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Live your life to the fullest

EVERY day we are bombarded with suggestions for making ourselves better: ways to be fitter, healthier, smarter, more attractive and more productive. We are a species driven by constant self-improvement, but even when the spirit is willing, the flesh is often weak. It takes discipline and scientific expertise to navigate the mass of frequently contradictory information. One minute we are told to eat five servings of fruit and vegetables each day, the next we are prescribed 10. Antibacterial soaps are sold in every supermarket, but we are told that excessive cleanliness could be contributing to a rise in allergies. Depending on who you speak to, gluten-free diets are the best thing since sliced bread or a passing fad. The list goes on.

In 2014, *New Scientist* published *The Scientific Guide to a Better You*, a collection of articles dedicated to giving you the tools to make the right choices. The field of self-improvement never rests, hence this volume: *The Scientific Guide to an Even Better You*.

Chapter 1 is dedicated to our most prized organ: the brain. Discover the best tips for boosting your learning power, from when to study to why video games can be valuable teaching assistants and why distractions could be a good thing. Whether you're after a better memory, more creative thinking or long-term focus, we have a workout for you.

Chapter 2 is all about what we put in our bodies, especially at mealtimes. We start off with a no-nonsense guide to so-called superfoods, then take a critical look at some of the health concerns du jour, from wheat allergies (if that's really what they are) to our obsession with fat and the adage that breakfast is the most important meal. Our ideas about what we should and shouldn't drink are also clouded by urban myth. Make yourself a nice cuppa and let us sort out fact from fake news.

Chapter 3 looks at the way you feel the world around you: your senses and how to enhance them. We introduce a surprising pair of mood-altering shoes, and take a look at ways to improve your vision and hearing.

Chapter 4 focuses on how to take care of your body. If you are obsessed with hygiene, there's an honest assessment of how much is too much. Top tip: the five second rule is not all it's cracked up to be and yes, you really must rinse the soap suds off those dishes, but maybe not for the reason you think. You can learn to cultivate the kind of fat that makes you thin, but don't go overboard – life would be a bore if we didn't allow ourselves a few guilty pleasures.

Chapter 5 offers a guide to key life skills. Learn how to be more confident, control your habits and find a purpose in life. It can make all the difference.

Stay cool calm and collected for Chapter 6, which is about emotions and how to manage them. Crying can be frowned on but has its advantages, so don't hold back. Empathy is a healthy emotion, but too much of it could be doing you more harm than good – there are better, more constructive ways to feel for the suffering of others. Boredom, on the other hand, could have hidden benefits.

Chapter 7 is dedicated to that sweetest moment of the day, when you can finally pull up the covers and switch off the light. We've compiled a comprehensive guide to getting the most out of your shut-eye, how to learn new skills while you sleep, and how to make the most of your nightmares. Finally, if it all gets a bit much, learn how to escape with a spot of lucid dreaming and wake to find you are now an even better you.

Catherine Brahic, Editor

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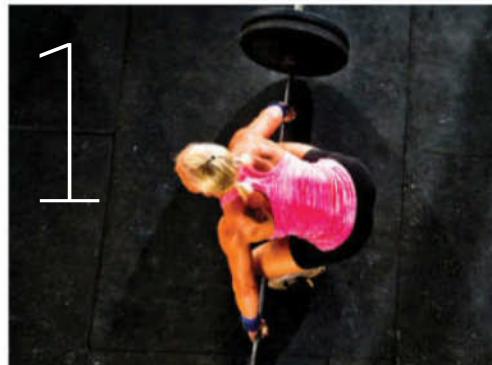
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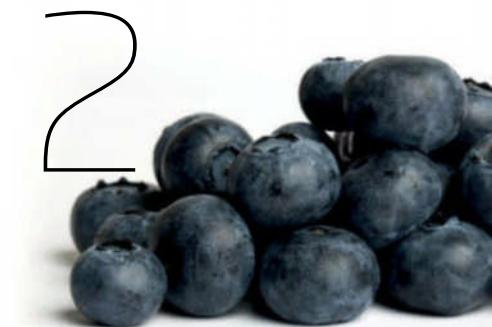
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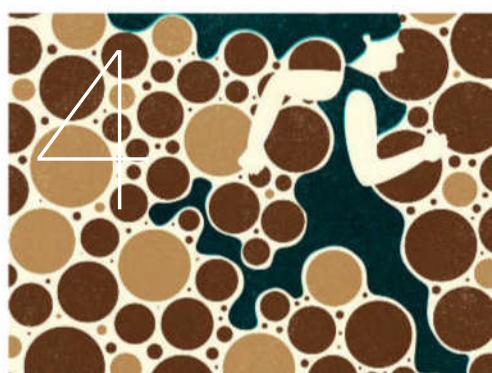
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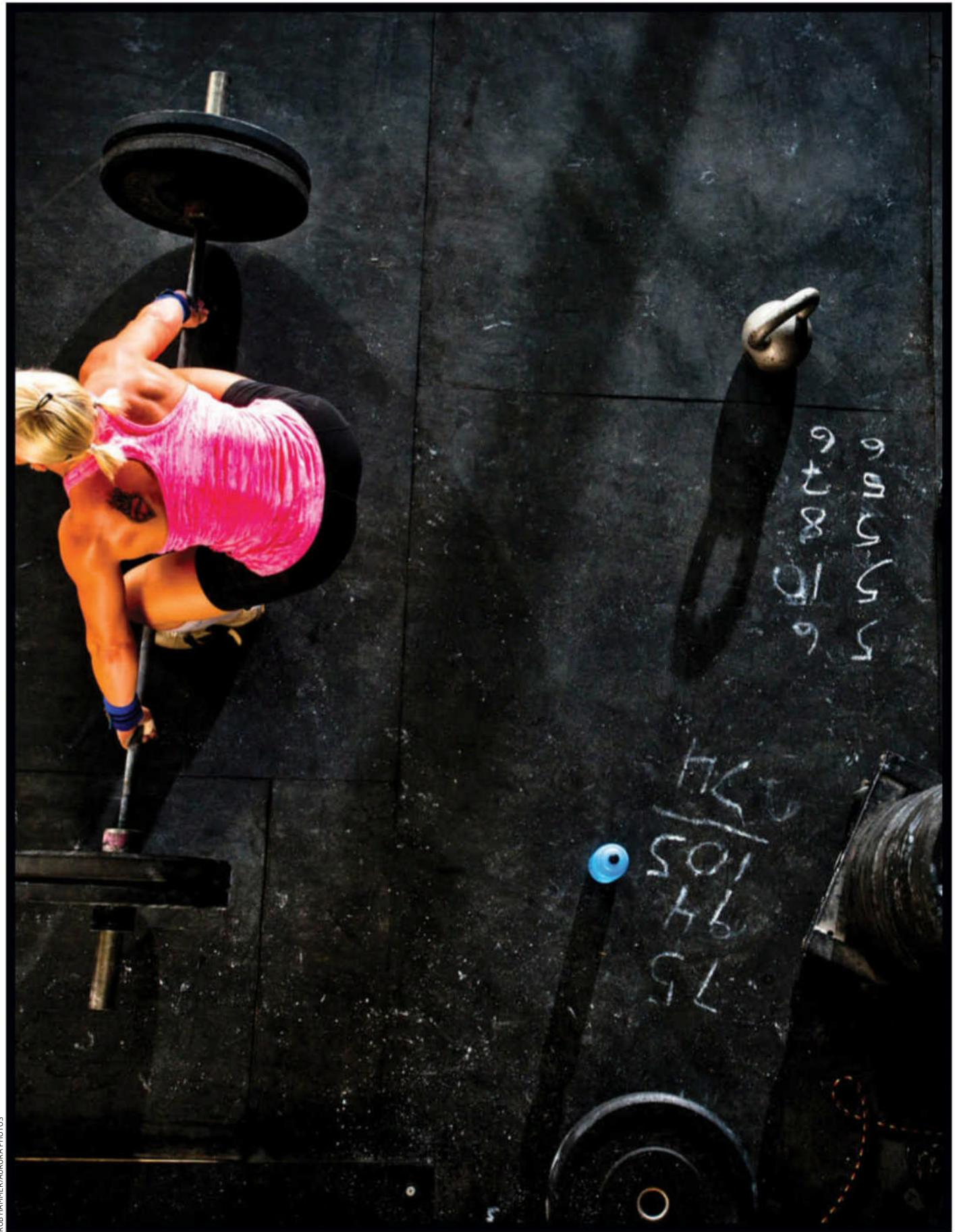
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Circuit train your brain

