking (see map, left).

As for me, all that running up and down the stairs does seem to be working, although I don’t have health data from 10 years ago to confirm my progress. Scans and tests showed my blood pressure and bone density are normal, and I have 6 per cent less body fat than an average man of my age. Also, only 20 per cent of my fat is the dangerous sort around organs in the abdomen, compared with 30 per cent in most of my peers. My heart fitness, measured on a treadmill, is above average and I have no chronic diseases that I know of. Now, imagine you were offered a pill that did all that. Wouldn’t you take it? ■



Whatever your age, regular physical exercise could be the surest way to train your brain as well, says [Christie Aschwanden](#)

Faster body, faster mind

ANYONE hoping for a quiet doze during John Ratey's speech would have been disappointed. Addressing 1100 of the world's leading educators, he invited them to join him in a spot of exercise. "We ran in place for 20 seconds, then rested for 10 seconds, then repeated this four more times," says Ratey.

This might seem an odd approach for a psychiatrist speaking at an education conference. But Ratey, who is based at Harvard Medical School, knew that getting the crowd to limber up before his speech was in his own interests – it would make them more alert and might even help them retain more of what they were about to hear. "It got the whole group ready to listen," he says. It was also the perfect introduction for a keynote speech on the ways that we can all use our bodies to improve our minds.

It has long been accepted that exercise cuts the risk of getting heart disease, and recent studies suggest a raft of more general benefits, such as reducing the risk of certain types of cancer and even preventing the onset of type 2 diabetes (See "The Best Medicine", page 73).

JON FRANK



Now it seems that gym junkies can also expect a boost in brain power.

This is not just the vague glow of well-being that is suggested by sayings such as “a sound mind lives in a healthy body”. Instead, Ratey and others are finding that fitness has a profound long-term influence on a wide range of cognitive abilities that shape your IQ. Physical activity seems to be important during childhood, powering the brain through the many changes that help us to mature into adulthood. But it may also play a role during our dotage, with a decline in fitness explaining why some people are more prone to dementia.

“It’s a really amazing effect, and it makes this one of the most exciting areas in exercise physiology,” says David Raichlen, a biological anthropologist at the University of Arizona in Tucson. Looking back into our species’ past, he is investigating whether our ancestors’ athleticism may even have accelerated the evolution of their intelligence millions of years ago. Our brains may, in fact, be a by-product of our brawn.

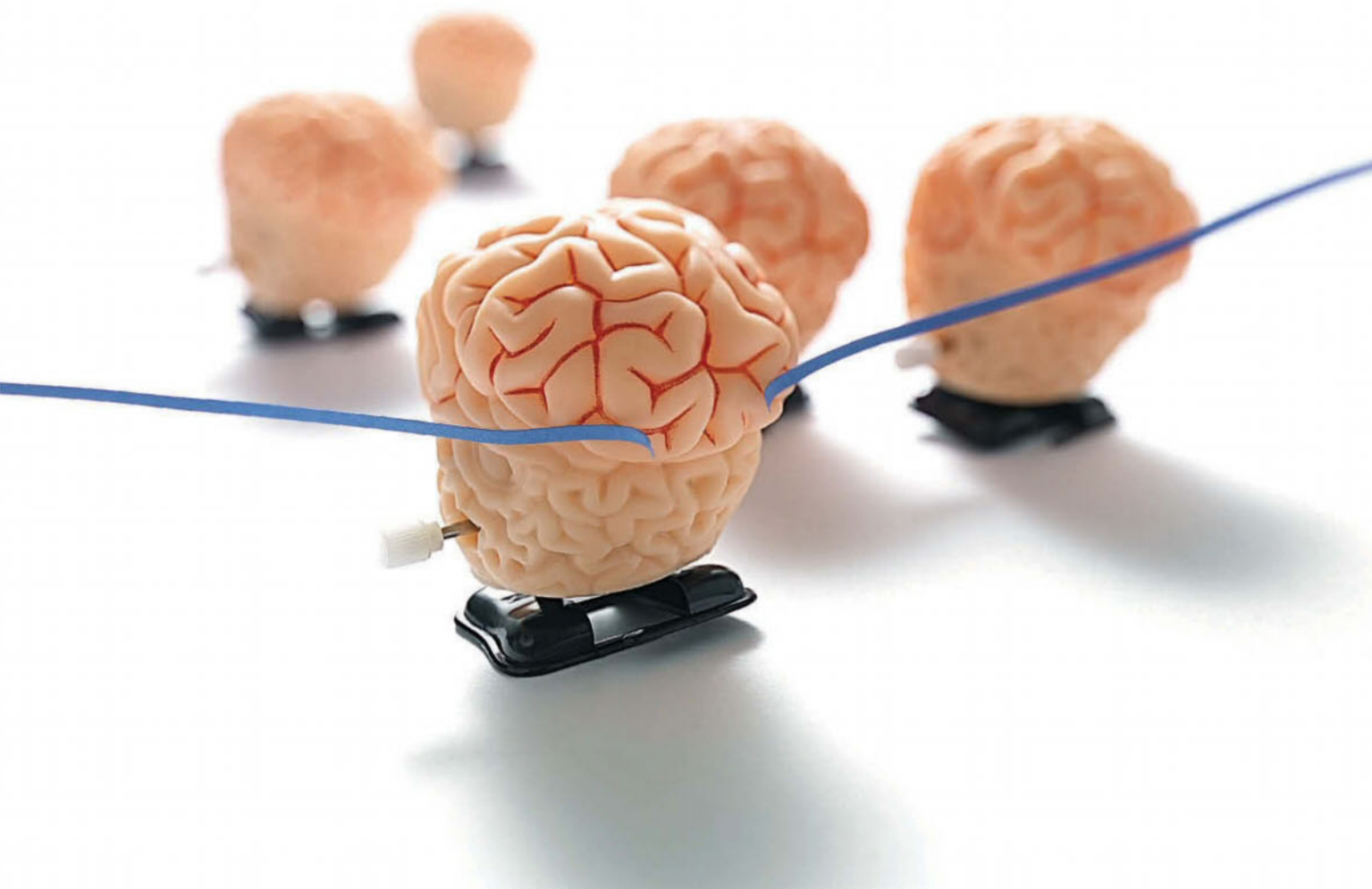
The link between fitness and the

performance of simple cognitive tasks was first suggested by studies in the 1960s, but its importance became more greatly appreciated about 30 years later. In the 1990s, Fred Gage, a geneticist at the Salk Institute in La Jolla, California, found that exercise seemed to cultivate the growth of new neurons in mice. At about the same time, Arthur Kramer, a cognitive psychologist at the Beckman Institute for Advanced Science and Technology at the University of Illinois, published a paper in *Nature* showing that previously sedentary adults who undertook an aerobic fitness plan for six months boosted their performance in cognitive drills that required executive control. That’s the kind of concentration that helps you to switch between different tasks without making mistakes, and it is a key contributor to more general intelligence.

Building on these experiments, a spate of later papers tracked people’s fitness and cognitive skills over several years, sometimes decades. Initially, most of the investigations examined older people whose mental abilities were expected to lose their

shine with age. One German study, published in 2010, tracked 4000 Bavarians over the age of 55 for two years. It found that those who rarely took part in physical activities were more than twice as likely to suffer from a cognitive impairment by the end of the study than those who engaged in exercise such as gardening, swimming or cycling a few times a week. Another study, which had followed a group of nearly 1500 people for 20 years, showed that these effects may be long-lasting. Those who exercised at least twice a week during middle age were much less likely to develop dementia by the time they reached their 60s and 70s, even when potentially confounding factors such as education, drinking and smoking were taken into account. The results should serve as a warning for couch potatoes: building good habits now could delay your mental decline in decades to come.

Although there are fewer studies of younger people, the available evidence suggests that physical activity enhances brain health at every stage of life. Some of the most striking statistics concern children aged 5 to 14 ➤



attending state-funded schools in New York City. Students in the top 5 per cent of the fitness rankings scored 36 percentile points higher on standardised academic tests than students ranked in the bottom 5 per cent. Similar results come from the records of 1.2 million men who enlisted for military service in Sweden between 1950 and 1976, which allowed researchers to compare the men's physical education grades at 15 with their cardiovascular performance at 18. Changes in fitness during these teen years seemed to correlate with the young men's intelligence scores and cognitive abilities by the end of that time period.

Taken together, all this research is reshaping our view of the relationship between body and brain. "When I was first thinking about this, I thought maybe there's a baseline healthy brain, and physical activity might improve it from there," says neurologist Megan Herting at the University of Southern California's Keck School of Medicine in Los Angeles, who has studied the impact of exercise on children's development. "But now I feel it's the opposite – the high-activity kids

might represent the baseline of how the brain is supposed to be active." The implication is that exercise is not an enhancer of normal cognition; it's a necessary condition.

What's behind the link? A short-term mood boost might be bringing some of the benefits. "People really enjoy that euphoric aspect of a runner's high and the clarity of mind you get from a routine workout," says Brian Christie, a neuroscientist at the University of Victoria in British Columbia, Canada. Stress can inhibit your brain's responses when solving a problem, blocking it from making the necessary connections. "If you go out for a walk, your stress levels usually plummet. And that's when the answer comes to you," Christie says. That might partly explain why fitter children tend to do better at their schoolwork, for instance.

Exercise probably contributes to more

"More athletic species tend to have proportionally bigger brains than less active animals"

permanent changes too. As one of the body's most energy-hungry organs, the brain relies on a steady supply of nutrients and oxygen through an intricate network of capillaries. Physical activity can encourage the construction of these supply lines, and it can also ease their maintenance. Matthew Pase at Swinburne University of Technology in Melbourne, Australia, has found that high blood pressure, particularly in the central large arteries that feed the brain, can lead to a slump in cognitive performance, perhaps because it damages those vessels. Since regular physical activity reduces blood pressure, it should protect the brain's food supply from this undue stress.

Improved fitness also cuts the risk of diabetes and obesity. These problems disrupt the brain's insulin system, which is thought to trigger a cycle of reactions that contribute to the build-up of the plaques linked to brain damage in people with Alzheimer's disease. Alongside these changes to the brain's overall health, exercise has been found to spur the release of neurotransmitters like serotonin, noradrenaline and dopamine, which help

regulate signalling in the brain. These neurotransmitters are the same ones that antidepressants and drugs for attention-deficit hyperactivity disorder act on, which is why a bout on a treadmill or bicycle is akin to taking a mix of Prozac and Ritalin, says Ratey. It also prompts the brain to send out growth factors such as insulin-like growth factor-1 (IGF-1) and brain-derived neurotrophic factor (BDNF), which Ratey calls “Miracle-Gro for your brain” because it creates an environment where neurons can flourish and promotes the formation of new connections between cells.

The roots of this connection between body and mind probably lie deep in our evolution. “Physical activity is a strong part of our evolutionary history. Our whole physiological system is built on being athletic,” Raichlen says. Perhaps the brain boost emerged to improve navigation. As animals forage and search for food, the surge in growth factors that accompanies their movements could encourage the neural and synaptic growth that helps them to remember the path, so they can revisit the spot later on.

Evolutionary leap

Alternatively, the link could just be an evolutionary accident, Raichlen says. “It may be that you’re up-regulating these things to improve your ability to exercise, and the effects in your brain are a by-product.”

Even if that’s the case, it may still lie behind some profound events in our prehistory. Raichlen points out that humans have far greater athletic endurance than our primate relatives – you wouldn’t find a monkey running a marathon. As our ancestors evolved for long-distance trekking to catch their food, they would have experienced a constant flood of those growth factors and neurotrophins that nourish the development of neurons and synapses. It is possible that the result was a leap in intelligence, Raichlen says.

A handful of studies so far offers some support for the hypothesis. A few years ago, Raichlen and his colleague Adam Gordon of University at Albany, State University of New York, measured the brains of various groups of animal species, including rodents, dogs, cats and ungulates, and used their maximum metabolic rate as a proxy for athleticism. Within each group, the species with greater capacity for physical activity tended to have bigger brains in relation to their overall body mass.

Raichlen also cites experiments that attempted to mimic evolution in the lab, by selectively breeding animals for certain traits. Mice bred for long-distance running, for instance, showed higher baseline levels of growth factors, along with a ramped up production of new cells in the hippocampus and marked brain growth in other regions,

Cycling to school may give children an easy ride to better grades



CHRISTOPH HET ZMANSSEDER/GETTY

including the mid-brain. And looking at the anatomy of early humans, Raichlen recently studied the evolution of traits like longer limbs – an indication of the capacity for more strenuous physical activity. His results, published in 2013, suggest that greater athleticism went hand in hand with increasing brain size – although he stresses that we are still missing direct evidence that the one caused the other. “The evolutionary story is really under-studied,” he says.

Whatever role exercise played in our evolution, the brain-enhancing consequence of exercise has serious implications today. The US Department of Health is now encouraging schools to offer more physical education and the Institute Of Medicine recommends that elementary school children get 30 minutes of physical activity a day, and then 45 minutes daily in middle and high school. “We need to have kids moving every day, not just because

“Even gentle activities, such as taking a walk a few times a week, can work wonders for your brain”

it makes sense health-wise, but because it raises test scores,” Ratey says.

The same principle applies to the older population, and offers an alternative to cognitive training strategies, such as brain teasers, that are often touted as ways to sharpen the ageing brain. There’s currently not a lot of evidence to back these up, says Kramer, since the improvements gained in the specific cognitive training tasks don’t seem to translate to everyday life. In contrast, new exercise regimes, typically conducted over six months or a year, tend to accelerate processing speed and improve attention and memory in all kinds of activities. Early results suggests that combining both approaches may be best of all.

What kind of exercise is ideal? An aerobic workout is essential, but depending on your current fitness it doesn’t have to be too strenuous. Kramer has found that even gentle activities, such as taking a walk a few times a week, worked wonders for some elderly volunteers – increasing the connectivity of their brain networks and the size of their hippocampi, and boosting overall recall.

For those who are already in good shape, Ratey advocates a kind of exercise called high-intensity interval training (HIIT), which consists of very short, very hard bursts of exercise. Pushing your body in this way triggers the pituitary gland to release human growth hormone, he says, which in turn enhances neurotransmitter levels.

As evidence for HIIT’s effectiveness, Ratey cites a German study in which participants incorporated two 3-minute intervals of high-intensity sprinting into a 40-minute run. They produced much higher levels of BDNF and noradrenaline, and performed 20 per cent better in a post-run vocabulary-building exercise than those who had taken more leisurely exercise. However, Ratey cautions that HIIT is something that first-time exercisers should build towards slowly.

Ratey practises what he preaches, exercising at least three times a week for 20 minutes, with six 30-second high-intensity intervals in each session. The regime produces results without requiring a lot of time, he says.

Kramer, who is now in his early 60s, also finds time to apply his discoveries to his life. He once climbed mountains, and ran marathons for many years, but these days he gets the bulk of his exercise on a stationary bike, where he can read the newspaper while he works out. At work, he uses a standing desk and walks between 30 minutes to an hour each day on a treadmill underneath it.

It’s never too late to begin getting these benefits, says Kramer. “I’m often asked, ‘If I’m 70 will it help me?’ The answer is: absolutely, yes.” ■



PIERLUIGI LONGO

Are you sitting comfortably? Well, don't!

MICHAEL JENSEN is talking to me on the phone, but his voice is drowned out by what sounds like a vacuum cleaner. Or maybe it's a lawnmower. I'm used to bad connections, but Jensen isn't using Bluetooth on a busy freeway. He's in his office at one of the US's top medical research facilities.

"I'm sorry," he says when I ask about the noise. "I'm on a treadmill."

I'd had a similar experience earlier with David Dunstan, an Australian researcher who talked to me on his speakerphone as he walked around his office at the Baker IDI Heart and Diabetes Institute in Melbourne.

It's not that Jensen and Dunstan are hyperactive. Rather, both are exercise researchers looking into the link between sitting down and premature death. And what they have found is clearly disturbing enough for them both to make sure they spend most of the day on their feet.

Jensen explains that he and his colleagues at the Mayo Clinic in Rochester, Minnesota, were studying weight control when they discovered that some people "spontaneously start moving round and don't gain weight" when they have overeaten.

These people don't dash to the gym – they just walk more, hop up from the couch to run errands or find other excuses to get on their feet. "This really got us thinking about this urge to move," Jensen says, "and how important that might be for maintaining good health."

That, in turn, led them to a field known as "inactivity research", which is revealing that inactivity, particularly in the form of sitting, is really bad for your health. It might sound like a statement of the obvious, but the killer point is this: inactivity is bad for you even if you exercise as well. Heading to the gym is not a licence to spend the rest of the day on your backside.

Even if you're fit and active, that desk job is seriously bad for your health, as Richard A. Lovett discovers to his horror

In 2010, a team led by Alpa Patel of the American Cancer Society in Atlanta, Georgia, analysed the data from a 14-year study of 123,000 middle-aged adults. When they compared mortality rates between those who spent 6 hours a day or more sitting and those who reported 3 hours or less – and taking into account other factors such as diet – they found something surprising. Extra time on the couch was associated with a 37 per cent higher mortality rate for women and 17 per cent higher for men. It is not clear why there is such a big gender difference

In another study, a team at the University of Queensland, Brisbane, analysed data on the television viewing habits of 8800 Australians. They calculated that each hour of television slices 22 minutes off the average life expectancy of an adult over 25. In other words, people who watch 6 hours of television a day can expect to die, on average, about five years younger than those who don't watch any.

There are many other studies reaching similar conclusions. In a review of all the evidence, Dunstan's team concluded that there was a "persuasive case" that excessive sitting "should now be considered an important stand-alone component of the physical activity and health equation".

The message is clear. Sitting still for hours at a time is a health risk regardless of what you

do with the rest of your day. Just as you cannot compensate for smoking 20 a day by running 10 kilometres at the weekend, a bout of high-intensity exercise does not cancel out the effect of watching TV for hours on end. Patel's study found that people who spent hours sitting had a higher mortality rate even if they worked out for 45 to 60 minutes a day. The researchers call these people "active couch potatoes".

But it is not just the couch that worries them. If the harm comes primarily through the inactivity itself – discounting sleep, which brings its own health benefits – the researchers suspect that other kinds of inactivity may be just as harmful as watching TV, be it reading a novel or sitting at an office desk.

To find out just how sedentary people are, Dunstan equipped hundreds of research subjects with accelerometers and inclinometers to monitor their daily activities. The accelerometers measured how energetic their movements were, and the inclinometers revealed how much time they spent sitting.

"The sobering reality," Dunstan says, "is that across a 14 or 15-hour waking day, we're getting 55 to 75 per cent sedentary time. Moderate-to-vigorous activity – what people like to call 'exercise' – occupies just 5 per cent or less of people's days."

Intrigued by our conversation, I began to wonder about my own lifestyle. I have always considered myself to be active, although arthritis has ended my marathon-running days. But maybe I've been kidding myself. To find out the reality, I bought an armband with a mix of accelerometers, skin-conductivity sensors and heat-flow detectors to determine my minute-by-minute exertion level.

What I learned was disturbing. On a typical working day, I am inactive for 8 hours in total. Although I run up to 25 kilometres a week and take long walks, there are periods when I sit ➤

for more than 2 hours at a time writing.

I also gave an armband to a friend, Bhavana Reddy, who is a physical therapist. Her activity pattern is totally different. On a typical working day she gets up, drives to work, walks into her office, spends a few minutes at the computer, and then it's move, move, move as she meets patients and demonstrates exercises. She spends much of the day on her feet. After work she goes for a run or rides her horse. Television? If she watches it, I'm not sure when. She has sedentary moments, but they only add up to 5 hours 30 minutes. Not only is that lower than my total, but the pattern is different. She sits frequently, but rarely for more than a few minutes at a time. Other than her workouts, her activities are never very intense, but there's nothing close to my extended writing sessions (see lower diagram, right).

Sitting targets

When I describe Bhavana's lifestyle to Dunstan, he gives the telephonic equivalent of a shrug. He points out that many professions, such as hairdressers and restaurant workers, probably fall into the same group. But such jobs are becoming less common. Once, file clerks actually carried files to the places where they were needed. Not any more. "The modern office worker is engaged with a computer screen while seated at a desk," says Dunstan.

That's not the lifestyle to which the human body is adapted. "From an evolutionary point of view, we are built to be active," says Audrey Bergouignan, a human physiologist at the University of Colorado, Denver. "Your grandparents were not going to the fitness centre. They were active all day."

Much of Bergouignan's own research involves bed-rest studies funded by space agencies. They are primarily concerned with the effects of low gravity on astronauts but the results also apply to earthbound inactivity.

In a typical study, healthy and previously active volunteers are confined to bed for anything from a day to three months. "They develop metabolic features very close to what we observe in obese people and people with type 2 diabetes," Bergouignan says.

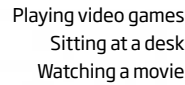
The studies reveal that inactivity produces a complex cascade of metabolic changes. For example, unused muscles not only atrophy, but shift from endurance-type muscle fibres which can burn fat to fast-twitch fibres that rely more strongly on glucose. Inactive muscles also lose mitochondria, the cells' power packs, which can also burn fat.

With the muscles relying more on carbohydrates for what little work they are doing, unburned lipids accumulate. "Your blood is going to become very fatty," Bergouignan says, which could be why sitting has been linked to heart disease. Fat also gathers in muscles, the liver and the colon –

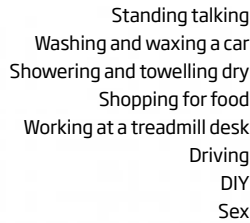
Are you an active couch potato?

Time spent doing sedentary activities is a health risk regardless of how much exercise you take. Low-intensity physical activities alleviate such risk, and more vigorous ones can improve health

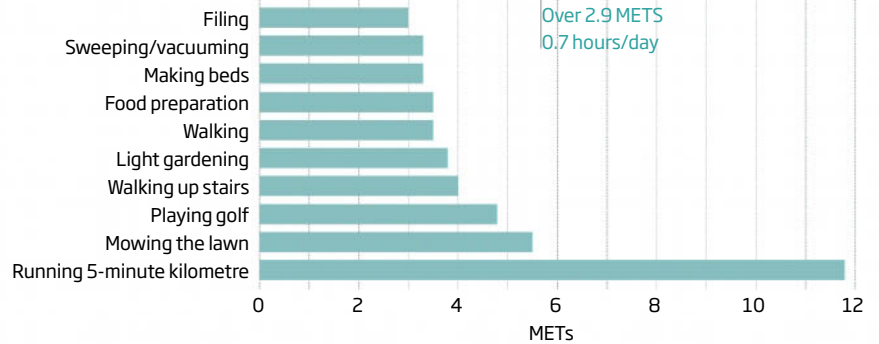
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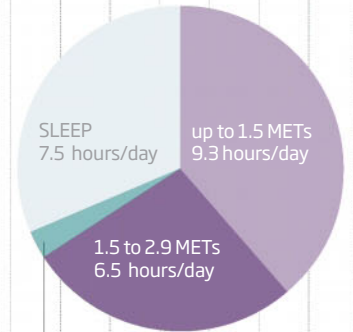
LOW-INTENSITY PHYSICAL ACTIVITIES



MODERATE-TO-VIGOROUS PHYSICAL ACTIVITIES



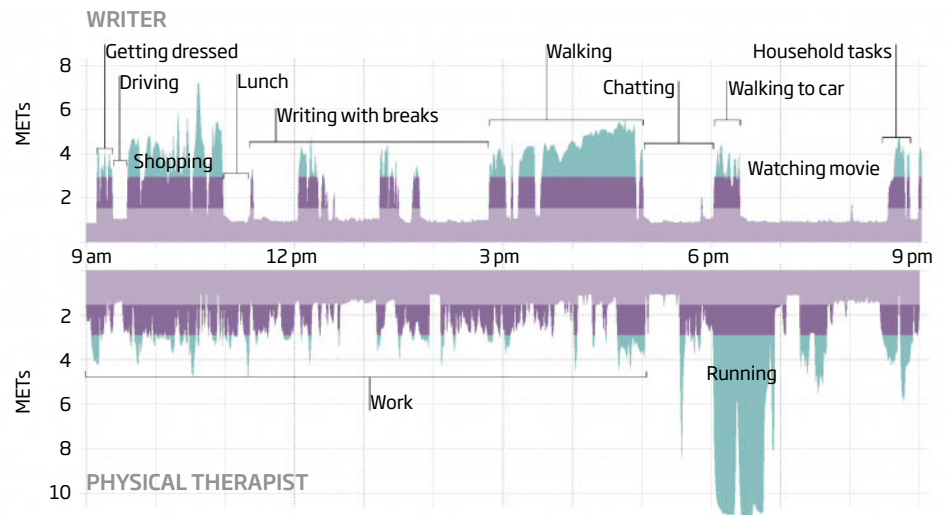
THE AVERAGE WESTERNER SPENDS MOST OF THEIR WAKING HOURS SITTING STILL



MET = Metabolic Equivalent of Task, a measure of the intensity of physical activity. 1 MET represents the average resting energy expenditure of a young, healthy adult: 3.5 ml of O₂ consumed/kg/min

Occupational hazard

The job you do is a major determinant of how much time you spend sitting down. Even though the writer's profile here has more peaks, the physical therapist's day is probably healthier overall





“People who watch 6 hours of television every day can expect to die five years earlier than people who don’t watch any”

places where it is not supposed to be stored.

Other changes involve insulin resistance, a diabetes-like condition in which glucose accumulates in the bloodstream even when the body produces insulin to sequester it. All of this happens very quickly. “In three days we have insulin resistance,” Bergouignan says.

Similar effects, she adds, occurred in a study in which normally active people were asked to curtail their exercise, in essence spending a few weeks imitating their sedentary friends.

So what can people do to avoid this – other than quitting their desk jobs and taking up nursing, hairdressing or waiting on tables? First of all it is important to note that exercise still has benefits – an hour’s workout cannot undo hours of sitting, but it is still good for your health. Patel’s gym-bunnies fared better than people who sat a lot and did not go to the gym.

That’s a message exercise advocates don’t want to get lost in the gloom. “We know that if you exercise 40 to 60 minutes a day, you’re going to have a health benefit,” says Iñigo San Millán, director of the Human Performance Laboratory at the University of Colorado

Hospital’s Sports Medicine Clinic in Denver.

Dunstan agrees. “We shouldn’t throw out the well-documented benefits of vigorous physical activity,” he says. Rather, we should think of extensive sitting as another risk factor that should be addressed separately.

Squirming on my seat

But how? One of the things I tried was fidgeting: tapping my feet while sitting at my desk or squirming on my seat. But when I looked at the data from my armband, I could barely discern the effect. Sitting still, I burn 1.3 calories per minute. Fidgeting raises it to 1.4.

“Fidgeting isn’t the same as standing up and walking around,” Jensen says. “Contrast that with puttering around your home or even going for a very gentle walk. There really is no comparison.” My armband agrees. The moment I stand up and move around, it starts fluctuating between 3.0 and 5.0 calories per minute. That is hardly vigorous. I easily burn 12 calories a minute while I’m running, but low-intensity activity is sufficient – and it adds

up. It all depends on how long you do it for, says Marc Hamilton, an inactivity researcher at the Pennington Biomedical Research Center in Baton Rouge, Louisiana. Anything that raises your metabolic rate above 1.5 times the resting rate is considered light activity. For me, that means burning about 2 calories a minute (my resting metabolic rate is 1.3 calories per minute), which is about half the energy I expend putting clothes in a washing machine (see upper diagram, opposite).

In his recent experiments, Dunstan has been bringing people into his lab so that he and his team can find out precisely what works. In one study, volunteers visited on three separate days. The first visit, they simply sat watching TV. On the other two, they watched TV but stood up three times an hour to spend two minutes on a treadmill. On one of the days they went at an easy pace, on the other they walked more briskly. On each visit they were given lunch with a sugary drink.

The scientists discovered that short activity breaks reduced the volunteers’ blood sugar and insulin spikes after the drink by roughly 25 per cent. “That is a good thing,” Dunstan says. “We want to avoid those big spikes.” Even more interestingly, ambling on the treadmill was just as effective as more energetic walking.

Jensen thinks that what makes these short bouts of activity effective is that they’re enough to burn off some of the glucose that’s accumulated in your bloodstream. “Your bloodstream isn’t that big,” he says. “In the whole body it’s only 5 litres.” For non-diabetics, that translates to less than 10 grams of glucose in the bloodstream. “If you just burn off 4 grams – 16 calories – that’s a lot of glucose you’ve taken out of the bloodstream.”

It’s easy to burn 16 calories. According to my armband, I can do it within 5 minutes simply by pacing around the room. That’s also a really good way to clear the mind. “People who get up and move around for 5 minutes every hour are every bit as productive as people who sit there for hours at a time,” Jensen says.

The next step, adds Dunstan, is to determine the best ways to build activity breaks into the day. Is it best to have frequent short breaks? Or less frequent, longer ones? Are treadmill desks and adjustable-height workstations even better, allowing workers to switch from sitting to standing or walking as they work? At home, the questions are similar. If you are working on the computer, Dunstan suggests, “take a break and do the dishes”. If you are watching TV, get up and move around every 20 minutes, or whenever there’s a break.

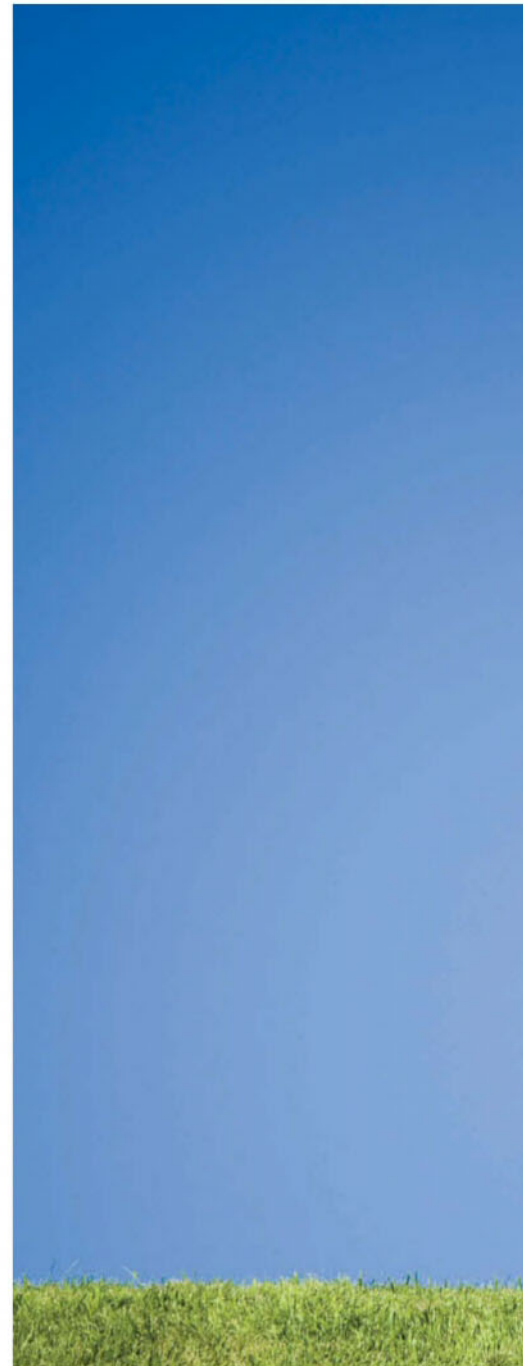
Patel adds that this may actually come as good news to the millions of people who have not been able to get close to recommended daily exercise levels. “The nice take-home message,” she says, “is that anything is better than nothing. Just getting up and moving at all is taking a big step in the right direction.” ■

You can't always get what you want...

...but the science of persuasion can help

Win someone round to your point of view, talk your employer into giving you a pay rise, or persuade your partner it's their turn to stack the dishwasher - getting people to do your bidding can be very handy. Persuasion is a crucial element of human interaction, from politics to marketing to everyday dealings with friends, family and colleagues.

Unfortunately it is both notoriously difficult to pull off and almost impossible to resist when done well. Psychologists have long been fascinated by persuasion - why some people are better at it than others and why some strategies work where others fail. To help you negotiate the minefield, here are some insights from science. By **Dan Jones** and **Alison Motluk**



1

Be their mirror

WHEN you're aware of it, it's one of the most infuriating behaviours imaginable. Yet mimic someone's mannerisms subtly – their head and hand movements, posture and so forth – and it can be one of the most powerful forms of persuasion. That's the conclusion of a number of studies.

William Maddux at the INSEAD business school in Fontainebleau, France, explored the effect of mimicry on a group of students in two role-play experiments, one involving negotiation between job candidates and recruiters, the second between buyers and sellers. In both cases, the outcome of negotiations was better for the would-be persuaders when they employed subtle mimicry. For example, in the buyer-seller experiment, two-thirds of sellers who mimicked their target secured a sale, as opposed to an eighth of those who did not.

Another study by Robin Tanner, now at the University of Wisconsin, Madison, invited students to try a new sports drink called Vigor and discuss it with a sales rep. The drink was actually Gatorade Ice and the reps were fake, though the students did not know this. Half of the reps were instructed to mimic the physical and verbal behaviour of half of the students they spoke to.

These “chameleon” reps elicited more positive ratings of the drink, and the students they mimicked consumed more of it during the chat. “Ours is the first study to show that mimicry can essentially enhance persuasion in interpersonal interactions,” says Tanner. Intriguingly, people felt especially positive about the drink and its market prospects when the mimic explicitly stated their vested interest in the success of the drink.

It is possible, though, that the reps in the “no mimicry” group subconsciously resorted to mimicry. Jeremy Bailenson and Nick Yee of Stanford University in California got round this by using virtual reality avatars. They asked 61 students to watch and listen to an avatar arguing that students should carry ID cards at all times – an unpopular proposal. For one group, the avatar moved in a pre-programmed human-like way. In the other, computers tracked the students' head movements, which the avatar mimicked after a 4-second delay (previous studies suggested a delay of 2 to 4 seconds works best). Students who had been mimicked were more likely to respond favourably.

But be warned, overt mimicry can backfire on you, or at least be very embarrassing if detected, says Tanner. “It's far from a free shot at persuasiveness.”

The crucial factors are: be subtle, leave a delay and, whatever you do, if you think there's even the slightest chance you've been rumbled, stop. ➤



ERIK/SAKON/RUBBERBALL/PUNCHSTOCK



IMAGEBANK

2

Accentuate the negative

IF YOU want to bring people round to your point of view, try “framing”, a favourite tactic of spin doctors. “Framing is about leading people to think about an issue or opinion in a way that is advantageous to you,” explains George Bizer of Union College in Schenectady, New York. “For example, opponents of inheritance taxes prefer to frame them as ‘death taxes.’”

Framing is a key tactic in election campaigns, so Bizer wanted to see whether voters were more or less persuadable to change their views when asked to frame them in different ways.

He asked 69 undergraduates to read an article about two fictitious candidates’ views and policies. One candidate, Rick, was conservative, while the other, Chris, was liberal. The students were then asked to choose between two statements: “I support X” or “I oppose X”. For half the students X was Rick; for the others it was Chris. Participants also rated their preference for

both candidates on a sliding scale from “strongly support” to “strongly oppose”.

They then read another article, this time arguing against the merits of their chosen candidate, and had their opinions reassessed. Overall, people whose preference had been expressed in terms of opposition to the other candidate were less likely to change their position.

“A simple change in framing - leading people to think of their evaluations in terms of whom they oppose instead of whom they support - leads to stronger, more resistant opinions,” Bizer concluded.

These findings fit with a broad body of research suggests that negative information is more persuasive than positive information. So if you want to sway someone when they are choosing between two options, think like a politician and go negative.

3

Keep it simple

IN MOST battles, outnumbering your opponent will hand you victory, and it would seem common sense that the more arguments you can call on, the more persuasive you'll be. Yet, the evidence suggests otherwise.

A number of studies have revealed that the more reasons people are asked to come up with in support of an idea, the less value they ascribe to each. The result: asking people to "think of all the reasons why this is a good idea" is likely to backfire, and may serve to harden their views.

Zakary Tormala and Richard Petty, then at Ohio State University, working with Pablo Briñol at the Autonomous University of Madrid in Spain, demonstrated the effect over a decade ago. The researchers told 59 university students that there was a plan to introduce new exams into their courses – an unwelcome prospect. They then asked half the students to produce two reasons why this was

a bad idea, and the other half eight reasons. On average, students who supplied just two arguments against the proposal were subsequently more opposed to the exam policy than those who gave eight.

Tormala and colleagues argue that the ease with which we can summon up thoughts affects how much confidence we place in them, and it is generally easier to think of two reasons for believing something rather than eight. "If you want to persuade people by getting them to think positively about your message, idea, product or whatever, ask them to generate just a few positive thoughts – three at most – because that's easy and they'll feel confident about their positive thoughts," says Tormala.

Conversely, next time you're in an argument, avoid the temptation to spin the "give me one good reason" line; it'll only strengthen your adversary's hand.

4

Choose your moment

HUNGER is a powerful thing, but how many times have you reached for a quick snack, only to regret it when it's lying heavily in your stomach? Just as your standards for food quality can slip when your stomach is empty, so you should avoid engaging in argument or doing battle with salespeople when your mental batteries are running low. Conversely, if you're trying to be persuasive, strike when your target is running low on mental energy.

Edward Burkley of Oklahoma State University in Stillwater studied the impact of cognitive exhaustion on the resistance levels of 78 students. The plan was to try to convince them to accept one month's summer holiday instead of three. Half the students came to the study fresh. The other half first had to complete a self-control task in which they wrote down all thoughts that came into their heads while suppressing any thoughts about a white bear.

This task, Burkley argued, would use up some of their reserves of self-control. Sure enough, he found that the students who had performed the white bear task were less resistant to the idea of giving up two months' holiday.

Burkley also studied the flip side of this effect. He asked a different group of students to rate the plan to shorten the holidays. Half were told it would be implemented within two years, making it personally relevant. The other half were told it would not be implemented for 10 years.

The idea was to test the hypothesis that students presented with the two-year scenario would use up more of their mental resources, because they would be more motivated to argue against that unwelcome suggestion.

The students then had to try to complete an impossible puzzle which they did not know was unsolvable – a technique commonly used in psychological research to measure how much self-control a person has. On average, students in the 10-year group persisted for more than a minute longer before giving up, suggesting they were less mentally exhausted than those in the two-year group.

Of course, there is a form of mental exhaustion that doesn't require thought: nag them into submission. Children have got this technique sussed, says Burkley.

5

Use the right medium

IN THIS fast-paced world, there is seldom time for face-to-face meetings. You are just as likely to conduct personal and business negotiations by email, or some other electronic medium, as you are in person. How does this impact your powers of persuasion?

The question intrigued Rosanna Guadagno, now at the US National Science Foundation in Arlington, Virginia, and Robert Cialdini of Arizona State University, who compared the persuasive power of online communication with face-to-face meetings.

In a study published in 2002, Guadagno and Cialdini had a group of students discuss the introduction of new exams. The group was split into same-sex couples. Unbeknownst to the subjects, each pair included an accomplice of the experimenters whose role was to provide arguments in favour of the idea. Half the discussions took place in an online chatroom, the other half sat face-to-face.

While overall men rated the proposals similarly whether they participated in the electronic or face-to-face sessions, women in face-to-face sessions rated them more

highly than those who only took part online. Guadagno and Cialdini suggest this is because groups of women tend to form communal bonds and reach agreement. Electronic communication disrupts the exchange of social cues women use to establish a communal bond and is therefore less conducive to persuasion.