Whether you need to focus better, improve your memory or curb unwanted cravings, specific exercise regimes can fine-tune your mind. Teal Burrell reports

PUMPING iron to sculpt your biceps. Yoga poses to stretch and relax. Running to whittle your waistline and get fit fast. There are loads of reasons why it's smart to exercise, and most of us are familiar with the menu of options and how each can shape and benefit your body.

But we are discovering that there are numerous ways in which exercise makes you smart too. Many of its effects have been going unnoticed, but if you were to peer inside the heads of people who like to keep active, you would see that different exercises strengthen, sculpt and shape the brain in myriad ways.

That the brains of exercisers look different to those of their more sedentary counterparts is, in itself, not new. We have been hearing for years that exercise is medicine for the mind, especially aerobic exercise. Physical fitness has been shown to help with the cognitive

decline associated with dementia, Parkinson's disease and depression, and we know this is at least in part because getting your blood pumping brings more oxygen, growth factors, hormones and nutrients to your brain, leading it – like your muscles, lungs and heart – to grow stronger and more efficient.

But a new chapter has begun in our understanding of the influence of physical exercise on cognition. Researchers are finding more specific effects related to different kinds of exercise.

They are looking beyond the standard recommendation of 30 minutes of moderate, aerobic exercise a day, for the sake of your brain. Are there benefits to going slower or faster? To lifting weights, or performing sun salutations? Whether you want a boost in focus for an exam, find it hard to relax or are keen to quit smoking, there's a prescription for you.

The first clue that exercise affects the brain came from rodent studies more than 15 years ago, which showed that allowing mice access to a running wheel led to a boost in neuron formation in their hippocampi, areas of the brain essential for memory. That's because exercise causes hippocampal neurons to pump out a protein called brain-derived neurotrophic factor (BDNF), which promotes the growth of new neurons. The mice showed improvements in memory that allowed them to navigate mazes better.

The findings were soon translated to humans. Older adults who did aerobic exercise three times a week for a year also grew larger hippocampi and performed better in memory tests. Those with the highest levels of BDNF in their blood had the biggest increases in this brain region.

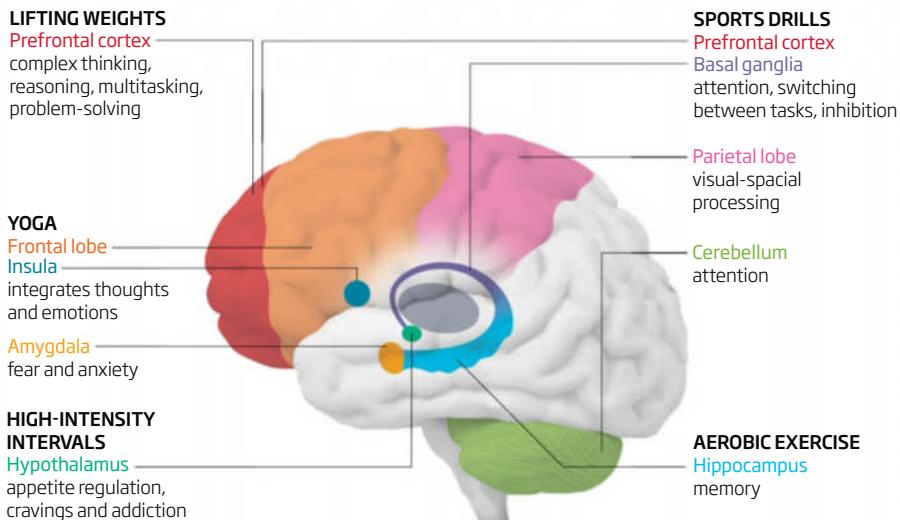
The idea that exercise helps to improve memory has been especially welcome given that the search for effective treatments for cognitive decline has been slow in progress. And it now seems that aerobic exercise such as running and cycling may help stave off Alzheimer's disease and other forms of dementia.

As the evidence for aerobic exercise accumulated, Teresa Liu-Ambrose at the University of British Columbia in Vancouver, Canada, began to wonder about other types of exercise. She had been looking for ways to halt dementia in people with mild cognitive impairment (MCI), a population of adults known to be at increased risk of developing dementia, and was especially interested in strength training, which has in recent years been added to US and UK government recommendations for physical activity.