On the other hand, groups of men typically try to establish their competence and independence, which can lead to competitive encounters. When two men who have not met before debate a point, online interaction is about as effective and persuasive as face-to-face.

But if they have met and had a competitive exchange, subsequent face-to-face meetings are less productive, whereas online exchanges fare far better. So although online communication can prevent women “connecting”, it can help men suppress competitive urges that hamper persuasion.

So, if you’re a woman and want to persuade other women you’d be better off meeting face-to-face, whereas men are less confrontational if contacted by email. The researchers have since found that people are also better at persuading members of their own sex, who they tend to have more in common with.

6

Style or substance?

IT WAS midnight when the knock came at the door. It was “Paul”, a “neighbour”, who’d “just moved in”. He spoke without pause or hesitation, detailing a problem with a truck that had run out of gas and his need for \$20, which he would, of course, return first thing in the morning. Later, Kurt often looked back and wondered just how it was he got taken in so easily.

“Paul” was a master con artist: Kurt later learned that four other people on the street had also been taken in by his sob story.

Maybe we shouldn’t be so surprised when things like this happen. Persuasion, it turns out, may have as much to do with how you say something as what you’re saying. And the less time you’re allowed to think about the content, the more the style of delivery matters. At least, those are the findings of

two marketing professors who decided to tease style and substance apart.

John Sparks at the University of Dayton in Ohio and Charles Areni, now at Macquarie University in New South Wales, Australia, knew from earlier work on courtroom transcripts that people equated certain kinds of speech with lack of credibility. In particular, hesitant phrases such as “I mean”, “you know” and “isn’t it?” reduced a speaker’s power. But no one had looked at the exact relationship between style and content.

The researchers asked 118 undergraduates to read a transcript of a testimonial about a computer scanner. In one version, the speaker used hesitations like “I mean” and “ummm”; in the other, he used none. They also gave half the students enough time to read it thoroughly, while the others

got just 20 seconds, to see how limiting a person’s understanding of the substance would alter the persuasiveness of the style.

The researchers found that in both versions style was important. When hesitant language was used, people were less easily convinced that this was a scanner worth buying - even when it was a better scanner at a lower price. Style was especially important, the researchers found, when time was short. “If you can’t pay attention to what the speaker is saying,” Sparks says, “you pay attention to how they say it.”

So take a lesson from Paul the conman. If you want to be persuasive, don’t stumble, pause or use language that shows hesitation. And for goodness sake, don’t give your listeners time to think about what you’re really saying.

WORKBOOK STOCK/JUPITER





7

Get them angry

ANGERING people may seem like an odd way to go about persuading them, but according to Monique Mitchell Turner at The George Washington University in Washington, DC, it is seriously underrated as a tool of persuasion.

Much study has gone into how emotions aid persuasion. The best known and most studied is fear. It serves well in campaigns that try to steer you clear of certain activities, like smoking or unprotected sex.

But fear doesn't always work, says Turner, and over time people become more resistant to scare tactics. The same applies to guilt. It can be effective, but not once people cotton onto the fact

they're being manipulated. Worse, it has to be carefully calibrated: too much and people resist. "We don't want people telling us we're bad people," says Turner.

Anger is different. For one thing, it's focused on someone else's misdeeds, not your own. Also, it's a very utilitarian emotion, she says, usually in response to a perceived injustice. "Anger makes people feel empowered," Turner says.

There has been a long debate, she says, about whether anger can be constructively harnessed. In studying groups that employ anger as a tactic - most notably animal rights groups such as People for the Ethical Treatment of Animals, as well as environment organisations and even political campaigns - she has found that, given the right conditions, it can.

First, people have to be convinced that the issue is relevant to them, that it affects them or their children or their community. At that point, says Turner, you need to hammer home what's wrong with the world as it is. Once you have got people roiled up, you can offer them a way to remedy the situation.

"When those feelings of anger are accompanied by the feeling that there is a solution to this problem, then the message is more likely to be persuasive," she says.

8

Break their resistance

HISTORICALLY, psychologists studying persuasion concentrated on what makes certain messages more appealing. But some researchers have begun thinking differently. A growing body of evidence suggests that breaking down people's resistance can be even more important.

The reason for this is that people are naturally suspicious of attempts to persuade them. This is especially true if they think they are being duped.

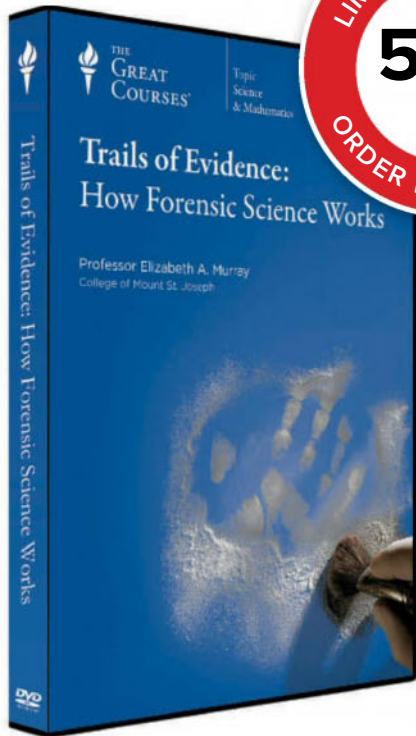
In lab studies, merely reminding people that they are vulnerable to manipulation - for example, showing them adverts with celebrities endorsing products they clearly know nothing about - makes them generally more difficult to persuade.

So far so obvious, but there's a useful point here. Resistance means that very persuasive arguments can backfire. People who successfully resist persuasion often become even more entrenched in their wrong-headed opinions, and the stronger, more credible or

authoritative they perceive the attempt at persuasion to be, the more certain of their opinions they become when they resist it.

At first, this seems paradoxical. You might think a strong, authoritative argument would hold greater sway. Not necessarily. It seems that if people resist good arguments presented by an expert, they conclude their own arguments must be even stronger. This sets up a catch-22. "If you want to change people's attitudes, it's good to have strong arguments," says Zakary Tormala of Stanford University. "But if they manage to resist your message, they might become more certain of the very attitudes you want to change."

How to overcome this deadlock? Richard Petty of Ohio State University in Columbus says: "Present positions closer to your target's views, then move them towards your goal a little at a time." You could also try boosting their self-esteem. "When people feel good about themselves, they are more open to challenging messages," he says. ■



Go Inside the Forensics Lab

Ever wonder how accurate detective dramas are? The truth is, fictional portrayals of crime scene investigations often get it wrong. It's a shame, because knowing how scientists approach cases isn't just fascinating, it can actually help you be a better juror or witness, sharpen your analysis of headline-grabbing crimes, and make you a more critical thinker.

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Life is full of choices, from the small and mundane, such as what to wear or eat, to the life-changing, such as who to marry, **what job to take** and how to bring up children. We jealously guard our right to choose. It is central to our individuality, the very **definition of free will**. Yet making decisions is fraught with danger. Sometimes we plump for an option that leaves us unhappy or full of regret. **Can science help?**

Making good decisions requires us to balance the seemingly antithetical forces of emotion and rationality. We must be able to **predict the future**, accurately perceive the present, have insight into the minds of others and deal with uncertainty.

Most of us are ignorant of the mental processes that lie behind our decisions, but this has become a **hot topic for investigation**, and what psychologists and neuroscientists are finding may help us all make better choices. By **Kate Douglas** and **Dan Jones**



OWAKIKULUJACORBIS

1

Don't fear the consequences

Whether it's choosing between a long weekend in Paris or a trip to the ski slopes, a new car versus a bigger house, or even who to marry, almost every decision we make entails predicting the future. In each case we imagine how the outcomes of our choices will make us feel, and what the emotional or "hedonic" consequences of our actions will be. Sensibly, we usually plump for

the option that we think will make us the happiest overall.

This "affective forecasting" is fine in theory. The only problem is that we are not very good at it. People routinely overestimate the impact of decision outcomes and life events, both good and bad. We tend to think that winning the lottery will make us happier than it actually will, and that life would be completely unbearable if we were to lose the use of our legs. "The hedonic consequences of most events are less intense and briefer than most people imagine," says psychologist Daniel Gilbert from Harvard University. This is as true for major events such as losing a job or a kidney as it is for trivial ones such as going to a great restaurant.

A major factor leading us to make bad predictions is "loss aversion" – the belief that a loss will hurt more than a corresponding gain will please. Psychologist Daniel Kahneman from Princeton University has found, for instance, that most people are unwilling to accept a 50:50 bet unless the amount they

could win is roughly twice the amount they might lose. So most people would only gamble £5 on the flip of a coin if they could win more than £10. Yet Gilbert and his colleagues have shown that while loss aversion affected people's choices, when they did lose they found it much less painful than they had anticipated. He puts this down to our unsung psychological resilience and our ability to rationalise almost any situation. "We're very good at finding new ways to see the world that make it a better place for us to live in," he says.

So what is a poor affective forecaster supposed to do? Rather than looking inwards and imagining how a given outcome might make you feel, try to find someone who has made the same decision or choice, and see how they felt. Remember also that whatever the future holds, it will probably hurt or please you less than you imagine. Finally, don't always play it safe. The worst might never happen – and if it does you have the psychological resilience to cope.



2

Go with your gut

It is tempting to think that to make good decisions you need time to systematically weigh up all the pros and cons of various alternatives, but sometimes a snap judgement or instinctive choice is just as good, if not better.

In our everyday lives, we make fast and competent decisions about who to trust and interact with. While at Princeton University, Janine Willis and her colleague Alexander Todorov found that we make judgements about a person's trustworthiness, competence, aggressiveness, likeability and attractiveness within the first 100 milliseconds of seeing a new face. Given longer to look – up to 1 second – the researchers found observers hardly revised their views; they only became more confident in their snap decisions.

Of course, as you get to know someone better you refine your first impressions. It stands to reason that extra information can help you make well-informed, rational decisions. Yet paradoxically, sometimes the more information you have the better off you may be going with your instincts. Information overload can be a problem in all sorts of situations, from choosing a school for your child to picking a holiday destination. At times like these, you may be better off avoiding conscious deliberation and instead leave the decision to your unconscious brain, as research by Ap Dijksterhuis, then at the University of Amsterdam in the Netherlands, and colleagues shows.

They asked students to choose one of four hypothetical cars, based either on a simple list of four specifications such as mileage and legroom, or a longer list of 12 such features. Some subjects then got a few minutes to think about the alternatives before making their

decision, while others had to spend that time solving anagrams. What Dijksterhuis found was that faced with a simple choice, subjects picked better cars if they could think things through. When confronted by a complex decision, however, they became bamboozled and actually made the best choices when they did not consciously analyse the options.

Dijksterhuis and his team found a similar pattern in the real world. When making simple purchases, such as clothes or kitchen accessories, shoppers were happier with their decisions a few weeks later if they had rationally weighed up the alternatives. For more complex purchases such as furniture, however, those who relied on their gut instinct ended up happier. The researchers conclude that this kind of unconscious decision-making can be successfully applied way beyond the shopping mall into areas including politics and management.

But before you throw away your lists of pros and cons, a word of caution. If the choice you face is highly emotive, your instincts may not serve you well.

In 2006, Joseph Arvai, then at Michigan State University in East Lansing, described a study in which he asked people to consider two common risks in US state parks – crime and damage to property by white-tailed deer. When asked to decide which was most urgently in need of management, most people chose crime, even when it was doing far less damage than the deer.

Arvai puts this down to the negative emotions that crime incites. “The emotional responses that are conjured up by problems like terrorism and crime are so strong that most people don't factor in the empirical evidence when making decisions,” he says.

“Whatever the future holds
it will hurt or please you less
than you imagine”

You might think that emotions are the enemy of decision-making, but in fact they are integral to it. Our most basic emotions evolved to enable us to make rapid and unconscious choices in situations that threaten our survival. Fear leads to flight or fight; disgust leads to avoidance.

Yet the role of emotions in decision-making goes way deeper than these knee-jerk responses. Whenever you make up your mind, your limbic system – the brain’s emotional centre – is active. Neurobiologist Antonio Damasio from the University of Southern California in Los Angeles has studied people with damage to only the emotional parts of their brains, and found that they were crippled by indecision, unable to make even the most basic choices, such as what to wear or eat. Damasio speculates that this may be because our brains store emotional memories of past choices, which we use to inform present decisions.

Emotions are clearly a crucial component in the neurobiology of choice, but whether they always allow us to make the right decisions is another matter. If you try to make choices under the influence of an emotion it can seriously affect the outcome.

Take anger. Daniel Fessler and colleagues from the University of California, Los Angeles, induced anger in a group of subjects by getting them to write an essay recalling an experience that made them see red. They then got them to play a game in which they were presented

3

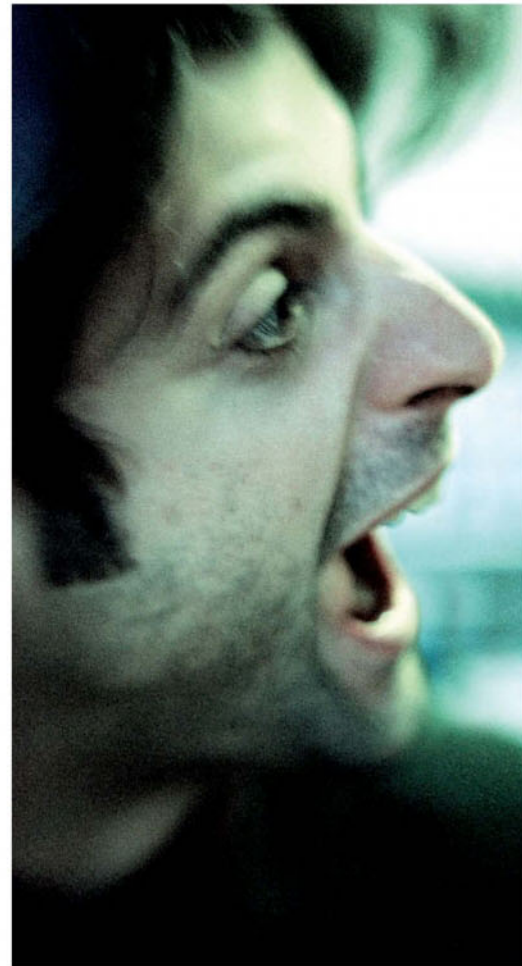
Consider your emotions

with a simple choice: either take a guaranteed \$15 payout, or gamble for more with the prospect of gaining nothing. The researchers found that men, but not women, gambled more when they were angry.

In another experiment, Fessler and colleague Kevin Haley discovered that angry people were less generous in the ultimatum game – in which one person is given a sum of money and told to share it with an anonymous partner, who must accept the offer otherwise neither gets anything.

A third study by researchers at the University of Chicago found that angry consumers were more likely to opt for the first thing they were offered rather than considering other alternatives. It seems that anger can make us impetuous, selfish and risk-prone.

Disgust also has some interesting effects.



4

Play devil's advocate

Have you ever had an argument with someone about a vexatious issue such as immigration or the death penalty and been frustrated because they only drew on evidence that supported their opinions and conveniently ignored anything to the contrary? This is the ubiquitous confirmation bias. It can be infuriating in others, but we are all susceptible every time we weigh up evidence to guide our decision-making.

If you doubt it, try this famous illustration of the confirmation bias called the Wason card selection task. Four cards are laid out each with a letter on one side and a number on the other. You can see D, A, 2 and 5 and must turn over those cards that will allow you to decide if the following statement is true: “If there is a D on one side, there is a 5 on the other”.

Typically, 75 per cent of people pick the D and 5, reasoning that if these have a 5 and a D respectively on their flip sides, this confirms the rule. But look again. Although you are required to prove that if there is a D on one

side, there is a 5 on the other, the statement says nothing about what letters might be on the reverse of a 5. So the 5 card is irrelevant. Instead of trying to confirm the theory, the way to test it is to try to disprove it. The correct answer is D (if the reverse isn’t 5, the statement is false) and 2 (if there’s a D on the other side, the statement is false).

The confirmation bias is a problem if we believe we are making a decision by rationally weighing up alternatives, when in

WASON CARD SELECTION TASK

Each of these cards has a letter on one side and a number on the other. Which two cards should you turn over to allow you to decide if the following statement is true:

“If there is a D on one side, there is a 5 on the other”?





PUNCHSTOCK

“Disgust protects against contamination,” says Fessler. “The initial response is information-gathering, followed by repulsion.” That helps explain why in their gambling experiments, Fessler’s team found that disgust leads to caution, particularly in women.

Disgust also seems to make us more censorious in our moral judgements. Thalia Wheatley, now at Dartmouth College in Hanover, New Hampshire, and Jonathan Haidt, now at New York University Stern School of Business, used hypnosis to induce disgust in response to arbitrary words. They then asked people to rate the moral status of various actions, including incest between cousins, eating one’s dog and bribery. In the most extreme example, people who had read a word that cued disgust went so far as to express moral censure of Dan, a blameless student councillor who was merely organising discussion meetings.

All emotions affect our thinking and motivation, so it may be best to avoid making important decisions under their influence. Yet strangely there is one emotion that seems to help us make good choices. In their study, the Chicago researchers found that sad people took time to consider the various alternatives on offer, and ended up making the best choices. In fact many studies show that depressed people have the most realistic take on the world. Psychologists have even coined a name for it: depressive realism.

fact we already have a favoured option that we simply want to justify. Our tendency to overestimate the extent to which other people’s judgement is affected by the confirmation bias, while denying it in ourselves, makes matters worse.

If you want to make good choices, you need to do more than latch on to facts and figures that support the option you already suspect is the best. Admittedly, actively searching for evidence that could prove you wrong is a painful process, and requires self-discipline. That may be too much to ask of many people much of the time.

“Perhaps it’s enough to realise that we’re unlikely to be truly objective,” says psychologist Ray Nickerson at Tufts University in Medford, Massachusetts. “Just recognising that this bias exists, and that we’re all subject to it, is probably a good thing.” At the very least, we might hold our views a little less dogmatically and make choices with a bit more humility.

“Searching for evidence that could prove you wrong is a painful process”

5

Keep your eye on the ball

Our decisions and judgements have a strange and disconcerting habit of becoming attached to arbitrary or irrelevant facts and figures. In a classic study that introduced this so-called “anchoring effect”, psychologists Dan Kahneman and Amos Tversky asked participants to spin a “wheel of fortune” with numbers ranging from 0 to 100, and afterwards to estimate what percentage of United Nations countries were African. Unknown to the subjects, the wheel was rigged to stop at either 10 or 65. Although this had nothing to do with the subsequent question, the effect on people’s answers was dramatic. On average, participants presented with a 10 on the wheel gave an estimate of 25 per cent, while the figure for those who got 65 was 45 per cent. It seems they had taken their cue from the spin of a wheel.

Anchoring is likely to kick in whenever we are required to make a decision based on very limited information. With little to go on, we seem more prone to latch onto irrelevancies and let them sway our judgement. It can also take a more concrete form, however. We are all in danger of falling foul of the anchoring effect every time we walk into a shop and see a nice shirt or dress marked “reduced”. That’s because the original price serves as an anchor against which we compare the discounted price, making it look like a bargain even if in absolute terms it is expensive.

What should you do if you think you are succumbing to the anchoring effect? “It is very hard to shake,” admits psychologist Tom Gilovich of Cornell University in Ithaca, New York. One strategy might be to create your own counterbalancing anchors, but even this has its problems. “You don’t know how much you have been affected by an anchor, so it’s hard to compensate for it,” says Gilovich.



SCIENCEFACTION/GETTY

6

Don't cry over spilt milk

Does this sound familiar? You are at an expensive restaurant, the food is fantastic, but you've eaten so much you are starting to feel queasy. You know you should leave the rest of your dessert, but you feel compelled to polish it off anyway. Or what about this? At the back of your wardrobe lurks an ill-fitting and outdated item of clothing. It is taking up precious space but you cannot bring yourself to throw it away because you spent a fortune on it and you have hardly worn it.