To test the idea, Liu-Ambrose compared the effects of aerobic exercise and strength training in 86 women with MCI. She measured the impact of these activities on two abilities ➤

The ultimate brain workout

Different physical exercises can bring specific mental gains, from improving memory to dealing with cravings or reducing stress



known to decline as the condition progresses: memory and executive function – which encompasses complex thought processes, including reasoning, planning, problem-solving and multitasking (see diagram, above).

Twice a week for an hour, one group lifted weights, while the other went for brisk walks quick enough that talking required effort. A control group just stretched for an hour instead. After six months of this, both walking and lifting weights had a positive effect on

spatial memory – the ability to remember one's surroundings and sense of place.

On top of that, each exercise had unique benefits. The group that lifted weights saw significant improvements to executive function. They also performed better in tests of associative memory, which is used for things like linking someone's name to their face. The aerobic-exercise group saw improvements to verbal memory – the ability to remember that word on the tip of your

tongue. Simply stretching had no effect on either memory or executive function.

If aerobic exercise and strength training have distinct benefits, is combining them the way to go? To address this, Willem Bossers of the University of Groningen in the Netherlands split 109 people with dementia into three groups. One group walked briskly four times a week for 30 minutes; a combination group walked twice a week and strength-trained twice a week for 30 minutes each; and a control group did no exercise. After nine weeks, Bossers put the participants through a battery of executive-function tests that measured problem-solving, inhibition and processing speed. He found that the combination group showed more improvement in executive function than the aerobic-only or control groups. "It seems that, for older adults, walking only is not enough. They need to do some strength training," he says.

Immediate attention boost

And these benefits extend to healthy adults too. In a year-long trial in healthy older women, Liu-Ambrose found that lifting weights, even just once a week, resulted in significant improvements in tests of executive function. Balancing and toning exercises, on the other hand, did not.

The combination of lifting weights and aerobic exercise might be particularly powerful because strength training triggers the release of a molecule called insulin-like growth factor-1 (IGF-1), a growth hormone produced in the liver that is known to affect communication between brain cells, and to promote the growth of new neurons and blood vessels.

On the other hand, aerobic exercise mainly boosts BDNF, says Liu-Ambrose. In addition, Bossers says strength training also decreases levels of homocysteine, an inflammatory molecule that is increased in the brains of older adults with dementia. By combining aerobic exercise with strength training, you're getting a more potent neurobiological cocktail. "You're attacking the system in two ways," he says.

The studies so far haven't addressed how long the effects last, but preliminary findings suggest adults will have to keep exercising to maintain the benefits.

Another approach is to start young, with findings that different types of exercise affect a child's mental capacity in a number of ways. For example, if you want kids to focus for an



FEELING ANXIOUS? SAY "OM"

After a running injury, Sara Lazar decided to try yoga. She initially rolled her eyes when the instructor touted the mental-health benefits, but after a while she realised she felt better able to handle difficult situations. She decided to look into it at her lab, then at Massachusetts General Hospital, recruiting people who were experiencing high levels of stress to attend yoga and meditation classes for eight weeks. They also practised at home for 20 minutes a day. By the end, brain scans showed the volunteers' amygdala – brain regions that process fear and anxiety – had shrunk, and participants reported feeling less stressed. While it's not yet clear why, yoga's meditative aspect helps develop a calmer outlook, which in turn reduces fear and anxiety, says Lazar.

"Lifting weights helps improve complex thoughts, problem-solving and multitasking"



BRUNO BARBRY/MAGNUM PHOTOS

hour – on a maths test, say – the best bet is to let them have a quick run around first. That's according to studies that show a simple 20-minute walk has immediate effects on children's attention, executive function and achievement in mathematics and reading tests. Letting kids sprint or skip about has the same effect. A brisk walk can also help children with attention-deficit hyperactivity disorder to focus, although again it's not yet clear how long the effects last.

These findings should be used to make decisions about the daily school routine, says Charles Hillman at the University of Illinois at Urbana-Champaign, who carried out some of the research. He agrees with current recommendations that children get at least an hour of exercise daily, but notes that it might be best spread over the course of the day. Because purely aerobic exercise keeps kids focused in the near term, giving them breaks to walk or move around every 2 hours might be the best way to promote learning.

In contrast, exercise that is highly structured and focused on specific skills, such as for a sport or to improve coordination, hampers attention. A bunch of drills and rules may be too taxing for children right

Mind over matter:
improving attention
can help mobility.
The stick is optional

before a test or a situation that requires sustained focus.

Instead, these kinds of specific exercises seem to build up attention span gradually over the long-term. Maria Chiara Gallotta at the University of Rome in Italy found that twice-weekly sessions of coordinative exercises, such as basketball, volleyball or gymnastics practice, over the course of five months helped children do better on tests that required concentration and ignoring distractions.

It has long been known that the cerebellum – the finely wrinkled structure at the base of the brain – is involved in coordinating movement, but it is now recognised as having a role in attention as well.

MIND GAMES FOR MOBILITY

Moving the body can tone the mind (see main story), but could the reverse also be true?

In other words, says Lindsay Nagamatsu at the Western University in London, Canada, can a mental workout influence how the body moves?

It is commonly assumed that everyday movements like walking and maintaining posture are automatic. But even if we don't consciously think about them, they still require a level of attention.

This becomes more apparent as we age, and Nagamatsu's earlier work shows that older people whose minds tend to wander, or who score poorly on attention tests, are more likely to take a fall. Physiotherapy and exercise improve mobility, but Nagamatsu wondered if a boost in attention span could too.

To test this, she used a computer game that is known to improve attention and perception called *Music Catch*. She got people aged between 60 and 80 to either play this game for a total of 15 hours over five weeks, or another game known to help with working memory and reasoning but not attention.

Before and after this she tested their walking speeds, a commonly used indicator of someone's risk of falling or being able to live independently.

Nagamatsu showed that the *Music Catch* group ended up with significant improvements in speed. The game seemed to be particularly helpful because it required paying attention to multiple things at once, as we do when walking while carrying on a conversation, for example.

And walking speed might be important more generally: "It has also been shown to predict morbidity and mortality in older adults," says Nagamatsu, "so I think that it's an important outcome to try to improve."