The force behind both these bad decisions is called the sunk cost fallacy. In the 1980s, Hal Arkes and Catherine Blumer from The Ohio State University demonstrated just how easily we can be duped by it. They got students to

imagine that they had just paid \$50 for a skiing weekend at a great resort in Wisconsin—only to discover that it clashed with a \$100 skiing weekend they had already paid for at a lesser resort in Michigan.

What would they do? Surprisingly, most opted for the more expensive but less appealing trip because of the greater cost already invested in it.

The reason behind this is that the more we have invested in something, the greater the commitment we feel towards it. And the investment needn't be financial. Who hasn't persevered with a tedious book or an ill-judged friendship long after it would have been wise to cut their losses?

Nobody is immune to the sunk cost fallacy. In the 1970s, the British and French governments fell for it when they continued investing heavily in the Concorde supersonic airliner project well past the point when it became clear that developing the aircraft was not economically justifiable. Stock-market traders are susceptible too, often waiting far too long to ditch shares that are plummeting in price.

To avoid letting sunk cost influence your decision-making, always remind yourself that the past is the past and what's spent is spent. We all hate to make a loss, but sometimes the wise option is to stop throwing good money after bad. "If at the time of considering whether to end a project you wouldn't initiate it, then it's probably not a good idea to continue," says Arkes.

"The more we invest
in something the more
committed we feel to it"

Consider this hypothetical situation. Your home town faces an outbreak of a disease that will kill 600 people if nothing is done. To combat it you can choose either programme A, which will save 200 people, or programme B, which has a one in three chance of saving 600 people but also a two in three chance of saving nobody. Which do you choose?

Now consider this situation. You are faced with the same disease and the same number of fatalities, but this time programme A will result in the certain death of 400 people, whereas programme B has a one in three chance of zero deaths and a two in three chance of 600 deaths.

You probably noticed that both situations are the same, and in terms of probability the outcome is identical whatever you pick. Yet most people instinctively go for A in the first scenario and B in the second. It is a classic case of the “framing effect”, in which the choices we make are irrationally coloured by the way the alternatives are presented. In particular, we have a strong bias towards options that seem to involve gains, and an aversion to ones that seem to involve losses. That is why

7

Look at it
another way

programme A appears better in the first scenario and programme B in the second. It also explains why snacks tend to be marketed as “90 per cent fat free” rather than “10 per cent fat”, and why we are more likely to buy anything from an idea to insurance if it is sold on its benefits alone.

At other times, the decisive framing factor is whether we see a choice as part of a bigger picture or as separate from previous decisions. Race-goers, for example, tend to consider each race as an individual betting opportunity, until the end of the day, when they see the final race as a chance to make up for their losses throughout the day. That explains the finding that punters are most likely to bet on an outsider in the final race.

In 2006, Ray Dolan from University College London and Benedetto De Martino, now at the University of Cambridge, used functional MRI to probe the brain’s response to framing effects. In each round, volunteers were given a stake, say £50, and then told to choose between a sure-fire option, such as “keep £30” or “lose £20”, or a gamble that would give them the same pay-off on average. When the fixed option was presented as a gain (keep £30), they gambled 43 per cent of the time. When it was presented as a loss (lose £20), they gambled 62 per cent of time. All were susceptible to this bias, some far more so than others.

The brain scans showed that when a person went with the framing effect, there was lots of activity in their amygdala, part of the brain’s emotional centre. De Martino was interested to find that people who were least susceptible had just as much activity in their amygdala. They were better able to suppress this initial emotional response, however, by drawing into play a part of the brain called the orbital and medial prefrontal cortex, which has strong connections to both the amygdala and parts of the brain involved in rational thought. De Martino notes that people with damage to this brain region tend to be more impulsive. “Imagine it as the thing that tunes the emotional response,” he says.

Does that mean we can learn to recognise framing effects and ignore them? “I don’t know,” says De Martino, “but knowing that we have a bias is important.” He believes this way of thinking probably evolved because it allows us to include subtle contextual information in decision-making.

Unfortunately that sometimes leads to bad decisions in today’s world, where we deal with more abstract concepts and statistical information. There is some evidence that experience and a better education can help counteract this, but even those of us most prone to the framing effect can take a simple measure to avoid it: look at your options from more than one angle.



8

Beware peer pressure

You may think of yourself as a single-minded individual and not at all the kind of person to let others influence you, but the fact is that no one is immune to social pressure. Countless experiments have revealed that even the most normal, well-adjusted people can be swayed by figures of authority and their peers to make terrible decisions.

In one classic study, Stanley Milgram of Yale University persuaded volunteers to administer electric shocks to someone behind a screen. It was a set-up, but the subjects didn't know that and on Milgram's insistence many continued upping the voltage until the recipient was apparently unconscious. In 1989, a similar deference to authority played a part in the death of 47 people, when a plane crashed into a motorway just short of East

Midlands airport in the UK. One of the engines had caught fire shortly after take-off and the captain shut down the wrong one. A member of the cabin crew realised the error but decided not to question the captain's authority.

The power of peer pressure can also lead to bad choices both inside and outside the lab. In 1971, an experiment at Stanford University in California famously had to be stopped when a group of ordinary students who had been assigned to act as prison guards started mentally abusing another group acting as prisoners. Since then studies have shown that

"If you are a member of a group or committee, never assume it knows best"

groups of like-minded individuals tend to talk themselves into extreme positions, and that groups of peers are more likely to choose risky options than people acting alone. These effects help explain all sorts of choices we might think are unwise, from the dangerous antics of gangs of teenage boys to the radicalism of some animal-rights activists and cult members.

How can you avoid the malign influence of social pressure? First, if you suspect you are making a choice because you think it is what your boss would want, think again. If you are a member of a group or committee, never assume that the group knows best, and if you find everyone agreeing, play the contrarian. Finally, beware situations in which you feel you have little individual responsibility – that is when you are most likely to make irresponsible choices.

Although there is no doubt that social pressure can adversely affect our judgement, there are occasions when it can be harnessed as a force for good. Since 2009, several cities across the US have adopted a report card system whereby homeowners are told how their consumption of water or electricity compares with their neighbours. Some are even accompanied by a smiley face or a frown. Several studies have shown that this kind of peer pressure works wonders – people who receive personalised reports reduce their consumption significantly more than those who get non-personalised bills.

9

Limit your options

You probably think that more choice is better than less, but consider these findings. People offered too many alternative ways to invest for their retirement become less likely to invest at all, and people get more pleasure from choosing a chocolate from a selection of five than when they pick the same one from a selection of 30.

These are two of the discoveries made by psychologist Sheena Iyengar from Columbia University, New York, who studies the paradox of choice – the idea that while we think more choice is best, often less is more. The problem is that greater choice usually comes at a price. It makes greater demands on your information-processing skills, and the process can be confusing and time-consuming. In addition, more choice also increases the chances of your making a mistake, so you can end up feeling less satisfied with your choice because of a nagging fear that you have missed a better opportunity.

The paradox of choice applies to us all, but it hits some people harder than others. Worst affected are "maximisers" – people who seek the best they can get by examining all possible options before they make up their mind. This strategy can work well when choice is limited, but flounders when things become too complex. "Satisficers" – people who tend to choose the first option that meets their preset threshold of requirements – suffer least. Psychologists believe this is the way most of us choose a romantic partner from among the millions of possible dates.

"If you're out to find 'good enough', a lot of the pressure is off and the task of choosing something in the sea of limitless choice becomes more manageable," says Barry Schwartz, a psychologist at Swarthmore College, Pennsylvania. When he investigated maximising and satisficing strategies among



10

Leave it to someone else

We tend to believe that we will always be happier being in control than having someone else choose for us. Yet sometimes, no matter what the outcome of a decision, the actual process of making it can leave us feeling dissatisfied. Then it may be better to relinquish control.

In 2006, Simona Botti, then at Cornell University, and Ann McGill from the University of Chicago published a series of experiments that explore this idea. First they gave volunteers a list of four items, each of which was described by four attributes, and asked them to choose one. They were given either a pleasant choice between types of coffee or chocolate, or an unpleasant one between different bad smells. Once the choice was made they completed questionnaires to rate their levels of satisfaction with the outcome and to indicate how they felt about making the decision.

As you might expect, people given a choice of pleasant options tended to be very satisfied with the item they picked and happily took the credit for making a good decision. When the choice was between nasty options, though, dissatisfaction was rife: people did not like their choice, and what's more, they tended to blame themselves for ending up with something distasteful. It

didn't even matter that this was the least bad option, they still felt bad about it. They would have been happier not to choose at all.

In a similar experiment, subjects had to choose without any information to guide them. This time they were all less satisfied than people who had simply been assigned an option. The reason, say the researchers, is that the choosers couldn't give themselves credit even if they ended up with a good option, yet still felt burdened by the thought that they might not have chosen the best alternative. Even when choosers had a little information – though not enough to feel responsible for the outcome – they felt no happier choosing than being chosen for.

Botti believes these findings have broad implications for any decision that is either trivial or distasteful. Try letting someone else choose the wine at a restaurant or a machine pick the numbers on your lottery ticket, for example. You might also feel happier about leaving some decisions to the state or a professional. Botti's work also suggests that people prefer having a doctor make choices about which treatment they should have, or whether to remove life support from a seriously premature baby. "There is a fixation with choice, a belief that it brings happiness," she says. "Sometimes it doesn't." ■

college leavers entering the employment market, he found that although maximisers ended up in jobs with an average starting salary 20 per cent higher than satisficers, they were actually less satisfied. "By every psychological outcome we could measure they felt worse – they were more depressed, frustrated and anxious," says Schwartz.

Even when "good enough" is not objectively the best choice, it may be the one that makes you happiest. So instead of exhaustively trawling websites in search of your ideal digital camera or barbecue, try asking a friend if they are happy with theirs. If they are, it will probably do for you too, says Schwartz. Even in situations when a choice seems too important to simply satisfice, you should try to limit the number of options you consider. "I think maximising really does people in when the choice set gets too large," says Schwartz.

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Get on with it!

The poet Philip Larkin once described work as a toad squatting on his life – a sentiment most of us can sympathise with at least some of the time. Work brings rewards and meaning, yet getting down to it and sticking at it can prove hard. Our inability to ignore distractions and tendency to procrastinate always seem to get in the way. The bad news is that both are deep-seated; the good news is that there are ways to overcome them. So what are you waiting for?



Focus, focus, focus

With distractions all around, how do you keep your mind on the job?

Richard Fisher is up for the challenge

I'VE NEVER thought of myself as particularly distractible, but today the evidence seems to suggest otherwise. While wondering how to start this article I have: 1) opened an email alert telling me I have spam; 2) stared at a colleague's new haircut; and 3) watched a cloud shaped like a cow turn into a sad face, and wondered if it meant anything. Getting down to work is proving to be rather a struggle.

Wandering attention is an occupational hazard for the average office worker; research suggests that interruptions can take up to 2 hours out of the working day. Of the many things that disrupt our flow, visual distractions, like email notifications, flashing telephone message lights or people walking past the window, are among the most difficult to ignore. In the office these kinds of distractions are annoying, but for pilots, air traffic controllers and truck drivers – occupations where there are many visual

distractions – they can be downright dangerous. A study of drivers by the US National Highway Traffic Safety Administration showed that glancing away from the road for more than 2 seconds doubles the risk of a crash or near-miss.

Clearly some people are better at concentrating through these kinds of distractions than others, but until recently there was no easy way to quantify someone's visual distractibility, or to reliably compare different people, and so no way to tell whether someone would make an excellent air traffic controller, or would be better suited to another role. Thanks to a simple computer test devised by psychologist Nilli Lavie and her colleagues at University College London that has all changed. Using their test it is, for the first time, possible to obtain an objective measure of an individual's ability to concentrate in the face of a visual distraction. Surprisingly, it also suggests that the way to keep people's minds on the job could be to make workstations more visually challenging, not simpler.

If eye-catching distractions sometimes seem impossible to ignore, that's probably because they are. Psychologist Jan Theeuwes at the Free University in Amsterdam tracked people's eye movements during experiments in which they were asked to concentrate on one coloured shape while ignoring shapes of other colours. No matter how hard they tried, people couldn't stop their eyes from wandering to the shape they were trying to ignore, Theeuwes found. "It seems automatic," he says. "The visual system takes over and selects things for us that we're not even looking for."

The distraction needn't be right in front of you: it could be a lurid advertisement at the roadside or a fly hovering around you that grabs your attention. "You don't have voluntary control – you can't say 'stop' to a distracter," Lavie says. "If you wish to ignore something, that doesn't mean that you will succeed." ➤

Ever decreasing span

Are TV and the internet shrinking our attention spans? Some researchers think that they might be. A classic study published in 2007 found that children who watched more than 2 hours of television a day during early childhood were more likely to develop attention problems later in life. The link held even if children were weaned off television as they grew up – the damage was done early, and seemed to last.

Could the internet be having a similar effect? It is certainly set up to cater for short attention spans. Web designers work on the assumption that users will

stay on a site for only a few seconds, and go to great lengths to make their pages eye-catching and easy to navigate.

Web surfers do not tolerate reams and reams of text, choosing instead to search for a word or phrase on page. So is all this spawning a generation of skim readers?

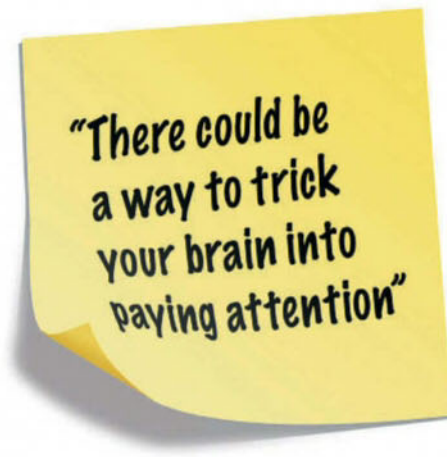
So far there are no clear answers. A few studies have found a link between internet addiction and Attention Deficit Hyperactivity Disorder (ADHD), although there is no clear cause-and-effect relationship between the two. Even the effects of "normal" internet use

can't be assessed, as the net still hasn't been around long enough to allow for long-term studies.

Erik Landhuis, a psychologist at Auckland University of Technology, New Zealand, says that if internet use has an impact on concentration, the mechanisms are unlikely to be the same as for TV. "Watching TV is a very passive activity," he says. "Surfing the internet is interactive, and requires at least some level of concentration on the part of the viewer. It may be that internet use changes attention patterns, rather than making them 'better' or 'worse'."



JAMES PORTER/GETTY



Before Lavie's test came along, most researchers investigating distractibility used the cognitive failures questionnaire (CFQ), developed by University of Oxford psychologist Donald Broadbent in 1982. It asks people to describe how often they get distracted in particular situations, from failing to notice road signs to forgetting to lock their front door. In various studies since then, people with high scores on the questionnaire have been found to suffer fallout from their distractibility, ranging from absent-minded injuries to forgetting to save computer files.

As a method of measuring distractibility, however, the CFQ has some serious limitations: it relies on people self-reporting their absent-mindedness, which may be unreliable and, more importantly, it is unable to separate distractibility from other factors like forgetfulness or poor organisational skills. It also gets us no closer to working out why some people are better at concentrating than others.

Lavie's test gets round these problems. The

test takes the form of a simple computer game in which volunteers are asked to concentrate on letters flashing up in a particular area on the screen, and to press one key if they see an N and another if they see an X (see diagram, opposite). Outside this area, other letters pop up as distractions. It measures how much these distractions increase the time it takes to press the correct button and the number of mistakes people make. At the end of the test the program generates an "index of distractibility", which corresponds to a measure of your powers of concentration.

Forced errors

I give it a go. It's easy at first, but soon irrelevant letters start popping up in my peripheral vision, slowing me down and forcing me to make errors. In her experiments, Lavie found that while distractions slowed everybody's reaction time, some people slowed by nearly twice as much as others. Some people don't even notice that

they have made mistakes, and walk away from the test thinking they have performed well, Lavie says.

When the going gets tough, however, something surprising happens: the difference between the poor concentrators and good concentrators disappears. During more visually intensive tasks, when the area of screen to focus on is more cluttered with letters, most people are able to ignore the distractions.

This suggests there could be a way to trick the brain into paying attention by tapping into the way it focuses its attention. The fact is that even the most inattentive people aren't total slaves to distraction. Being able to focus on the important aspects of the world around us is crucial to nearly everything we do, be it driving a car, watching television or just walking down the street. Without some kind of underlying sorting mechanism, the world would be a surge of information with no way for us to prioritise the important stuff.

Until recently, psychologists disagreed on how the brain deals with this problem. One camp reckoned that the act of concentration induces your brain to become blinkered to irrelevant distractions, so it won't process them at all. Imagine concentrating on driving: you watch for road signs and hazards while tracking the bend of the road and the car in front. These researchers argued that while doing these tasks your brain is less likely to take note of a billboard at the roadside.

The other camp thought that the minute we open our eyes we perceive everything, and that the brain sorts through what's important after this information has been collected. So back in the driving seat, your brain's visual system would perceive the billboard but would prioritise the information about the upcoming bend in the road.

In 1997 Lavie did a series of experiments which, she says, showed that both camps were

A drain on the brain

Research has shown that it is easier to concentrate on a task if it is complicated enough to force your brain to concentrate (see main story). But be careful not to ask your brain to cope with too much at once, or to tax it in the wrong way.

In experiments, psychologist Nilli Lavie at University College London asked people to complete word-based tasks while holding a sequence of numbers in their working

memory. While they did so, she distracted them with images of famous faces. Functional MRI showed the area of the brain associated with face recognition lit up, indicating that the brain couldn't help processing the distractions. This suggests that anything that requires you to hold information in working memory could make you more prone to distraction.

This means that talking on your cellphone while driving -

even hands-free - will almost certainly make you much more prone to visual distractions and less likely to react to new information, such as a child running into the road. Also, if you are preoccupied with other stimuli or emotions, like stress, this will tax your working memory and increase your chance of being distracted, says Lavie. "If you have a tricky task, do it when you're not so occupied," she says.

A world of distraction

Work is where you go to get some work done, but working environments - especially open-plan offices - are packed full of distractions competing for a slice of your attention.

Visual stimuli are particularly distracting as it's physically impossible to stop your eyes following them. Background noise such as people typing and chatting is not too difficult to block out, but intermittent

noises are another story.

A study of office workers by psychologist Gloria Mark of the University of California, Irvine, found that noisy distractions from ringing telephones were responsible for 9 per cent of troublesome distractions, while people calling from another desk accounted for another 4 per cent. Once workers were distracted it took them up to 25 minutes to focus back on

what they were working on.

It's a wonder that any work ever gets done.

A different study found that 1 in 3 workers in large open-plan offices rated draughts from air conditioning or leaky windows as the worst distraction.

Mark's study also found that nearly half of all workplace interruptions are self-generated. For those, we have no one to blame but ourselves.

wrong. Concentrating in itself is not enough to screen out distractions. Moreover, there is an upper limit to what our eyes can perceive - it can't take in everything at once.

In one of these experiments, she asked people to complete quick-fire word-based tasks on a computer screen while distracting them. The person's goal was either to decide whether words appearing on a computer screen were upper or lower case, or the trickier task of counting each word's syllables. On the screen's periphery, a simulation of a moving star field gave the sensation of moving forward or backward through space - a distraction Lavie asked people to ignore. Using functional MRI, she monitored activity in a part of the brain called V5, in the visual cortex, which becomes active when we experience such sensations of movement.

The results were surprising. During the simple word puzzles, V5 was active despite people consciously attempting to ignore the star field. There goes one side of the attention debate: it would appear that you can't always filter out distractions simply by concentrating. But that wasn't the whole story. The brain

imaging also showed that when the word task became harder - for instance, syllable-counting rather than identifying the letter's case - the V5 region became less active. People had become more successful at ignoring the star field.