Practising complicated movements activates the cerebellum and, by working together with the frontal lobe, might improve attention in the process.

Making sure children are physically fit can have lasting cognitive benefits too, says Hillman. He has shown that children who are fit have larger hippocampi and basal ganglia, and that they perform better in attention tests. The basal ganglia are a group of structures important for movement and goal-directed behaviour – turning thoughts into actions. They interact with the prefrontal cortex to influence attention, inhibition and executive control, helping people to switch between two tasks, such as going from

sorting cards by colour to sorting cards by suit.

Hillman focuses on children aged 8 to 11 because areas like the hippocampi and basal ganglia are still maturing, so intervening at a young age can make a big difference. And even small gains in fitness lead to measurable changes in the brain. In some of his studies, Hillman has put kids on year-long after-school fitness programmes. Many are overweight, and while they don't lose much weight, their brains do change. They are going from being unfit to slightly less unfit, says Hillman. "But we're still finding benefits to brain function and cognition."

Adults too can reap brain gains from sporty challenges, says Claudia Voelcker-Rehage at Chemnitz University of Technology in Germany. Her research on older adults showed an increase in basal ganglia volume following coordination exercises that included balancing, synchronising arm and leg movements, and manipulating props like ropes and balls, but not from aerobic exercise.

Surf yourself smart

So why the added benefits? Such activities require an understanding of where things are in space, so one explanation is that they activate both the visual system and the parietal lobe, the part of the brain that integrates sensory and spatial information.

Indeed, Voelcker-Rehage found that these types of exercise improved visual-spatial processing, required for mentally approximating distances – for instance, being able to assess whether you have time to cross the street before an oncoming car reaches you – more than aerobic exercise.

Another explanation comes from research by Tracy and Ross Alloway, both at the University of North Florida in Jacksonville. They found that just a couple of hours of activity of the type we often enjoy during childhood, such as climbing trees, crawling along a beam, or running barefoot, had a dramatic effect on working memory.

This is the ability to hold on to information and manipulate it in our minds at the same time. "It prioritises and processes information, allowing us to ignore what is irrelevant and work with what is important," says Tracy Alloway. "Working memory influences nearly everything that you do, from the classroom to the boardroom."

So what is it about climbing trees or beam balancing that is so beneficial? The researchers only found positive results when the activities were a combination of two things.

LET LOOSE FOR CREATIVITY

Daniel Schwartz practises what he preaches. During our interview he is strolling through Stanford University's leafy campus, an activity that according to his research boosts divergent creativity – otherwise known as thinking outside the box.

It is walking at a leisurely, everyday pace that does this, not at a speed that would be aerobically challenging or make you out of breath. In Schwartz's study – which he thought of while out on a walk – people came up with more unique uses for everyday objects when walking outside or on a treadmill than when seated. He even found that taking a walk has a stronger effect on creativity than IQ. And people continued to be more creative afterwards, suggesting a saunter before a brainstorming session is a good idea.

Or, if you're more of a jitterbug, Peter Lovatt, a dance psychologist at the University of Hertfordshire, UK, suggests you "put on some music and start having a boogie", and the key is to keep it loose. After a session when people had to improvise dance moves, they came up with more creative answers to problems than after a structured dance session or no dancing at all. It seems that creative movements – no matter how silly – lead to creative problem-solving. In fact, the sillier the better: the trick is to move in different ways. So if you tend to move your arms a lot when you dance, focus on your hips instead. "Having a spontaneous wiggle – without any pre-planning – is really good for divergent thinking," Lovatt says.



Taking a stroll can get the creative juices flowing

"Chocolate lovers consumed half as much after a brisk 15-minute walk. For smokers, 10 minutes of biking reduced cravings"

They needed to challenge the sense of proprioception – the position and orientation of the body – and also needed at least one other element, such as navigation, calculation or locomotion. Basically, the advantages came from exercises in which we need to balance and think at the same time.

A good example is surfing, says Alloway. "In order to even catch a wave, you have to pay so much attention to proprioceptive information or you slip off your board; you also have to judge the best position to be in order to catch it, as well as to determine if another surfer has priority to catch a wave."

In their study, a group who did yoga, which involves proprioception but not much mental reasoning, didn't see improvements in working memory; nor did a group merely learning new information in a lecture setting.

The results were the same for children and adults. "The adults in our study showed improved working memory after just a couple of hours of doing playground-type activities," Alloway says.

The more we learn about the effects of exercise on the brain, the more different types of benefits are emerging, extending beyond cognition to changes in behaviour.



MARTIN PARR/MAGNUM PHOTOS

One popular fitness trend is high-intensity interval training, which involves quick spurts of all-out exercise. Its sheer toughness is claimed to provide the same benefits as longer efforts in a fraction of the time.

These workouts might have an extra advantage: short bursts of activity can help curb cravings. And although the tougher the better, they don't necessarily have to be gut-busting hard.

To test the effects of intensity training on

appetites, Kym Guelfi at the University of Western Australia in Perth invited overweight men to come into the lab on four separate occasions. On three of the visits, they spent 30 minutes on an exercise bike, but at different intensities – a moderate, continuous pace; alternating between intervals of high-intensity cycling for 1 minute followed by 4 minutes of moderate cycling; or alternating between very high intensity, 15-second sprints followed by one really easy minute. The fourth visit consisted of resting for the full 30 minutes.

Craving control

After the most intense intervals, the men ate less of the provided, post-workout porridge and less food overall for the next day and a half compared with days they cycled moderately or simply rested.

One explanation could be that the exercise reduced levels of the “hunger hormone”, ghrelin. This is responsible for telling the part of the brain that controls eating – the hypothalamus – when the stomach is empty. When full, ghrelin production shuts off and hunger wanes. Following the most intense intervals of exercise, ghrelin levels were lowest.

If intensity isn't your thing, you could also play with the thermostat. Guelfi and others have shown that exercising in the heat reduces appetite, while exercising in the cold increases it. Again, hormones like ghrelin or a small protein called peptide YY could well be at play.

And although vigorous activity might curb appetite and stall cravings for longer, even moderate exercise can help. Adrian Taylor, now at Plymouth University in the UK, has found that short bouts of activity can reduce cravings for both sugary snacks and cigarettes.

In earlier work, Taylor found that chocolate

lovers consumed around half as much of it after a brisk 15-minute walk as those that rested quietly. For smokers, 10 minutes of moderate biking helped reduce self-reported cravings. Smokers' brains were also scanned while they viewed images designed to trigger cravings. Following cycling – despite staring at pictures of cigarettes after being deprived for 15 hours – the smokers' brains appeared relaxed. Regions implicated in addiction were less activated after exercise, as if the tempting cigarette were no more meaningful than a pencil.

It's conceivable that exercise merely distracts from the urge, but studies show that cravings were reduced more following a short bike ride than after another distracting task involving mental arithmetic.

It's still early days, and while some of the studies point at possible mechanisms behind the benefits, other effects have yet to be explored. One theory is that certain types of exercise increase blood-vessel formation in the brain, and so keep it working well. Exercises that activate specific regions may bring more blood to those areas, possibly building new vasculature that improves its functioning, whether it be for better memory or better problem-solving. And doing something unfamiliar, like learning a dance step or balancing on a beam, could also create novel connections between neurons, Voelcker-Rehage suggests.

What is clear is that these effects can endure well into old age, and it's never too late to start. The hippocampus shrinks as we get older, leading to the typical struggles with memory. But aerobic exercise not only prevents this loss – it reverses it, slowing the effects of getting older. Voelcker-Rehage has found that the brain requires less energy to complete certain tasks after exercise. “We would say that points to the fact that the brain is more efficient,” she says. “It works more like a young brain.”

And in a study looking at yogis that had been practising for many years, Sara Lazar of Harvard University found that some brain regions were remarkably well preserved compared with those of healthy controls that were matched for age, gender, education and race. “The 50-year-old's brain looked like a 25-year-old's,” notes Lazar.

If you're still unsure which type of exercise to pick, there's some overlap between the different exercises and benefits, so Liu-Ambrose's suggestion is simple: “If you're not active, do something that you enjoy.” The best exercise is the kind that you'll actually do. ■

EIGHT WAYS EXERCISE CAN BOOST YOUR BRAIN

IMPROVE WORKING MEMORY – surfing, running, climbing trees

BOOST CREATIVITY – dance or stroll

DE-STRESS – yoga

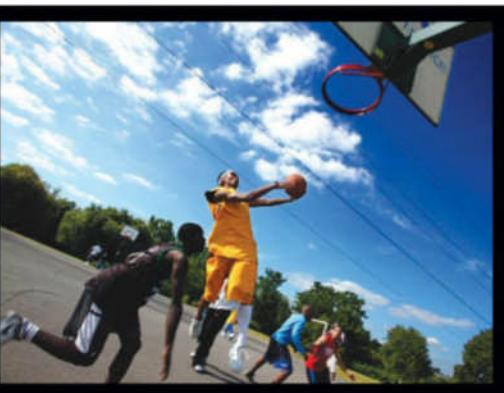
IMMEDIATE ATTENTION – unstructured play

LONG-TERM FOCUS – play sports

KEEP THE BRAIN YOUNG – running, yoga

CURB CRAVINGS – interval sprints

PROBLEM-SOLVING – lifting weights



XAVIER ZIMBARDO/GETTY

KNOW IT ALL

It's never too late to learn something new, but what's the best way to go about it, wonders Emma Young

EVEN when school exams are just a distant memory, our thirst for knowledge goes on. Whether we are after a new skill or fluency in another language, want to play a musical instrument or explore a new passion, we are lifelong learners. Even if we simply need to bone up on trivia to win the pub quiz or impress someone we fancy, our need to know is never-ending. So you would think we'd have learning down to a fine art. In fact, some of the most common techniques are pretty useless (see "What doesn't work", page 14). But the good news is we can share some of the secrets of successful learning, and no matter what your age or ability, they can work for you.





01

KNOW WHEN TO LEARN

Older adults have morning brains. A study on a group of people aged between 60 and 82 at the Rotman Research Institute at Baycrest Health Sciences in Toronto, Canada, found they were better able to focus and ignore distractions, and did better at memory tests, between 8.30 am and 10.30 am than between 1 pm and 5 pm. In fact, fMRI scans revealed that in the afternoon, these people's brains were "idling" – they had switched to the so-called default mode, associated with daydreaming. In younger adults, by contrast, areas related to the control of attention were still very active right into the afternoon.

However, to get the most from their efforts, younger people can time their learning, too. Another study found that 16 and 17-year-old girls performed better on tests of factual memory if they studied the material at 3 pm rather than at 9 pm, but acquired skills involving movements faster if they practised in the evening. "The results suggest it might be better to use the afternoon for studying languages, and the late evening for playing piano or another musical instrument," says Christoph Nissen at the University of Freiburg in Germany.

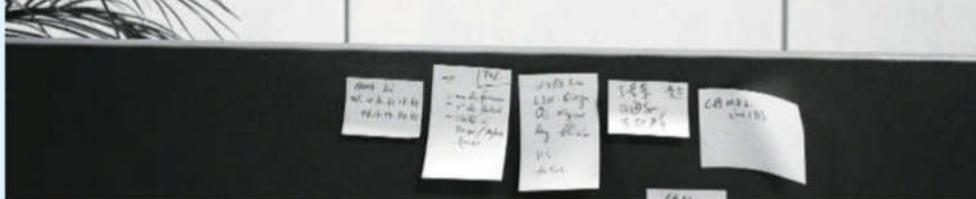
Why should timing matter? We know that sleeping after learning a new fact or skill helps consolidate memories. Nissen suspects that the "critical window" between learning and sleep is shorter for movement-related learning than for other types of memory. Whether adults can benefit as much as teenagers from these windows isn't clear. "There is evidence that adolescents have a higher capacity to learn – and they sleep better," he says. ➤



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02

QUIZ YOURSELF

In a landmark study on the importance of self-testing, Jeffrey Karpicke at Purdue University in West Lafayette, Indiana asked students to learn the meaning of 40 Swahili words (see "Swahili 101", right). Those who had to repeatedly recall these words during the training session scored an average of 80 per cent in a test a week later, while those who just studied the words without actively testing themselves scored an average of just 36 per cent. Other work since then backs up the idea that self-testing is more effective than some other common learning strategies, such as drawing bubble diagrams to represent ideas in a passage of text.

If that sounds like too much hard work, take heart. Nate Kornell at Williams College in Williamstown, Massachusetts, and his colleagues have found that what matters is trying to retrieve the information you are learning, rather than succeeding. Being given the correct answer seems, counter-intuitively, to be as big a boost to later performance as remembering it by yourself.