What was going on during the harder puzzle? We have a limited capacity for absorbing visual information, says Lavie. "We're not machines. We can't perceive everything." So when a more visually intensive task - such as processing the star field as well as the word - "loads" the brain's attention, we become increasingly blind to distractions, and our performance on the task will improve: reaction times get faster and error rates drop. That means that the harder you are forced to concentrate, the less likely you are to be distracted.

The part of the brain in charge of controlling whether we accept or ignore distractions is a region called the parietal cortex. It sits close to the visual cortex, which feeds it information from the eyes for distribution to other parts of the brain. Many studies have shown that the parietal cortex is crucial to concentration. For

example, people with lesions in the parietal cortex are known to be less able to concentrate on a task than those with undamaged brains. "Some people equate it to a switchboard," says Lavie. And according to her theory, even when the parietal cortex is healthy, if too many calls come in to it, the switchboard jams and can't accept any new information, however distracting.

Loading the brain to render it blind to distractions is a strategy that has been repeated in various other experiments, and the concept has been widely accepted, says John Duncan, an attention researcher at the University of Cambridge.

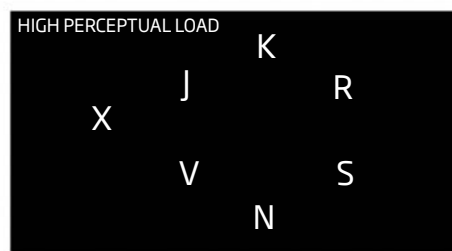
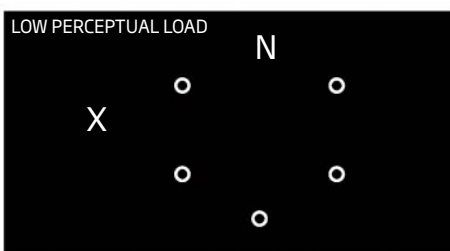
Lavie's team has since found that the technique also works to reduce mind wandering - what Lavie calls "being distracted by your own mind". In another study, volunteers were asked to complete a similar word puzzle. During the test, each person would be asked what they were thinking about. "We found that 60 per cent of the time, people were engaged in thoughts unrelated to the task," says Lavie. When the same volunteers attempted the more difficult version of the task, however, their minds were less likely to wander. "Mind wandering was reduced by around 20 per cent," says Lavie.

Lavie's findings could have practical benefits for anyone who is... well, boring. For example, someone giving a presentation might be able to reduce the impact of distractions elsewhere in the room, not by making their slides clear and easy to read, but by perhaps adding a textured background or moving images.

Back in the lab at University College London, Lavie is scribbling the results of my distractibility test on a piece of paper. My score was disappointingly average, but Lavie says it isn't necessarily something I should worry about. Phew. For one minute there, I thought my ability as a writer might suf

HOW VISUAL DISTRACTIONS AFFECT PERFORMANCE

Volunteers are asked to focus on the six positions on the right of the screen, and to press one button when they see an X appear at any of these points, and another button when they see an N. The test measures how reaction times and the number of mistakes are influenced by distractions elsewhere, like the X on the left. When the area of focus contains few letters (corresponding to a low perceptual load), the ability to concentrate despite outside distractions varies considerably from person to person. But when there are many letters within the area of focus (high perceptual load), individual differences are ironed out and everyone can ignore the distractions. This suggests that making a task more visually stimulating aids concentration



SOURCE: NILLI LAVIE, UNIVERSITY COLLEGE LONDON

The thief of time

Resisting the temptation to procrastinate is easier when we understand what makes us prone to postpone, says **Heather Pringle**



ADRIAN WEINBRECHT/GETTY

DOUGLAS ADAMS did everything humanly possible to avoid the daily drudgery of plonking down at his desk and pounding out his novel *The Salmon of Doubt*. The eccentric British writer soaked for hours in the bathtub, lollygagged away entire days in bed and dreamed up ever more fanciful excuses for his exasperated editor. When he died in 2001, he had spent a decade on the book without even a complete first draft to show for it. Adams was a poster boy for procrastinators everywhere, even though he did manage to finish four *Hitchhiker's Guide to the Galaxy* books and many others. "I love deadlines," he once quipped. "I like the whooshing sound they make as they fly by."

We all struggle occasionally with the desire to postpone an unpleasant job, be it dealing with boring paperwork, studying for an exam or clearing out clutter. "Everyone has times when at the end of the day they don't know what they have done with it," says retired psychologist Robert Topman. "But procrastinators have these big black holes." For some 15 to 20 per cent of us, the problem is serious. Regularly delaying tasks you know you should start working on immediately doesn't just prevent you achieving your goals and full potential; it can also be expensive, bad for your health, and may even endanger your life and those of the people around you.

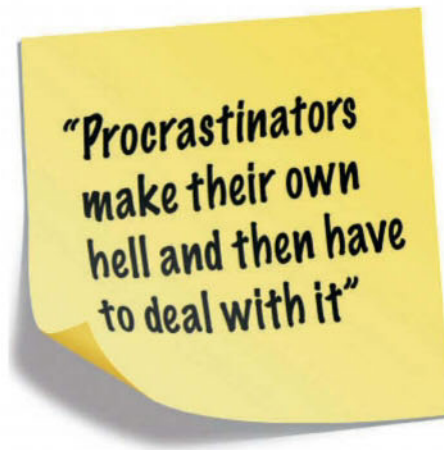
There have been numerous attempts to identify what makes a procrastinator. Perfectionism, a fear of failure and having a hostile or rebellious personality have all been blamed. Now one researcher has taken a broader view of the problem, looking not just at the ditherers themselves but also at the sorts of tasks and situations most likely to suffer delays. Using all the available information from previous studies, psychologist Piers Steel at the University of Calgary in Alberta, Canada, has identified the four key factors behind procrastination and used them to draw up a formula that predicts when it is likely to occur. Steel claims his analysis could not only help unhappy procrastinators minimise their delaying tactics, but also shed new light on motivation in general.

So does leaving things till the last minute ever pay off, or do procrastinators inevitably pay a price for their delay? One North

American survey found that individuals who leave the preparation of tax returns to the last moment make errors costing them \$400 per return on average – so no pay-off there.

Then there are the students, journalists and others who spend their evenings in the pub and watching TV, leaving assignments and term papers to the eleventh hour, confident that they do their best work under pressure. Are they deluding themselves? Bruce Tuckman, an educational psychologist at Ohio State University in Columbus, decided to test this claim in one of his study-skills classes.

First he gave 116 students a questionnaire to measure how prone they were to procrastination. Then he tracked each student's progress on a series of 216 course activities and assignments, most of which had to be done online by a specified time



and submitted electronically. Students who scored low on the procrastination questionnaire and who worked at a steady pace tended to fare well academically, with an average grade of 3.6 out of 4. Not so those who scored high on the questionnaire, whose grade average was just 2.9. It is possible that they were simply not as bright as their peers, but previous studies have shown virtually no correlation between general mental ability and procrastination. Instead, Tuckman believes that students are merely indulging in wishful thinking when they claim that deadline pressure hones their performance. "They really don't know how well they would actually do

if they didn't procrastinate," he says.

The pitfalls of delay don't end there, however. In 2007, psychologist Fuschia Sirois, then at the University of Windsor in Ontario, Canada, revealed that procrastination also poses health risks. Using an online survey of 254 adults from Europe, the US, Canada and Australia, Sirois discovered that those who continually postponed things were less likely than others to get annual medical and dental check-ups and to practise basic healthy behaviours, such as exercising regularly. The survey also revealed that procrastinators suffered more from stress and illnesses such as flu and digestive problems. "Procrastination is bad for your health in more ways than one," she notes.

Sirois also asked whether subjects had accident-proofed their homes in standard ways, such as clearing stairways of trip hazards and regularly testing their smoke alarms. The more serious the procrastinator, she discovered, the less likely they were to take steps to prevent home accidents. "They weren't looking after basic household safety issues, from owning a fire extinguisher and making sure that the batteries in the smoke detector worked, to seeing that faulty electrical appliances were dealt with," she says. Even in households with a history of accidents, procrastinators still put off addressing problems or asking others, such as building managers, to do so.

"Procrastination is a style of dealing with problems that's not only maladaptive and potentially dangerous for the individual, but also for the people around them," she says. "We tend to think that procrastinators make their own hell and then have to deal with it. But it does seem to be having a wider impact."

Someone who knows this all too well is Steel. Sitting in his office, he recalls some of his own experiences with procrastination. As a college student he once fell asleep during an exam, after a long night of last-minute cramming. Later, while working as an industrial psychologist, he decided to take a fresh look at the causes of his desire to defer. It took him over a decade of planning – and postponing – to write a book on the subject.

When Steel began his quest, however, he quickly discovered a wealth of data. Other researchers had conducted hundreds of

studies looking for connections between procrastination and a variety of factors including age, sex, the nature of the task, the timing of rewards, and a host of personality traits. Each seemed to Steel like a separate piece of a bigger puzzle which nobody had attempted to piece together. This, he decided, would be his task.

Why the delay?

Between the late 1990s and the mid 2000s, Steel spent countless hours poring over the results of 553 studies – including published articles, dissertations and papers that researchers had stashed in their filing cabinets – translating their diverse statistical findings and research designs into common mathematical currency. In the case of just one suspected cause of procrastination – perfectionism – researchers had published nearly 70 studies, some reporting a strong link, others discerning no link at all. To reconcile these conflicts, Steel examined and evaluated each study, giving greater weight to those with the most subjects and the strongest research designs. He gradually built up a mega-database. “It was a very mathematically intensive endeavour,” he says. He published his analysis in 2007.

So what did he find? First, some people are more at risk of procrastination than others. Men postpone things slightly more than women, and the young tend to loiter over tasks considerably more than seniors do. “I joke that this is because older people are coming closer to the final deadline, so they can’t afford to put things off,” says Steel. Surprisingly, there was no evidence that rebelliousness, neuroticism or perfectionism caused people to put things off. “Actually, perfectionists procrastinate less than other people,” he says, “but worry about it more.”

There were, however, four factors that stood out as the most strongly linked with procrastination: how confident a person is of completing a particular task successfully; how easily distracted an individual is; how boring or unpleasant the task is; and how immediate the reward for completion will be. The more uncertain of success or easily sidetracked you are, the more likely it is that you will put off an assignment or chore. Conversely, the more



Get on with it!

No one is entirely immune to procrastination, so Piers Steel at the University of Calgary in Alberta, Canada, has devised several strategies to help us do away with delay.

- Make a firm commitment to your boss or partner to finish a task by a certain time. This will make delays more embarrassing and difficult to cover up.

- Strip your workspace of all distractions, from your iPhone to your Xbox. Then turn off your

email alert. “We have all these temptations,” says Steel. “We’ve made our world motivationally toxic.”

- Many people say that they put things off because they are too tired to deal with them, so get a good night’s sleep and try tackling the most unpleasant and difficult tasks early in the day.

- Set a series of realistic goals. Some counsellors and therapists recommend drawing up weekly, daily or even hourly goals. The

more readily sidetracked you are, the more you need to divide your main task into smaller chunks.

- Promise yourself a reward for each goal that you meet.

- Believe in yourself. “The old saying is true,” says Steel. “Whether you believe you can or believe you can’t, you are probably right.”

- Outsource your motivation. Get someone else to regularly goad you into action.

pleasant the task and the more immediate its payback, the greater the chance you will get on with it quickly. “We prize the now so much more than the later,” says Steel. “So if a task can be realised now and we can have the pleasure now, we value that a lot more than something that will have a larger reward with greater certainty later.” Such findings, says Steel, reveal that procrastination cannot be chalked up to just one factor. It arises both from individual differences in personality and from the particular situations we find ourselves in. Moreover, he even suggests that he can predict when dallying is likely to occur. “Procrastination can be understood, or summarised at least, by a mathematical equation,” he says. This calculates how likely you are to do something immediately – the task’s utility – by taking into account the four key variables, each of which can be quantified or measured by questionnaire: how confident you are of succeeding in the task (E); how pleasant you perceive the task to be (V); how easily distracted you are (Γ); and how much time will elapse before the reward for completing the task arrives (D). It reads as follows:

$$\text{Utility} = \frac{E \times V}{\Gamma \times D}$$

More recently, Steel has been looking at the way procrastination affects the ability to see a task through to completion. While his original formula seems to hold true for starting a task, the pursuit of a goal is more dependent on an individual’s impulsivity, Steel says. “Boredom is a wonderful predictor, too,” he adds.

Mañana!

Intriguing as Steel’s conclusions are, they garnered a mixed reception. Tim Pynchyl, a psychologist at Carleton University in Ottawa, Canada, says his work with extreme procrastinators reveals a different story that has nothing to do with balancing these competing factors. “They don’t talk about this mental calculus,” he says. “People say that they put things off because they are debilitated by guilt or shame, or because they love the rush of the last-minute effort.”

Others, however, think that Steel is on to something. “People have a perpetual competition between satisfying their present

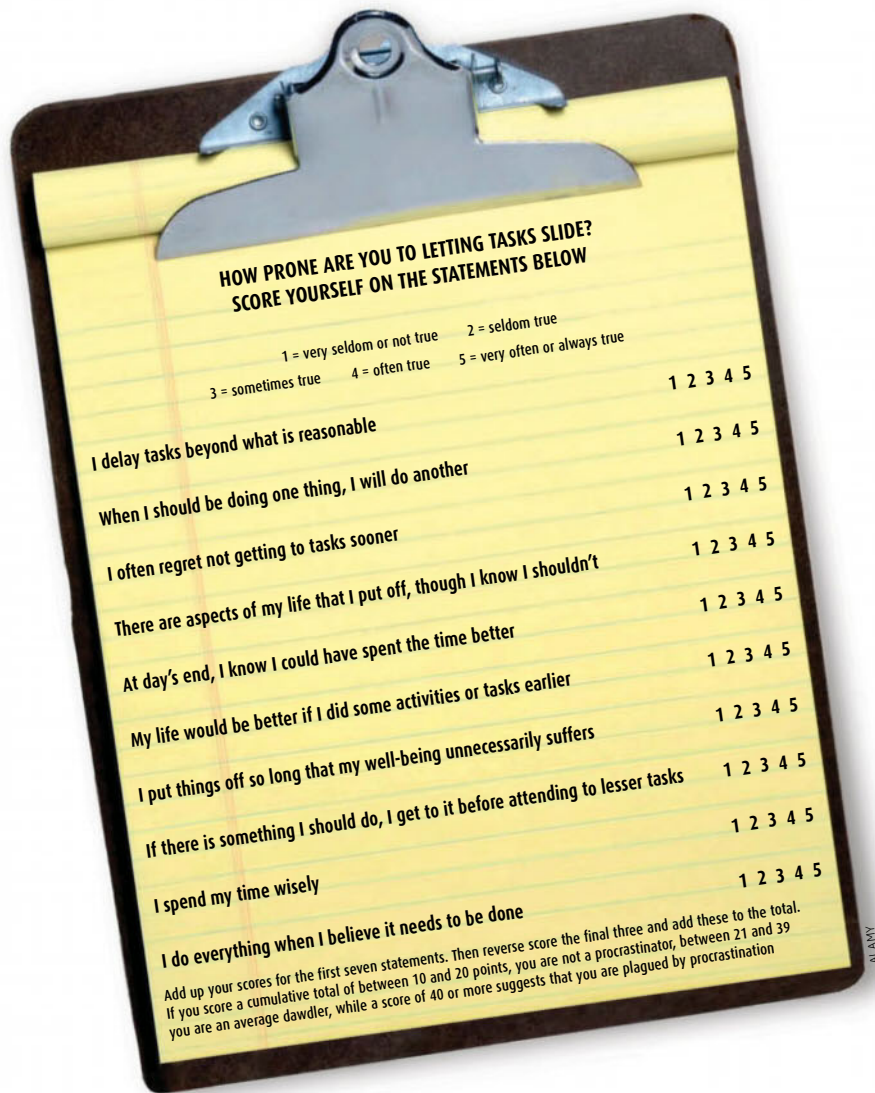
selves or their future selves,” says management expert John Kammeyer-Mueller at the University of Minnesota. Steel’s formula illuminates many puzzles of human nature, he says, from why teenagers drop out of school and why people are unfaithful to their partners, to why those who are overweight fail to stick to their diets. “Steel provides a good set of tools for understanding how the internal conflict between desires plays out.”

Steel believes it also explains why some drug addicts refuse to enter rehab or why some farmers drag their heels on conservation, for example. In short, they live in the moment, rather than preparing for an uncertain future. Governments could be seen as especially prone to this kind of failure of will. “Some people would characterise the climate debate in these terms,” Steel says. “Should we suffer a little bit now in order to avoid the chance of huge devastation later on down the road? We have the technology to deal with climate change now, but wanting to deal with it is another matter entirely. The cure is in the long

term, but the medicine is in the short term.”

So what is to be done to limit this damaging dilly-dallying? Some individuals can take a disciplined approach to tackling the tasks before them, but with others a lack of confidence and a tendency to become sidetracked make procrastination the norm. If the job at hand is seen as unpleasant, procrastination is even more likely. However, Steel says that we can all find ways to increase our motivation – from making a task appear less unpleasant or more immediately rewarding, to minimising the distractions we face (see “Get on with it!”, left).

If the worst comes to the worst, diehard procrastinators can always follow the example of Douglas Adams and surround themselves with friends and colleagues who will hold their feet to the fire. Steel describes how on one occasion, Adams’s editor booked him into a hotel room and stood guard over him until he finished a promised manuscript. “Adams tried to outsource his motivation,” he says. “That was his way around the problem.” ■





Quantify thyself

You already know you're anything but average, says Nic Fleming, but armed with the proof it's possible to become fitter, healthier and happier

IT IS a few minutes before midnight and I am pacing around my living room in circles. My wife appears at the top of the stairs looking concerned. Glancing at the display of a small black box attached to my belt, I tell her that I'll come to bed soon. I need to reach 15,000 paces. She is not placated.

No, I haven't lost the plot. I have temporarily joined ranks with a growing number of people who measure many aspects of their lives, often in minute detail. Leading the charge is the Quantified Self movement, and they want to know whether all this information could be useful, helping them to lose weight, become fitter or even anticipate medical problems.

Like it or not, you may soon be joining them. What's on offer is just too compelling: recording our activities and mining the resulting data could make us healthier and happier. But does it live up to the hype?

Until recently, gathering detailed personal data involved a visit to a lab, expensive equipment or plenty of spare time and notebooks. But today's self-trackers have it easy. Now there are weighing scales that produce graphs of your weight, watches that count calories, motion-sensing stickers that know how often you brush your teeth, and gadgets that tell women they are ovulating.

If these tools really can deliver on the promises being made for them, it won't be long before we see an awful lot more of them. But do they actually work, how easy are they to use, and what are the downsides? To find out, I kitted myself out and set off on a month-long journey of data-driven self-discovery.

Devices that measure physical activity make

up the biggest slice of the personal data gadget market. Little wonder when simply wearing a pedometer can boost activity levels, with those using the devices taking an average of 27 per cent more steps per day than those who do not use them. That's 2491 extra paces. Pedometer use is associated with lower body mass index and blood pressure. However, studies show that only people given specific targets tend to show improvements.

This has been taken on board by device designers. I used a Fitbit ultra, a pedometer that set me a daily target and gave me rewards for reaching certain milestones. This explains why I found myself pacing around in circles at

"Many self-trackers say simply keeping track of their activity makes them more efficient"

home in the middle of the night: If I reached 15,000 steps I knew I would be emailed a digital badge. I had succumbed to "gamification" – the use of motivators and incentives usually found in games to encourage people to complete chores and other tasks – which many developers build into their devices to make sure people meet their targets.

Many self-quantifiers say simply keeping track of their activity makes them more efficient. As a writer prone to distraction, that idea was attractive. So I downloaded RescueTime, which records the software and websites I use, decides whether they are

productive and serves up the results in graphs and stats. It offers productivity-boosting tools such as temporary blocking of online distractions. RescueTime's developers have claimed that consistent users save on average 3 hours 54 minutes per week.

It had some obvious shortcomings, such as defining email as of neutral productivity and Twitter as highly unproductive, when I use both for work. Users with more patience than me can customise it by assigning personal productivity ratings to activities and manually defining time away from their screens. Still, RescueTime did show that I am consistently more productive later in the day. It provides a score out of 100: my average was 72 in the afternoon compared to 60 before lunch.

One of the more innovative self-quantifying gadgets is the Zeo, a forehead sensor that tracks your sleep. The sensor picks up electrical signals from the brain, as well as muscle contractions and eye movements, to measure deep, light, REM and total sleep. This data is sent via Bluetooth to users' smartphones and presented in daily graphs. That's useful to know considering that recent studies have shown that insufficient sleep is associated with increased risk of higher body fat levels, type 2 diabetes, heart attacks and impaired immune system functioning.

My average night's sleep lasted 6 hours 57 minutes, of which 2 hours 52 minutes was REM sleep, and 59 minutes was deep sleep. As the test went on I noticed I was going to bed earlier (apart from my occasional nocturnal wanderings). By the end of the month, I was sleeping around an hour longer than I was when the test started. ➤

Perhaps that's because my experiment was influencing my behaviour. Such an effect has been known to psychologists since at least the 1920s, when the owners of the Hawthorne Works near Chicago carried out experiments to see how light levels affected productivity. They were surprised to find that no matter how they changed the lighting conditions, workers always became more productive than usual. It turned out the workers were working harder because they knew they were being studied – a phenomenon called the Hawthorne effect.

Self-quantification can also help fine-tune bad habits to minimise their harmful effects. Although I knew that drinking too much alcohol disrupts sleep, I did not know how much was too much. But the Zeo provided concrete answers. Correlating my Zeo's daily sleep graphs with my alcohol consumption showed that my best night's sleep of all occurred on a night when I had two glasses of wine; when I consumed more, both sleep quality and quantity were hit.

Early learning

Combining data from different aspects of life can be powerful. That's what Larry Smarr did. Director of the California Institute for Telecommunications and Information Technology in La Jolla, Smarr is an early adopter and unofficial ambassador of the quantified life. He not only uses Zeo and Fitbit but routinely has blood and stool samples analysed for biochemical disease markers.

In 2008, this revealed his levels of the inflammatory marker C-reactive protein (CRP) were more than 10 times higher than normal. His doctor told him not to worry but to return if he had any symptoms. A few months later he felt intense pains in his abdomen. This time the doctor diagnosed a colon wall infection. Smarr knew that elevated CRP could indicate a build-up of plaques and an increased risk of heart attack, so he paid for ultrasound scans, which showed his carotid artery was thickening. Could his heart be in trouble? Then, a stool sample analysis showed he had more than 100 times the normal level of lactoferrin, another inflammation marker. Smarr took his data to a gastroenterologist who concluded that Smarr may have a mild form of Crohn's disease.

There's an app for that...

If you can think of it, there are apps, gadgets and software that can help you track it



SLEEP
The **ZeoSleeP Manager**

and **SleeP Cycle** app let you break down your sleep by duration and type



FITNESS
Gadgets such as the **Fitbit**

and the **Nike Fuelband** count your every step, and distance covered, so you don't have to



MOOD
Apps such as **Mood Panda** and

Moodscope let you investigate what throws you off your zen



HYGIENE
Did you brush your teeth this morning?

Strides will keep track of your other good habits too



FOOD
You can track your food intake

with a focus on calories using **DailyBurn**, or by the individual bite using **80 Bites**



TIME
Rescue Time

helps you figure out where all your time goes



VITAL SIGNS
Monitor your blood

pressure level, heart rate and other vital signs with apps like **HeartWise**



SOCIAL HABITS
Chronos

lets you track where you spend your time, and who you spend it with

“Diseases in modern medicine are determined by symptoms, as they have been for hundreds of years,” he says. “Quantified health is in the process of completely changing that.” Smarr thinks self-tracking will lead to a future in which diseases will be diagnosed before symptoms set in.

It could also usher in a new era of personalised medicine. Think of all the norms and guidelines by which you live your life – how many actually apply to you? For example, we are advised to eat two 140-gram portions of oily fish per week no matter what we weigh. Regardless of when we perform at our best, most of us work from nine till five. Women in the US are advised to have mammograms every year from the age of 40, largely irrespective of their specific genetic risks.

These conventions are applied despite the decades scientists have spent defining the multitude of ways we vary as individuals, from our vulnerability to illness and dietary needs to our body clocks and alcohol tolerance. The “tyranny of the average” has held sway for so long largely because of our inability to keep track of our data. Few individuals have had the time to keep records of things like sleep patterns, blood glucose, activity and diet.

Self-tracking could change all that. In his recent book *The Creative Destruction of Medicine*, cardiologist Eric Topol describes how treating people in the same way just because they have similar symptoms can be frustrating, wasteful and potentially harmful. For example, the anticoagulant Plavix, which is often given to patients who have had stents inserted to prop open diseased coronary arteries, is less effective in 30 per cent of people with genetic variants that stop them metabolising the drug, potentially putting some at an increased risk of blood clots. Mass cancer screenings may extend some lives but can also lead to preventative surgery that could be unnecessary in some cases, such as mastectomies. Now, with huge amounts of medical information and personal data at our fingertips, medicine is ripe for radical transformation, says Topol.

Granted, not everyone will rush to analyse their stools like Smarr did. But thousands of people who have migraines, allergies and diabetes, for example, are tracking their diet, medication, sleep and health metrics – such as



“With huge amounts of medical information and personal data at our fingertips, medicine is ripe for radical transformation”

blood glucose levels and heart rate – in a bid to identify correlations.

Topol is not alone in seeing personal health tracking as a way of redefining the doctor-patient relationship. “Interactive tools and devices will take some of the burden and delay out of the existing system,” says Matt Jameson Evans, an orthopaedic surgeon who co-founded HealthUnlocked, a UK company specialising in online health tools.

To cash-strapped public health providers, novel technologies and greater patient involvement are attractive. The first results from the UK Department of Health’s Whole System Demonstrator trial, the largest evaluation of remote healthcare tools conducted to date, were published in 2012. Every day, those in the trial – 1365 people with heart failure, diabetes and chronic obstructive pulmonary disease (COPD) – measured

variables such as weight, blood glucose, pulse rate and blood oxygen saturation, and sent the results to their doctors. In the year following the trial, those that did the remote measuring were 6 per cent less likely to be admitted to hospital compared to the trial’s control group. More interestingly, they were also 20 per cent less likely to have to be admitted as an emergency.

Self-tracking could even generate new medical knowledge. On websites like PatientsLikeMe and CureTogether, tens of thousands of people already share data on symptoms and treatments for hundreds of illnesses. In 2011, CureTogether analysed data submitted by members who had been using the drug Imitrex to treat migraine. The analysis revealed that those who suffered from vertigo or dizziness alongside their migraines were 3.1 times more likely to feel worse after

taking the drug than those who did not suffer these additional symptoms.

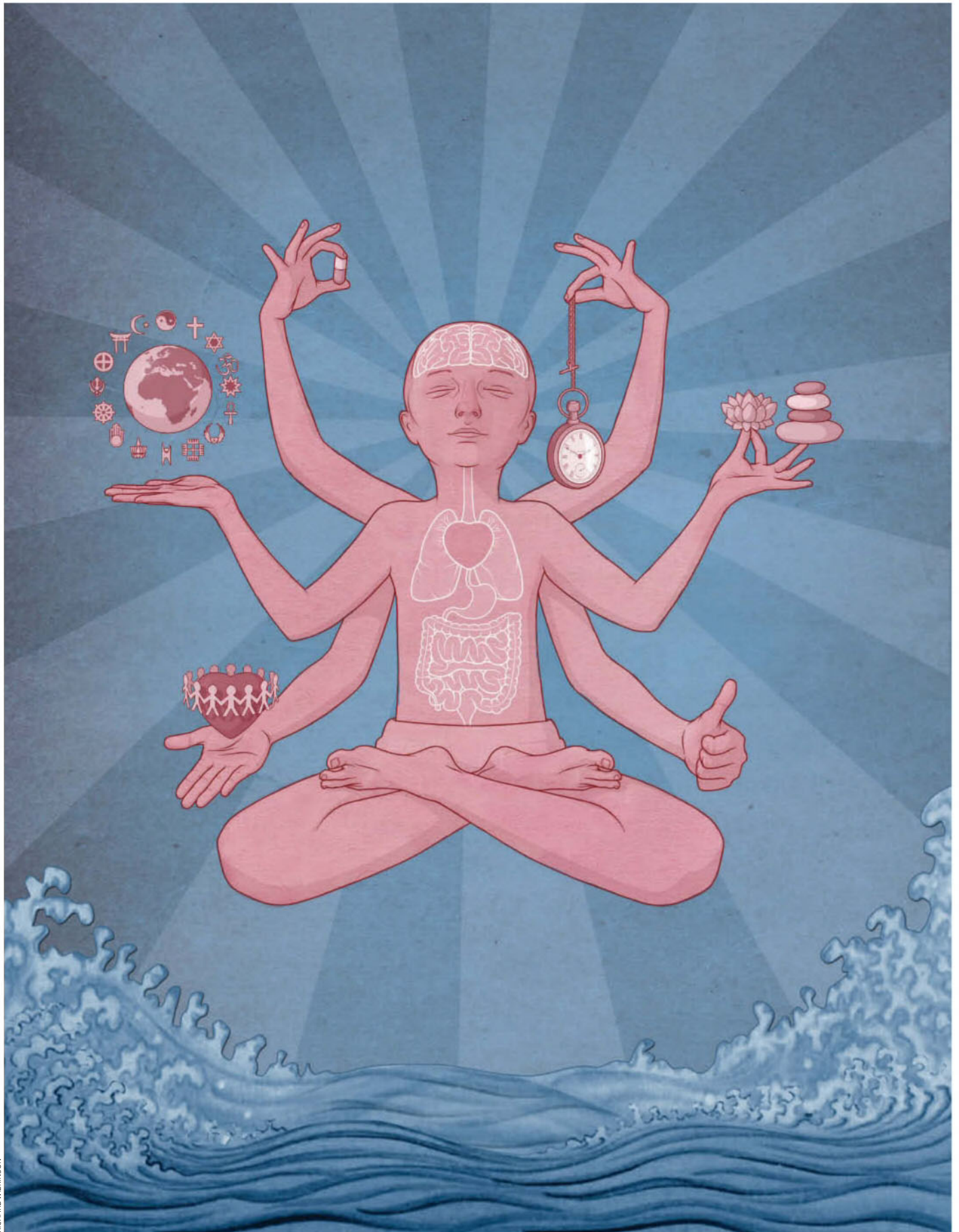
Not everyone thinks self-tracking is ready for prime time. A key problem is the failure of devices to talk to each other. Although I wanted to see how my physical activity affected my sleep, I could see no easy way to combine my Fitbit and Zeo data. Until developers make it easier for people to manage their data, self-quantifying will be held back from mainstream use, says Adriana Lukas, founder of the Quantified Self London group.

And in common with other technologies, the gadgets will only sell widely if they are easy to use. I tried a system to quantify my skills during the weekly football matches I play. It was supposed to tell me how far and fast I ran, and the speed and spin I put on the ball. Unfortunately, it was baffling to use, buggy and not terribly relevant to the skills needed in defence, where I play.

Some fear that self-tracking could soon become expensive or inconvenient to avoid. Already, some car insurers offer discounts if drivers install driving monitors, and health insurers are watching these developments closely. That raises privacy issues. “Once the data exists, it’s going to be very hard to keep control over it if you have given it to a third party,” says Lukas.

Despite these issues, the Quantified Self movement has gained momentum. Its membership tripled in size between 2012 and 2014 to more than 33,000 members in 120 cities across six continents. As the technologies improve, the personal and commercial benefits they offer could make it an unstoppable trend. With Apple being one of several big players working on self-tracking devices, it is unlikely to be long before the ability to free us from the tyrannies of the average will outweigh potential costs.

My month of self-quantification taught me several things. Paying more attention to things in your life by tracking them can lead to behavioural changes. Getting new data and well-presented graphs is only interesting in itself for a short time. The time and hassle involved in charging devices and recording data is only worth it if you’re really motivated. And targets only work for so long before the novelty wears off, even when you’re the proud owner of a badge for walking 15,000 steps. ■



RICHARD WILKINSON

INNER HEALING

A drug that we can all get for free has wide-ranging health benefits, with no side effects. It's called the mind. **Jo Marchant** reveals six ways to raid your own built-in medicine cabinet

Use the placebo

"I TALK to my pills," says Dan Moerman, an emeritus professor of anthropology at the University of Michigan-Dearborn. "I say, 'hey guys, I know you're going to do a terrific job!'"

That might sound eccentric, but based on what we've learned about the placebo effect, there is good reason to think that talking to your pills really can make them do a terrific job. The way we think and feel about medical treatments can dramatically influence how our bodies respond.

Simply believing that a treatment will work may trigger the desired effect even if the treatment is inert – a sugar pill, say, or a saline injection. For a wide range of conditions, from depression to Parkinson's, osteoarthritis and multiple sclerosis, it is clear that the placebo response is far from imaginary. Trials have shown measurable changes such as the release of natural painkillers, altered neuronal firing patterns, lowered blood pressure or heart rate and boosted immune response, all depending on the beliefs of the patient. There is even evidence that some drugs work by amplifying a placebo effect – when people are not aware that they have been given the drugs, they stop working. On the flip side, merely believing that a drug has harmful side effects can make you suffer them. The nocebo effect, as it's known, can even kill.

It has always been assumed that the placebo effect only works if people are conned into believing that they are getting an actual active drug. But now it seems this may not be true. Belief in the placebo effect itself – rather than a particular drug – might be enough to encourage our bodies to heal.

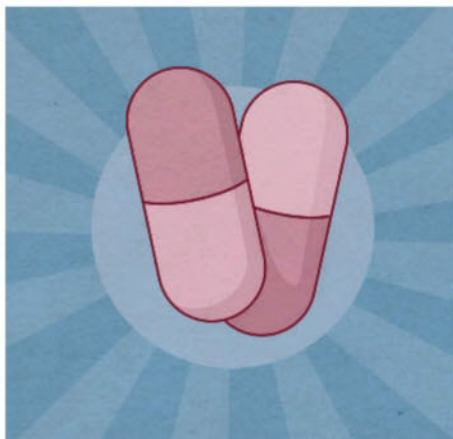
Ted Kaptchuk of Harvard Medical School in Boston and colleagues gave some people with irritable bowel syndrome an inert pill. They told them that the pills were "made of an inert substance, like sugar pills, that have been shown in clinical studies to produce

significant improvement in IBS symptoms through mind-body self-healing processes", which is perfectly true. Despite knowing the pills were inert, on average the volunteers rated their symptoms as moderately improved after taking them, whereas those given no pills said there was only a slight change.

"Everybody thought it wouldn't happen," says study co-author Irving Kirsch, a psychologist at Harvard Medical School. He thinks that the key was giving patients something to believe in. "We didn't just say 'here's a sugar pill'. We explained to the patients why it should work, in a way that was convincing to them."

As well as having implications for the medical profession, the study raises the possibility that we could all use the placebo effect to convince ourselves that something simple such as sucking on a sweet or downing a glass of water, for example, will banish a headache, clear up a skin condition or boost the effectiveness of any actual drugs that we take.

"Our study suggests that might indeed help," says Kirsch. While Moerman talks to his pills, Kirsch recommends visualising the desired improvement and telling yourself that something is going to get better. ➤





Think positive

“Everything’s going to be fine.” Go on, try to convince yourself, because realism can be bad for your health. Optimists recover better from medical procedures such as coronary bypass surgery, have healthier immune systems and live longer, both in general and when suffering from conditions such as cancer, heart disease and kidney failure.

It is well accepted that negative thoughts and anxiety can make us ill. Stress – the belief that we are at risk – triggers physiological pathways such as the “fight-or-flight” response, mediated by the sympathetic nervous system. These have evolved to protect us from danger, but if switched on long-term they increase the risk of conditions such as diabetes and dementia.

What researchers are now realising is that positive beliefs don’t just work by quelling stress. They have a positive effect too – feeling safe and secure, or believing things will turn out fine, seems to help the body maintain and repair itself. An analysis of various studies concluded that the health benefits of such positive thinking happen independently of the harm caused by negative states such as pessimism or stress, and are roughly comparable in magnitude.

Optimism seems to reduce stress-induced inflammation and levels of stress hormones such as cortisol. It may also reduce

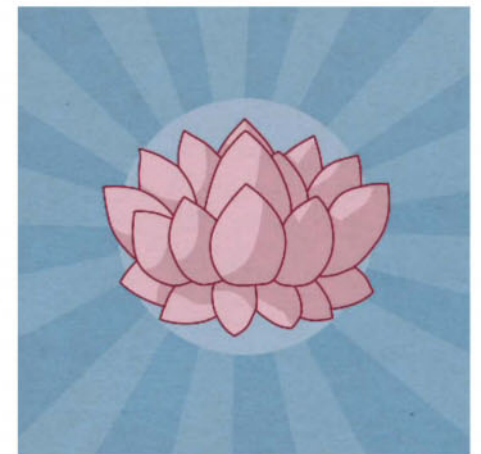
susceptibility to disease by dampening sympathetic nervous system activity and stimulating the parasympathetic nervous system. The latter governs the so-called “rest and digest” response – the opposite of fight-or-flight.

Just as helpful as taking a rosy view of the future is having a rosy view of yourself. High “self-enhancers” – people who see themselves in a more positive light than others see them – have lower cardiovascular responses to stress and recover faster, as well as lower baseline cortisol levels.

Some people are just born optimists. But whatever your natural disposition, you can train yourself to think more positively, and it seems that the more stressed or pessimistic you are to begin with, the better it will work.

David Creswell from Carnegie Mellon University in Pittsburgh, Pennsylvania, and his colleagues asked students facing exams to write short essays on times when they had displayed qualities that were important to them, such as creativity or independence. The aim was to boost their sense of self-worth. Compared with a control group, students who “self-affirmed” in this way had lower levels of adrenaline and other fight-or-flight hormones in their urine on exam day. The effect was greatest in those who started off most worried about their exam results.

Trust people



Meditate

Monks have been meditating on mountaintops for millennia, hoping to gain spiritual enlightenment. Their efforts have probably enhanced their physical health, too.

Trials looking at the effects of meditation have mostly been small, but they have suggested a range of benefits. There is some evidence that meditation boosts the immune response in vaccine recipients and people with cancer, protects against a relapse in major depression, soothes skin conditions and even slows the progression of HIV.

Your attitude towards other people can have a big effect on your health. Being lonely increases the risk of everything from heart attacks to dementia, depression and death, whereas people who are satisfied with their social lives sleep better, age more slowly and respond better to vaccines. The effect is so strong that curing loneliness is as good for your health as giving up smoking, according to John Cacioppo of the University of Chicago, Illinois, who has spent his career studying the effects of social isolation.

"It's probably the single most powerful behavioural finding in the world," agrees Charles Raison of the University of Arizona College of Medicine in Tucson, who studies mind-body interactions. "People who have rich social lives and warm, open relationships don't get sick and they live longer." This is partly because people who are lonely often don't look after themselves well, but Cacioppo says there are direct physiological mechanisms too - related to, but not identical to, the effects of stress.