"This finding was quite surprising," says Kornell. "Memory researchers have long assumed that there are 'paths' in memory from the question to the answer and - here's the part that appears to be wrong - that you learn more by travelling your own path than by travelling part way, or the wrong way, and then being told the answer." His finding suggests we may have to rethink how memory works. But it also offers hope to lackadaisical learners everywhere.

03

LEARN WITHOUT LEARNING

It sounds too good to be true, but learning needn't be hard work. You can even do it when your mind is on something else.

Beverly Wright at Northwestern University in Evanston, Illinois, asked one group of volunteers to practise distinguishing between sounds of a very similar frequency. Another group spent half the time in active practice, and the other half just hearing the sounds in the background while they performed a written task. Both groups scored about the same on a final test – but only if the passive learning happened within 15 minutes of the active session; the effect vanished entirely if the delay was longer than 4 hours.

What might be happening? Wright thinks active training puts the neural circuitry involved in a particular task into a state conducive to learning, and that this state continues for some time after the training ends. While it lasts, similar stimulations to those that were being learned will be processed by the brain "as though they are occurring during active training", she says.

So far, Wright and her team have investigated only the learning of a skill rather than facts or events. But Lynn Hasher at the University of Toronto, Canada, and colleagues have found that a spell of passive learning following active study can also help older adults learn a list of words. The volunteers in her study reported that during the passive phase, they didn't even notice that the words were being repeated.

If you want to give it a try, take note: passive learning is more effective while you are doing something relatively undemanding. So you might want to listen to foreign vocab as you get the dinner ready, rather than while writing emails.

04

USE DISTRACTIONS

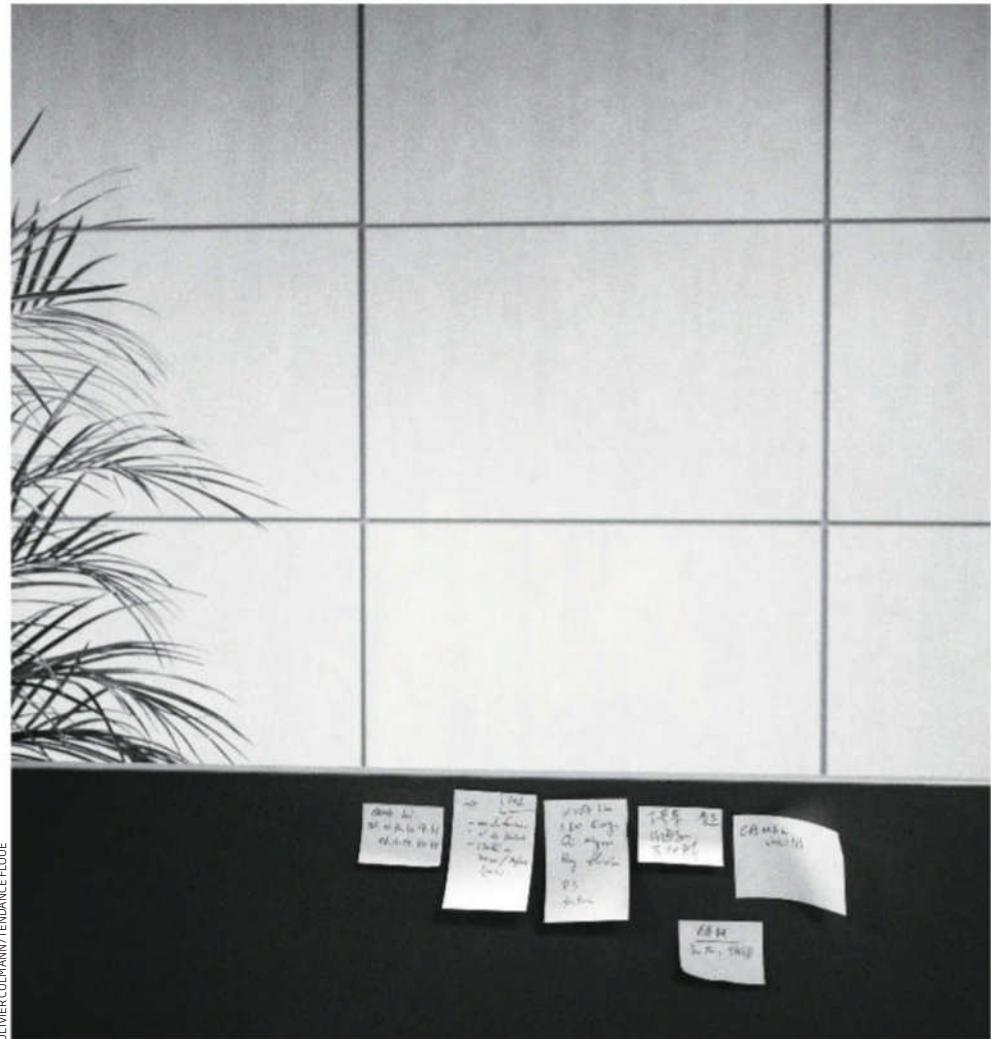
Find your attention wandering? Use this to your advantage. "People have an underlying assumption that divided attention is bad," says Joo-Hyun Song at Brown University in Providence, Rhode Island. It's true that if you frequently break off from studying to send a text message or to focus on a tune on your headphones, odds are you won't learn as well as you would in uninterrupted silence. "But learning has a later, skill-retrieval part," she adds. "People hadn't studied the role of divided attention in memory recall later." Doing just that, Song found that distraction while learning can be beneficial – if you are also going to be distracted when you have to use what you have learned.

It is common knowledge that context can boost learning. If you study a list of words while smelling vanilla, for example, you will probably remember more of them if the scent of vanilla is in the air during recall. Song found that divided attention can itself act as a powerful context. In her studies, people who were distracted during learning and recall performed just as well as those who weren't distracted on either occasion, and better than people who were distracted in only one situation. It didn't matter whether or not the distractions were the same on both occasions, but the degree of distraction had to be similar. Intriguingly, Song also found that divided attention was a more powerful learning aid than environmental contexts such as a smell.

There are important implications, she says. "In training, people should consider where they will actually acquire and use their skills." If you are going to have to remember what you have learned in an environment where you are likely to feel distracted – in a packed foreign city or a noisy pub on quiz night – you would actually do better to have distractions while you are learning.