In 2011, Cacioppo reported that in lonely people, genes involved in cortisol signalling and the inflammatory response were up-regulated, and that immune cells important in fighting bacteria were more active, too. He suggests that our bodies may have evolved so that in situations

of perceived social isolation, they trigger branches of the immune system involved in wound healing and bacterial infection. An isolated person would be at greater risk of physical trauma, whereas being in a group might favour the immune responses necessary for fighting viruses, which spread easily between people in close contact.

Crucially, these differences relate most strongly to how lonely people believe themselves to be, rather than to the actual size of their social network. That also makes sense from an evolutionary point of view, says Cacioppo, because being among hostile strangers can be just as dangerous as being alone. So ending loneliness is not about spending more time with people. Cacioppo thinks it is all about our attitude to others: lonely people become overly sensitive to social threats and come to see others as potentially dangerous. In a review of previous studies, published in 2010, he found that tackling this attitude reduced loneliness more effectively than giving people more opportunities for interaction, or teaching social skills.

If you feel satisfied with your social life, whether you have one or two close friends or quite a few, there is nothing to worry about. "But if you're sitting there feeling threatened by others and as if you're alone in the world, that's probably a reason to take steps," Cacioppo says.

Meditation might even slow the ageing process. Telomeres, the protective caps on the ends of chromosomes, get shorter every time a cell divides and so play a role in ageing. Clifford Saron of the Center for Mind and Brain at the University of California, Davis, and colleagues have shown that levels of an enzyme that builds up telomeres were higher in people who attended a three-month meditation retreat than in a control group.

As with social interaction, meditation probably works largely by influencing stress response pathways. People who meditate have lower cortisol levels, and one study showed they have changes in their amygdala, a brain area involved in fear and the response to threat.

One of the co-authors of Saron's study, Elissa Epel, a psychiatrist at the University of California, San Francisco, believes that meditation may also boost "pathways of restoration and health enhancement", perhaps by triggering a release of growth and sex hormones.

If you don't have time for a three-month retreat, don't worry. Imaging studies show that meditation can cause structural changes in the brain after as little as 11 hours of training. Epel suggests fitting in short "mini-meditations" throughout the day, taking a few minutes at your desk to focus on your breathing, for example: "Little moments here and there all matter."

Hypnotise yourself



Hypnotherapy has struggled for scientific acceptance ever since Franz Mesmer claimed in the 18th century that he could cure all manner of ills with what he termed "animal magnetism". "The whole field is plagued by people who don't feel research is necessary," says Peter Whorwell of the University of Manchester in the UK.

Whorwell has spent much of his professional life building a body of evidence for the use of hypnosis to treat just one condition: irritable bowel syndrome. IBS is considered a "functional" disorder - a rather derogatory term used when a patient suffers symptoms but doctors can't see anything wrong. Whorwell felt that his patients, some of whom had such severe symptoms they were suicidal, were being let down by the medical profession. "I got into hypnosis because the conventional treatment of these conditions is abysmal."

Whorwell gives patients a brief tutorial on how the gut functions, then gets them to >

use visual or tactile sensations – the feeling of warmth, for example – to imagine their bowel working normally. It seems to work: IBS is the only condition for which hypnosis is recognised as a possible treatment by the UK’s National Institute for Health and Clinical Excellence, though only for those who have failed to respond to other treatments. Despite this, Whorwell still has trouble convincing doctors to prescribe it. “We’ve produced a lot of incontrovertible research,” he says. “Yet people are still loath to agree to it.”

Part of the problem is that it isn’t clear exactly how hypnosis works. What is clear is that when hypnotised, people can influence parts of their body in novel ways. Whorwell has shown that under hypnosis, some IBS patients can reduce the contractions of their bowel, something not normally under conscious control. Their bowel lining also becomes less sensitive to pain.

Hypnosis probably taps into physiological pathways similar to those involved in the placebo effect, says Irving Kirsch of Harvard Medical School. For one thing, the medical conditions that the two can benefit are similar, and both are underpinned by suggestion and expectation. The downside is that some people do not respond as strongly to hypnosis as others.

Most clinical trials involving hypnosis are small, largely because of a lack of funding, but they suggest that hypnosis may help pain management, anxiety, depression, sleep disorders, obesity, asthma and skin conditions such as psoriasis and warts. Finding a good hypnotherapist can be tricky as the profession is not regulated, but hypnotising yourself seems to work just as well. “Self-hypnosis is the most important part,” says Whorwell.

Know your purpose



In a study of 50 people with advanced lung cancer, those judged by their doctors to have high “spiritual faith” responded better to chemotherapy and survived longer. Over 40 per cent were still alive after three years, compared with less than 10 per cent of those judged to have little faith. Are your hackles rising? Of all the research into the healing potential of thoughts and beliefs, studies into the effects of religion are the most controversial.

There are thousands of studies purporting to show a link between some aspect of religion – such as attending church or praying – and better health. Religion has been associated with lower rates of cardiovascular disease, stroke, blood pressure and metabolic disorders, better immune functioning, improved outcomes for infections such as HIV and meningitis, and lower risk of developing cancer.

Critics of these studies, such as Richard Sloan of Columbia University Medical Center in New York, point out that many of them don’t adequately tease out other factors. For instance, religious people often have lower-risk lifestyles, churchgoers tend to enjoy strong social support, and seriously ill people are less likely to attend church. Nonetheless, a recent analysis of studies in the area concluded, after trying to control for these factors, that “religiosity/spirituality” does have a protective effect, though only in healthy people. The authors warned there might be a publication bias, though, with researchers failing to publish negative results.

Even if the link between religion and better health is genuine, there is no need to invoke divine intervention to explain it. Some researchers attribute it to the placebo effect – trusting that some deity or other will heal you may be just as effective as belief in a drug or doctor. Others, like Paolo Lissoni of San Gerardo Hospital in Milan, Italy, who did the lung-cancer study mentioned above, have said that the positive emotions associated with “spirituality” promote beneficial physiological responses.

Yet others think that what really matters is having a sense of purpose in life, whatever it might be. Having an idea of why you are here and what is important increases our sense of control over events, rendering them less stressful. In Saron’s three-month study of meditation (see “Meditate”, page 116), the increase in levels of the enzyme that repairs telomeres correlated with an increased sense of control and an increased sense of purpose in life. In fact, Saron argues, this psychological shift may have been more important than the meditation itself.

He points out that the participants were already keen meditators, so the study gave them the chance to spend three months doing something important to them. Spending more time doing what you love, whether it’s gardening or voluntary work, might have a similar effect on health. The big news from the study, Saron says, is “the profound impact of having the opportunity to live your life in a way that you find meaningful”. ■

Retune your immune system

All that stands between you and a horde of hungry microbes are your immune defences. So keep them in peak condition by following these tips from **Jessica Hamzelou**

ACHOO!" A sniffing friend is sneezing just inches away. You would love to cover your face or run away, but in the interests of politeness all you can do is try not to inhale in their direction and hope your immune system is on the case.

Some people seem to catch everything that is doing the rounds, from coughs and colds to stomach bugs. Other people never seem to get ill. What's their secret?

A lot is down to dumb luck. There are some things affecting the performance of your immune system that you cannot change: your age, your gender, your genes, and most importantly, whether or not you have had a previous brush with an invading bug.

But there are plenty of factors you can control. I'm not talking about downing

supplements sold as "immune boosters"; the claims for most such pills are not based on hard evidence. But there are plenty of other ways you can keep your immune system revved up and raring to go.

It's not all about boosting activity, though. Many common conditions are caused by the immune system reacting to things it shouldn't. When it attacks parts of the body the result is autoimmune disorders like multiple sclerosis, type 1 diabetes and inflammatory bowel disease. When it responds to molecules that are foreign but harmless, like those from pollen or peanuts, the result is allergies, asthma or eczema. Again, there are ways of encouraging your immune system to behave. So help it out by following these tips.

WATCH WHAT YOU EAT

From an old-fashioned faith in the healing powers of chicken soup to more modern obsessions with so-called superfoods, we like to think some things we eat can help ward off infections. The vast majority of these beliefs have little evidence to back them up, but there are dietary interventions that appear to work.

Numerous supplements are sold on the basis of supposed immune-boosting powers, but their health claims usually stem from tests done on cells in the lab. That is just the first stage of gathering evidence, though; the only way to know for sure if something will work is a randomised, controlled trial done on people, preferably several trials.

By that measure, zinc supplements probably come out best, with evidence they can both prevent colds and shorten their duration if started within 24 hours of the symptoms appearing. Zinc may work by stopping the cold virus from replicating or preventing it from gaining entry to cells lining the airways.

The old favourite echinacea also seems to work, although only for treatment, not prevention, and even then the evidence is mixed - perhaps because what is sold as echinacea is actually a variety of preparations of various parts of three different plant species. The only other supplement with any credibility is vitamin C, which also seems to reduce symptoms slightly but doesn't prevent them.

Vitamin C boosts immune cell activity in theory, so why does it perform so poorly in practice? It seems that while vitamin supplements help people who are malnourished avoid diseases caused by vitamin deficiency, such as scurvy, there is no extra benefit to exceeding the recommended levels, which most people in the West hit anyway. In fact, popping vitamin pills - including vitamin C - may even be harmful overall. A recent study, for example, found that selenium and vitamin E could increase the risk of prostate cancer.

If you really want to support your immune

system, the best approach is simply to eat a plentiful supply of fruit and vegetables. They contain not just vitamins but also thousands of other compounds called phytochemicals, which have numerous beneficial effects we are only just starting to understand.

It is also important to focus on the quantity of food, not just its quality. People who are obese are more likely to get a range of infections, including respiratory, skin and urinary ones. Piling on the pounds makes it harder to breathe, which predisposes people to colds and flu, and the excess fat releases chemical signals that interfere with immune functioning.

Think carefully about how you shed the pounds, though, because yo-yo dieting is also harmful. Frequent cycles of weight loss and regain seem to reduce the performance of natural killer cells, an important branch of the immune system that targets cancerous cells and those infected with viruses.

BEFRIEND YOUR BACTERIA

The human gut is riddled with bacteria. That is a good thing – as well as helping you to digest food, these friendly bugs are essential for a healthy immune system.

The gut flora, as it is known, competes with harmful microbes for nutrients and physical space. It also releases antimicrobial compounds and communicates with the immune system in complex ways that we are only just starting to unravel.

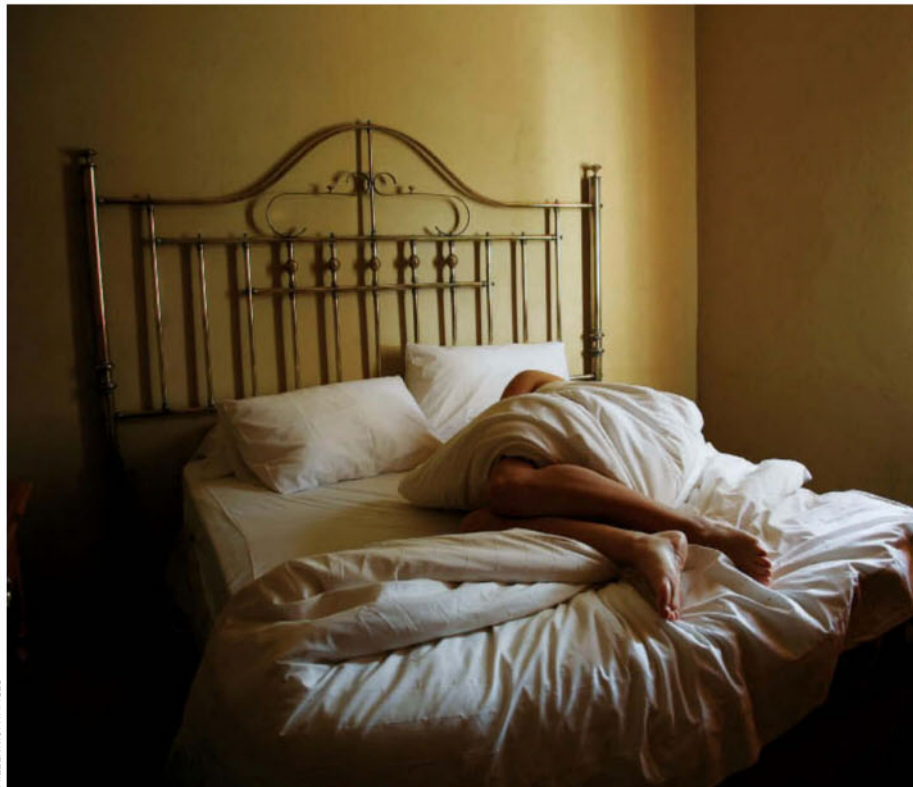
Given all this, it is not surprising that damaging your gut flora can leave you prone to bacterial infections. That's why when you take antibiotics for one infection, you are sometimes hit by another; the friendly bacteria are collateral damage. The superbug *Clostridium difficile*, for example, often strikes hospital patients after a round of antibiotics, and is arguably just as big a medical headache as antibiotic-resistant species such as MRSA. It causes diarrhoea, fever and a potentially fatal build-up of intestinal gas called toxic megacolon.

Instead of nuking your friendly bacteria you should nurture them. That is the aim of probiotics, daily yogurt drinks designed to boost the number of good guys. After initial doubts that this approach would deliver enough microbes to do anything useful, studies now support the idea that probiotics can help treat gut infections, including those associated with *Clostridium difficile*, and even ward off coughs and colds.

As well as probiotics there are prebiotics. The idea here is to feed up your existing friendly bacteria with certain nutrients, often forms of soluble fibre. In one study, people in hospital who took prebiotics were less likely to succumb to further bouts of *C. difficile* infection.

For people whose gut flora is beyond help, there is another option: a faecal transplant. Unappealing as it sounds, transferring someone else's faeces into a bowel severely infected with *C. difficile* has produced some striking successes. This is one immune booster, however, that you won't consider unless you are seriously unwell.

Send in the friendly bacteria



MILLENNIUM IMAGES

TAKE A DEEP BREATH

Close your eyes. Count to 10. Whatever you do, stay calm. Stress can weaken the immune system transiently but significantly.

Despite its New Age associations, studying the links between mind and body is now a respectable field of research, sometimes termed “psychoneuroimmunology”. Some of the classic studies have looked at immune responses after getting a vaccine. For instance, one of the pioneers in this field, Ronald Glaser at Ohio State University in Columbus, showed that people stressed out by looking after a relative with Alzheimer's disease had worse antibody and T-cell responses to a flu vaccine. Their wounds were slower to heal, and they also caught more throat infections.

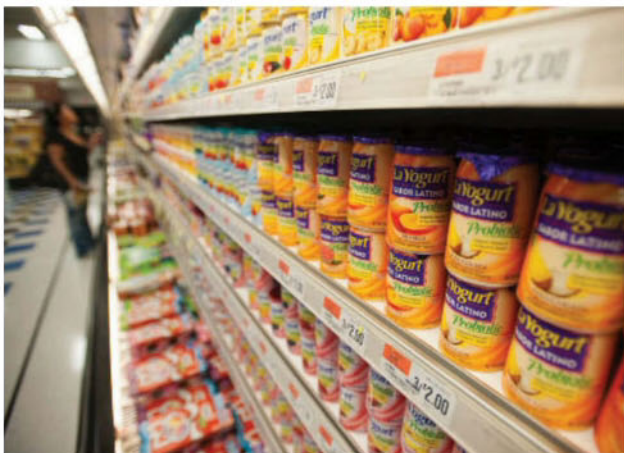
While there are myriads of signalling pathways between the brain and the immune system, the key players seem to be the stress hormones cortisol and noradrenalin. These bind to receptors on immune cells and

interfere with their ability to respond to antigens, leaving us more susceptible to infections.

On the other hand, a little of the bad stuff might be beneficial. An analysis of over 300 studies found that a short stressful experience, like public speaking, boosted blood levels of immune cells. “A slight elevation of stress hormones is good for you,” says Bruce Rabin at the University of Pittsburgh in Pennsylvania (for more on the putative benefits of mild stress see “Go for the burn”, page 50).

He doesn't recommend setting out to get stressed, but instead advises learning how to cope better with any stress that comes along. “Be optimistic, fit, have a sense of humour,” he suggests. Most important of all is to keep your friends. “Loneliness is the killer.”

This could be why women cope with bereavement better than men. “Women have friends that they talk to about personal issues,” says Rabin. “It's a buffer.”



RICHARD LEVINE/ALAMY

SAFEGUARD YOUR SLEEP

How much shut-eye did you get last night? Even a moderate lack of sleep can put you at greater risk of catching a bug. In a seminal study published in 2009, the average sleep duration of 153 healthy adults was recorded before they were given a sniff of a cold virus. It turned out that people who typically slept less than 7 hours a night were almost three times as likely to catch a cold as the rest of the group. This suggests people should make sure they are well rested before getting vaccinated, says Mark Opp, a neurobiologist at the University of Washington.

Opp recommends at least 8 hours and 20 minutes a night.

Early to bed, your immune cells are depending on it

That sounds a lot, but he reckons it is what everybody would get if left to their own devices. "If you take healthy subjects and let them sleep as long as they like, they sleep a little more each night, until it levels off at this duration," he says.

Sleep quality is also important, and that means making sure you are snoozing in a cool, dark and quiet place, says Opp. Living near a noisy place such as a train station is not a good idea, even if you think you are immune to the clatter. "People will say they're accustomed to the noise, but studies show that their sleep has been disturbed," says Opp. "If I put electrodes on their head, the brain activity would change to an awake pattern every time a train went by."

BRING ME SUNSHINE

Having a healthy immune system isn't all about cranking up the dial to maximum. There is a large class of conditions caused by immune cells attacking things they should leave in peace – namely the body itself. Known as autoimmune disorders, the list includes type 1 diabetes, inflammatory bowel disease, multiple sclerosis and rheumatoid arthritis.

These conditions have been linked to a lack of vitamin D – the so-called sunshine vitamin. Some foods, such as dairy products and oily fish, are rich in vitamin D but most is made in the skin when it is exposed to the sun's ultraviolet rays.

Vitamin D appears to play a key role in keeping the immune system in check. The first

"More people may die from cancers caused by lack of sunshine than from skin cancer"

clue that this was the case was the higher rate of autoimmune disorders in parts of the world with less sunlight. Since then, researchers have found that vitamin D suppresses the immune system by inhibiting the proliferation of immune cells and the signalling factors that spur them into action. The compound is even being investigated as a way of stopping people rejecting organ transplants.

Sunshine's effects don't stop at vitamin D. Melatonin, a hormone secreted by a gland in the brain in response to changes in light, stimulates certain kinds of immune cells.

Vitamin D is also vital for calcium absorption and bone health. Unfortunately, growing awareness of the risks of skin cancer has led some people to shun the sun.

Skin cancer aside, vitamin D may protect against many other common types of cancer, including breast, prostate and colon. One research group has calculated that in the US, more people die from internal cancers caused by lack of sun exposure than from skin cancer.

So how much time should you spend in the sun? Michael Holick at Boston University in Massachusetts reckons you should expose your hands, arms and face for a quarter of the time it would take to cause reddening two to three times a week.

If that is impossible – between November and March in the UK, for example, when the sun is not strong enough even if it comes out – then supplements or vitamin D-rich foods are a good substitute. But don't overdo it: the current UK recommendation is to take no more than 25 micrograms a day.

Homeland security

Our bodies have several lines of defence against foreign invaders

BONE MARROW

Where all our immune cells are produced

Non-specific immune cells



Provide generic first-line of defence against all-comers

B-cells

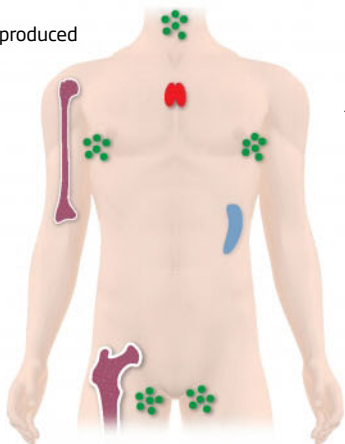


Make antibodies, which mark targets for destruction

T-cells



Kill cancerous and virus-infected cells, and direct other immune cells



THYMUS

Here, T-cells are trained to distinguish foreign antigens from those of our own body

SPLEEN

Stores and recycles immune cells. A key place where foreign antigens are brought to the attention of the immune system

LYMPH NODES

Act as minor garrisons for immune cells

"Most important for dealing with stress is to keep your friends; loneliness is the killer"

FIT FOR PURPOSE

It can be hard to motivate yourself to stay physically fit, but now there is yet another reason to try: even short bursts of exercise give your immune system a boost.

When 500 adults were tracked for 12 weeks, those who were the most physically active – five sessions or more of aerobic exercise a week – spent nearly half the number of days sick with an upper respiratory tract infection such as a cold or tonsillitis.

As your heart gets pumping, immune cells usually stuck in the blood vessel walls are washed into the circulation where they can do their stuff, says Mike Gleeson, an immunologist at Loughborough University in the UK. Levels of these cells in the blood double

“Athletes get more colds than those of us who just keep conventionally fit”

during exercise, upping the immune system’s ability to respond to pathogens, says Gleeson. “Exercise increases immunosurveillance.”

It is possible to overdo it, but you would have to be extremely dedicated. Gleeson’s team recently looked at how many colds athletes got compared with people who just kept fit in the conventional sense. Those who trained for 11 hours or more a week got more infections than those who worked out for between 3 and 6 hours a week.

Too much exercise has a similar effect to stress, raising levels of stress hormones such as cortisol that alter the functioning of immune cells (see “Take a deep breath”, page 120). “Even though there’s an increase in cells, their function is depressed,” says Gleeson.

He recommends exercising little and often, for no more than 2 hours at a stretch: “Restrict yourself to moderate exercise such as jogging or swimming.”



GET A GOOD START

What better way to engineer the perfect immune system than to start from scratch? Although you can’t do that for yourself, you can with your children. In the womb, babies automatically share their mother’s antibodies, which cross the placenta. This antibody donation can continue after birth through breastfeeding.

Breast milk is chock-full of immune-boosting ingredients. There is lactoferrin, for instance – a protein that inhibits the growth of bacteria – and sugars that block bacteria from binding to the body’s cells. Breastfeeding reduces infection rates, particularly in the developing world.

There is another way of furnishing a child’s immune system with first-class defences that is quick, relatively cheap and arguably one of medicine’s greatest achievements: vaccination against a dozen or more fatal diseases, available at a clinic near you.

Unfortunately, some anti-vaccine campaigners claim this amounts to “overloading” the immune system – an idea

that has no basis in fact considering the millions of microbes we face down in every speck of dirt. The few antigens within a vaccine, even multiple vaccines given at once, are a barely appreciable added burden, according to the World Health Organization.

Some childhood diseases, though, are caused by immune defences going into overdrive, including asthma, eczema and allergies to pollen or foods. We know that children are less likely to get such allergic conditions if they grow up on farms or have pets, lots of siblings or spend time in day care.

The hygiene hypothesis says that allergies are on the rise in the West because these days children aren’t exposed to enough germs. “If your environment at an early age is too clean, you’re not developing cells to respond to it,” says Arne Akbar, an immunologist at University College London. Although no one is suggesting neglecting basic hygiene, the general advice is to “let kids be kids”, and allow them to play in the dirt.



Breast milk is full of compounds that help newborns fight off infections

"Considering the millions of germs in every speck of dirt, a few vaccines at once cannot overload the immune system"

FRANCOIS PERRIEREA

AGE SHALL NOT WITHER THEM

Like most parts of the body, the immune system weakens with age. That is why older people catch more infections, are more likely to get cancer, and are more prone to shingles, a painful rash caused by the chicken pox virus reactivating after lying dormant for years.

You can't stop yourself from growing older but that doesn't mean you have to just sit there and take it. At the moment the only option is to take a leaf out of the kids' book and get fully vaccinated. As well as annual flu shots, older people can get a one-off vaccine for pneumococcal disease, which causes pneumonia and meningitis, and the "childhood" jab against diphtheria, tetanus and pertussis. A one-off vaccine giving partial protection against shingles has also been developed. The UK's National Health Service offers it to anyone aged 70 or 79.

In future there may be more high-tech countermeasures, such as rejuvenating the thymus - a gland in the chest where an important class of immune cells called T-cells mature. From puberty onwards the thymus

gradually shrinks and is taken over by fat, and then it is downhill all the way.

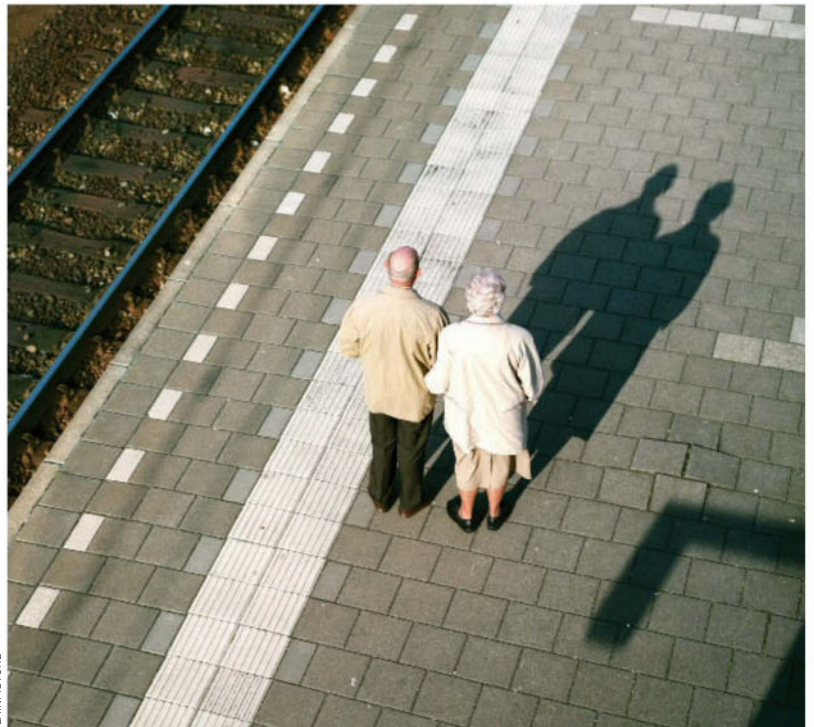
There may be ways to reverse this decline, though. One candidate is injections with growth hormone, which has shown promise in people whose immune system has been depleted by AIDS.

Visible ageing is also seen at the cellular level. Every time immune cells multiply in response to a bug they recognise, parts of their chromosomes called telomeres shorten until there are none left. At this point they lose the ability to divide and become useless. As people age, more and more of their circulating immune cells approach the end of their lifespan.

This is unavoidable, but there is one microbe it might be particularly helpful to steer clear of: cytomegalovirus (CMV). Most people have a long-standing dormant infection with CMV which reawakens every so often, perhaps due to stress. This rarely makes them ill but causes unusually widespread activation of immune cells, so hastening their decline.

One theory is that CMV plays a key role in immune ageing. If that's true, then there is good news - a number of vaccines against CMV are in development.

The immune system declines with age



PLAINPICTURE



NDLNESS
ply regularly

SMILES
Oral administrat

LOVE
Give as required

WARMTH
Store in a cool, dry place

HAPPY
MEMORIES

FOND
MEMORIES
Keep out of
reach of children

SYMPATHY
Handle with care

JOY
Do not mix with use

AFFE
Take tw

FOND
MEMORIES

SMILE
To be worn at all

LOVING
KINDNESS
Apply copiously

GOOD
WILL
Before and
after meals

NIC
THOUGHT
WARNING
May cause
health benefits

AFFECT
Handle with

NICE
THOUGHTS

GOOD
WISHES
Dispense
liberally

KIND
THOUGHTS
4 times a day

BLESSII
Distribute

TENDERNE
Apply every day

COUNT
YOUR
BLESSINGS

CAF

LOVE
As needed

Wishful thinking

Your body contains a nerve that underpins your health and happiness, and you could make it work better with just the power of your mind.
Emma Young investigates

EVERY day, Nancy Havill tries to think kind thoughts about other people. Sometimes, she does this while sitting on a cushion in front of a candle and a bowl of smooth pebbles. “But I also like the informal practice, when I am walking around my neighbourhood, or from the bus stop, and I send random kind thoughts to the people I encounter,” she says.

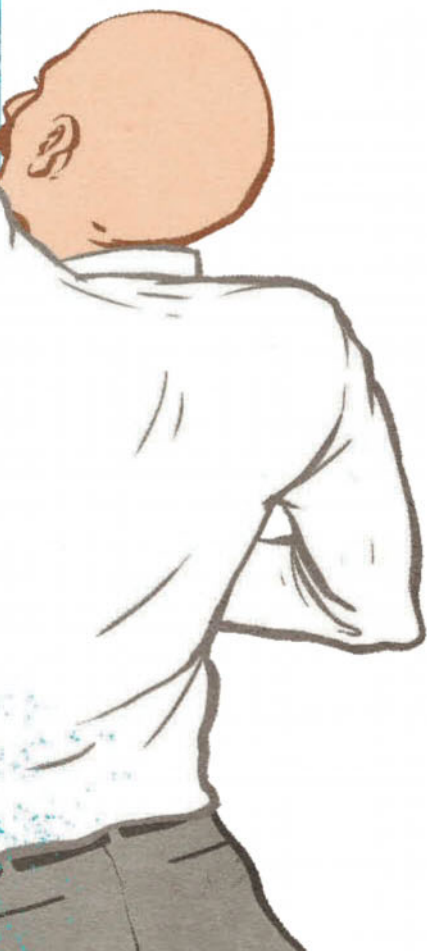
It all sounds rather New Age. But Havill is no credulous crystal-touting hippy. She is a research associate at the University of North Carolina at Chapel Hill, where psychologist Barbara Fredrickson has uncovered a surprising link between meditating on kind thoughts and a whole range of indicators of physical health and mental well-being. It might boost your immune system, protect you from cardiovascular disease, reduce vulnerability to stress, improve thinking and emotional control, and even raise levels of empathy, sociability and self-esteem.

Too good to be true? Perhaps, but in recent years, evidence linking physical health and psychological well-being has been steadily accumulating. “We all know these two are intricately connected, and in fact are integrated parts of one system,” says Elissa Epel at the University of California, San Francisco. So ideas that a decade ago might have been dismissed out of hand are now gaining wider acceptance.

In this case, the object of attention is the vagus nerve, also known as the 10th cranial nerve, which connects your brain to internal organs including the lungs, digestive tract and, most notably, the heart. That much has been apparent since the second century when the

Roman anatomist Galen of Pergamon explored the human nervous system. We now know that the vagus is a key component of the parasympathetic nervous system, the branch of the nervous system that works subconsciously to calm you down after a stressful event. When you are threatened or insulted, you experience the “fight or flight” response; your body goes on full alert and your heart races, priming you to act. When danger passes, or action is not required, it is the vagus nerve that soothes you, returning your body to a relaxed state in which it can engage in other important pastimes such as digestion and sexual arousal. The stronger the activity of your vagus, the more readily you assume this “feed and breed” state rather than being stressed out. The strength of that activity is known as vagal tone.

There are several ways to measure vagal tone, but all involve tracking your heart rate in conjunction with your breathing rate (see “Is there an app for that?”, page 126). “Your heart rate speeds up a bit when you inhale and slows down a bit when you exhale,” says Fredrickson, allowing freshly oxygenated blood to circulate more rapidly when you breath in and putting a break on the heart’s tendency to race when you breath out. This subtle, healthy arrhythmia is controlled by the vagus nerve and varies considerably between individuals. Vagal tone is at its peak in childhood, decreases during adolescence, and by adulthood “it is about as variable as height”, says Bethany Kok, a social neuroscientist at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, and former colleague of ➤



KELLY DIXSON

Fredrickson. Genes seem to account for perhaps 65 per cent of this variance, but people who are overweight and do little exercise tend to have low vagal tone. Some researchers think childhood experiences, such as being in stressful or protective environments, may also have a lifelong effect, but this isn't yet clear. Either way, once we reach adulthood, vagal tone tends to be stable.

For people lucky enough to have high tone, the rewards are great, or so a battery of studies seems to indicate. First, there are physical health benefits. The vagus nerve plays a role in stimulating insulin production, and people with low tone are not as good as those with high tone at regulating their blood glucose levels. They also have more difficulty suppressing inflammation. Both these factors are associated with heart failure, stroke and diabetes. And the link between low vagal tone and dying from cardiovascular disease appears to be quite strong.

Spark and smile

Then there are mental benefits. People with higher vagal tone tend to be intellectually sparkier, with a better working memory and ability to focus their attention. Some work even suggests that the low vagal tone commonly seen in people with chronic fatigue syndrome may account for the cognitive slowness that can accompany the condition.

Intriguingly, newborns with the strongest vagal tone can be highly reactive and irritable for the first five or six months of their lives. Thereafter, however, people with high tone tend to be more emotionally stable, less stressed and happier than the average.

IS THERE AN APP FOR THAT?

Your vagus nerve is the branch of your nervous system responsible at a subconscious level for helping you to relax, rest and digest. If it is working well, you are said to have high vagal tone, which brings a range of physical and mental benefits (see main story). Vagal tone was once thought to be fixed in adulthood, but it now appears that it can be increased. So how is it measured?

The nerve's interplay with heart rate as you breathe can be used to infer vagal tone. Inhaling temporarily suppresses vagal nerve activity, increasing heart rate and helping oxygenated blood circulate. When you breathe out, your heart rate slows. The bigger the difference between your heart rate when breathing in compared with breathing out, the higher your vagal tone. There are dozens of ways to quantify this difference, but the most common way measures the amount the heart rate varies between typical breathing cycles. The difference can range from near zero to a few hundred milliseconds. Doctors use an EEG to take this measurement. But there are now various gizmos on the market that promise to help you monitor and improve your vagal tone.

Stephen Porges, also at the University of North Carolina, believes this is because the experience and regulation of emotion is dependent on the state of the nervous system. Someone with an underperforming parasympathetic nervous system, he argues, could struggle to stay calm in the face of provocation and take longer to recover from a stressful experience. Indeed, low vagal tone is a risk factor for depression, and vagal nerve stimulation is being used to help people with treatment-resistant depression.

High tone has also been linked with sociability. It seems to help people form stronger relationships and derive more pleasure from social interactions. The precise mechanisms that underpin this are still pretty murky, but Porges suggests that it is because the vagus nerve is connected to other nerves involved in making eye contact, facial expressivity and the ability to tune in to the frequency of the human voice, all of which are crucial for effective social interactions. A recent study also linked high vagal tone to increased empathy in adolescents. All of which may help to explain the finding that such people are highly valued as friends.

This is an enviable range of physical, mental, emotional and social advantages, but until recently it seemed to be the preserve of people lucky enough to have naturally high vagal tone. Then some researchers started questioning the orthodoxy. About a decade ago, there were hints that exercise might improve vagal tone, and it has since been claimed that this is one reason why exercise is so good for you. What Fredrickson is now suggesting takes things to a new level: you can simply think your way to better vagal tone, and so to increased health and happiness.

A pioneer in the field of positive psychology, Fredrickson was intrigued by studies linking vagal tone with emotional and social well-being, and so decided to take a look for herself. Working with Kok, she measured the vagal tone of 73 adults, then asked them to report all their positive emotions every day for nine weeks, and to rate the degree to which they felt socially connected. Sure enough, those whose vagal tone was highest at the start of the study reported greater positive emotion. But there was something else. All the volunteers also showed an increase in positive emotions and feelings of social connectedness – and the more pronounced this effect, the more their vagal tone had increased over the nine weeks.

Encouraged by these findings, Fredrickson decided to see whether she could boost vagal tone still further. In previous research, she had

People with high vagal tone tend to be highly valued as friends



BEN ROBERTS/PHOTODEBUT/PICTURETANK

Could wishing others well improve your own health and happiness?

NOW CLOSE YOUR EYES

There is evidence that meditation can increase your vagal tone (see main story) and so improve your mental and physical health. Assuming you were willing to engage in a bit of loving kindness meditation to boost your well-being, how would you go about it?

First, find a quiet place and adopt a position that makes you feel relaxed yet alert. With your eyes closed, try to envisage your heartbeat, and then consciously concentrate on your breathing. Now, visualise someone – it can be yourself, a loved one or someone you barely know – and think of their good qualities. Once you are feeling positive towards them, repeat these traditional phrases of loving kindness meditation: May X feel safe; May X feel happy; May X feel healthy; May X live at ease. After a few minutes, let go of X's image and start thinking nice thoughts about someone else.



ALIX MINDEPLAINPICTURE

found that loving kindness meditation – the type Havill practises – increases feelings of social connectedness. Her original study suggested that such feelings are associated with increases in vagal tone, so this time the volunteers first learned to meditate (see “Now close your eyes”, above). Fredrickson, Kok and colleagues then asked them to keep a daily record of the amount of time they spent meditating and the most powerful of 20 different emotions (both positive and negative) they felt that day. The volunteers also rated their daily social interactions, indicating to what extent they felt “in tune” with the people with whom they had spent most time. After nine weeks, vagal tone had increased significantly in meditators but not in people who neglected their practice. Those who started with the highest scores had the greatest increases in positive emotions and social connectedness.

“Learning loving kindness meditation improves vagal tone,” says Fredrickson. And good vagal tone improves emotional and social well-being. So an “upward spiral” exists, in which higher vagal tone promotes greater social connectedness and positive emotions, which then promotes even higher vagal tone. She calls social connectedness a potent “wellness behaviour”, noting that social isolation is associated with an increased risk of death comparable to smoking, drinking too

much alcohol, obesity or physical inactivity. If she is correct, vagal tone is an important player in the mind-body connection, and loving kindness meditation is a key to improving our mental and physical well-being, deepening our personal experience, and lengthening our lives.

Persuaded? Others think that Fredrickson is on to something, though it is still early days. Gary Berntson at Ohio State University in Columbus, who researches brain mechanisms underlying behaviour and emotions, says

“Your vagus nerve is in the branch of your nervous system that helps you relax, rest and digest”

the work is very interesting. “It’s clearly speculative but she does have some neat data that support the speculations.” He would like to see more research on the causal pathways and mechanisms. Epel, who studies the effect of stress on biological ageing, also thinks there could be something in it. “The vagus nerve is such an important connection between the brain and the heart, and also related to the immune system, and responsive to what we are doing and feeling.” However, she points out that we have a lot to learn about the dynamics

of the vagus. She is also curious about the effects of different sorts of meditation. For example, mindfulness meditation – which involves the monitoring of moment-by-moment experience – has been more widely studied and found to have positive health effects including improved immune function.

Meanwhile, if you are tempted to think well of others, there is one thing you should know: improving vagal tone is hardest for people who have low tone to begin with. But whatever your level, there is hope – and regular meditation may not even be necessary. Exercise also boosts vagal tone, although there still isn’t enough research to quantify its impacts. Repeated exposure to “excitatory” music may do too. Andy Martens at the University of Canterbury in Christchurch, New Zealand, has found that hearing positive feedback about yourself can increase vagal tone, suggesting that anything that enhances your self-esteem might help. And Kok has published work showing that just reflecting on positive social experiences during the day boosts vagal tone.

Havill, meanwhile, is quietly positive about the effects of her meditation. “I have noticed an improved calmness and clarity of mind,” she says. But she tries not to expect too much. “One of the things the teachers instruct is not to be too goal-oriented.” It sounds like a win-win strategy. ■

COMING SOON

NewScientist
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ISSUE FOUR

THE
HUMAN
STORY

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THE MOST REMARKABLE SPECIES THE EARTH
HAS EVER KNOWN*

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