WHAT DOESN'T WORK

These common methods to boost learning are surprisingly useless



OLIVER CULMANN/TENDANCE FLOU

05

BUDDY UP

While solo studying is important, thrashing out difficult material with other people can pay dividends. Saundra McGuire at Louisiana State University, and Nobel prizewinner Roald Hoffman recommend you alternate group work with study time by yourself. Specifically, once you have tried to go it alone, you can benefit from the collective wisdom of a small study group of three to six people.

McGuire and Hoffman say that study

groups need two key elements to promote "meaningful learning": discussion and problem-solving activities. If group members make up quizzes for each other, this can help them prepare for tests. However, after discussing the material, clarifying anything you are confused about, and using the opportunity to mock-test each other, you should then go back and work on the problems and get ready for any exams on your own, they say. ➤

SWAHILI 101

Quizzing yourself while learning these Swahili words will dramatically improve your recall of them

adhama	honour
adui	enemy
buu	maggot
chakula	food
dafina	treasure
elimu	science
fagio	broom
farasi	horse
fununu	rumour
goti	knee
kaputula	shorts
ndoo	bucket
pombe	beer
sumu	poison
tabibu	doctor
theluji	snow
tumbili	monkey
usingizi	sleep
yai	egg
ziwa	lake



06

PLAY VIDEO GAMES

This may come as a pleasant surprise to the parents of teenage gamers. Gaming is the ideal downtime activity if you are learning to type or play a new sport or instrument – anything, in fact, that involves a fairly constant and predictable structure and requires the coordination of sensory input and physical movements. Just make sure it's action video games you play.

A team led by Jay Pratt at the University of Toronto, Canada, found that people who played action video games, such as *Call of Duty*, for at least 6 to 8 hours a week were faster at learning a lab-based task that involved hand-eye coordination. They weren't any better at the start, they just improved more quickly. Pratt thinks this is because gaming speeds up a person's ability to form accurate brain "templates" for hand-eye-coordinated action. "Action games, which have harder levels as the game progresses, place a lot of demands on the visual, cognitive and sensorimotor systems to constantly improve the efficiency of all these systems," he says. This is why they are more likely to have an effect on other sensorimotor tasks than something like *The Sims*.

It's hard to be sure what difference regular gaming would have on performance in the real world, since there are so many variables, Pratt concedes. "But if one is in a new job that requires a high level of sensorimotor skill, say, then playing several hours of action video games each week could be a worthwhile investment."

07

CHILL OUT

If sleep consolidates memories, would taking a break from studying have a similar effect? To find out, Lila Davachi at New York University scanned people's brains while they looked at a series of images, then asked them to think about whatever they wanted. During this rest period, there was increased activity in the hippocampus (involved in memory) and "thinking" regions in the cortex. What's more, the greater the activity in both regions, the better an individual remembered the images they had seen when tested later. Davachi thinks her work shows the consolidation of memories during rest.

If you have just studied a list of vocabulary or perhaps tried to memorise some key historical dates, then taking a proper break afterwards should help you to remember this information, she says. "This is something we don't appreciate much, especially when today's information technologies keep us working round the clock."

But what counts as a "proper break"? Davachi has been working on this too. What she has found, is that a rest can help consolidate memories as long as it activates different populations of neurons in the brain, or whole brain regions, from those that were active during the learning period. So if you have just put in some hard mental study, going off to practise your tennis backhand should do the trick. Having said that, a little lie-down might seem more tempting and may be even more productive. We still don't know the relative benefits of chilling versus taking a nap, when it comes to learning.

08

PRETEND TO TEACH

You are likely to remember something better if you think you might have to teach it later. Kornell discovered this when he gave students at Williams College 10 minutes to study a 1500-word passage about *The Charge of the Light Brigade*. Those who were told beforehand that they would have to pass on what they had learned to someone else later remembered more points from the text, and their memories were better organised, than those who thought they were simply going to be tested on the text.

Better yet, independent learners can trick themselves into reaping the benefits of this insight. "Our research shows that pretending



➤ KEYWORD MNEMONICS

✖ COPYING YOUR NOTES

✖ ELABORATE MENTAL IMAGERY



09

10

DO INTERVAL TRAINING

that you'll have to teach will help you learn in the same way," says Kornell. And if you actually then do the teaching, all the better. There are many well-known cognitive benefits to asking yourself whether you can recast what you are learning in your own words, he adds. "It leads to active retrieval from memory, and helps with organising one's thoughts as well as identifying knowledge gaps that one needs to fill." Kornell and his team note that teachers often instruct their students to prepare for a test, but this doesn't encourage them to pick the learning strategy that should ultimately lead to a better score.

You've just learned a series of brilliant chess openings, so when should you go back and revise them to maximise your chances of actually remembering them when it counts? "The longer you wait the better," says Kornell. "There are limits on how long you should wait, but they are very, very long." It's true that waiting makes it harder to remember the information when you come back and test yourself, so it makes your life difficult and can feel like a bad thing. "But the harder it is, the more you learn. So when you need the information later, for example, when actually piloting that airplane or playing that chess match, you'll do better," Kornell says.

Refining this idea, Hal Pashler at the University of California, San Diego, and his team recommend spacing the intervals between revisions as a proportion of the time between initial learning and when you want to remember the information. They have discovered that the best interval to use depends on how long you want to remember something for. To maximise recall a week later, you should revise the info about two to three days after learning. "If you want to remember for a long time, it's good to have quite a lot of spacing, maybe at 10 per cent of the time," says Pashler. So if you need to recall something in a year, revise it about a month after learning and then monthly thereafter. To remember something for 10 years, you should ideally review it once a year. No one knows what brain mechanisms underpin this. But having long gaps between learning, revision and retrieval might tell your brain that this is knowledge you will probably need in the long term, he says.

Pashler's team is now trying to develop practical learning tools, based on the research. They have developed an algorithm that can generate personalised study spacing plans. The formula uses measures of how difficult the material is and how well a particular student is performing based on early test results. In one study of people learning Spanish, the team found that individualised plans improved retention at the end of the semester by 16.5 per cent, compared with 10 per cent for a one-size-fits-all spacing plan.

JUST DO IT

All is not lost – if you do find it hard to sit down and study, and you do badly in an exam or a performance as a result, don't beat yourself up about it.

Michael Wohl at Carleton University in Ottawa, Canada, and colleagues found that students who had forgiven themselves for procrastinating before an initial set of exams performed better in the next set and procrastinated less than students who hadn't. They also said they felt more positive.

Wohl thinks self-forgiveness allows us to shrug off negative feelings about ourselves, so helping to improve our performance in future. However, he stresses that this doesn't work for serial procrastinators. "We've found that self-forgiveness for chronic, unhealthy behaviour can help maintain the status quo – that is, continued unhealthy or poor behaviour."

If this sounds like you, you may need to take more drastic action. Learning requires willpower – self-control in the moment. Willpower is like a muscle, argues Roy Baumeister at Florida State University, so the more you use it, the stronger it gets. What's more, he has found that by exercising willpower in one area, you can boost it in another. By making an effort to do anything from keeping your house tidier to sitting up straight instead of slouching, you should also enhance your ability to just sit down and study or practise. What are you waiting for? Why not start right now? ■



AGERY

PERSONALISED LEARNING STYLES

SUMMARISING THE MATERIAL

The power of your mind

Our brains have hidden depths. Whether it's psychological tricks that change our behaviours or the healing power of hypnosis, our minds are surprisingly open to manipulations that can change us for the better, finds Dan Jones

DURING the second world war, the US government found itself wrestling with a meaty problem. It was trying to encourage citizens to eat offal so that better cuts of meat could be shipped to the troops abroad. But the message wasn't getting through.

So the government recruited some serious brainpower: renowned anthropologist Margaret Mead and the father of social psychology, Kurt Lewin. Instead of telling people that eating offal was a patriotic duty, Mead and Lewin tried to understand their psychological resistance to eating it in the first place. They found that offal was stigmatised as the food of the poor, and also that people were unsure how to cook it. So they launched a campaign to rebrand offal "variety meat" and teach the public how to prepare it. As more people experimented with it, offal lost its stigma and became a dietary mainstay.

It may sound like a straightforward marketing campaign, but for today's psychologists the initiative has gained near-legendary status. Many cite it as a forerunner to something they call "wise psychological interventions" – apparently simple actions that produce long-lasting changes in behaviour.

Psychologists now believe that WPIs could be the solution to all sorts of problems, from educational

underachievement to obesity. Over the past few years they have been quietly assembling a toolkit, and could soon be trying them out on us all.

At the heart of WPIs is the idea of "mental unblocking" – removing psychological barriers that keep people stuck in damaging patterns of behaviour. Simplistic though this may seem, it is actually surprisingly hard to achieve. "Some people think that if it's just about psychology, people should be able to do it for themselves," says Greg Walton, a psychologist at Stanford University in California. "But it's not that easy." Just because it would be beneficial for you to unthink something doesn't mean you can just do it, he says. That is where wise interventions come in.

The use of psychology to make us better people may sound familiar. Superficially WPIs are a lot like "nudges" – external interventions designed to guide people towards better choices. That might mean placing fruit at eye level in a canteen, for example, or making people opt out of a pension scheme rather than opt in.

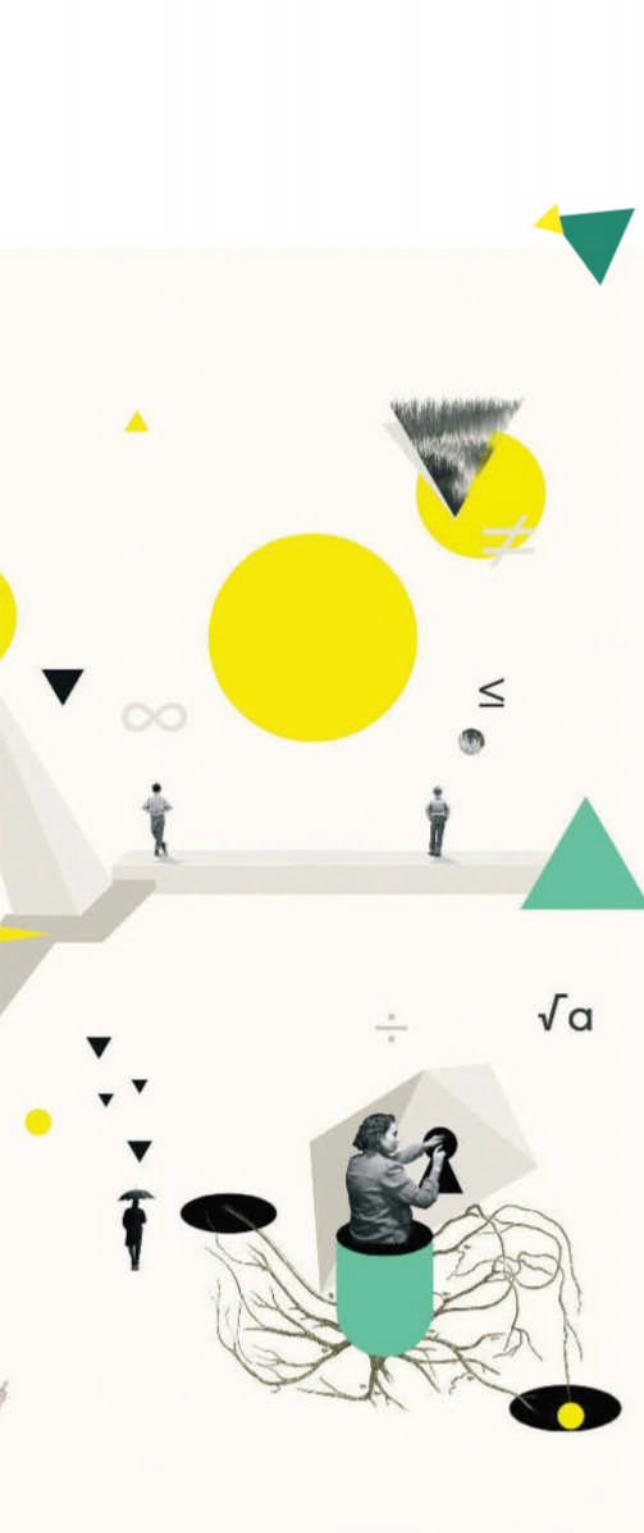
However, wise interventions are different in a number of ways. Nudges are usually specific to a given choice at a given time, whereas WPIs aim to alter behaviour in a lasting way. More significantly, nudges tend to rely on

NATALIE NICKLIN

environmental cues, whereas WPIs are rooted in theories about basic human psychology.

Another early demonstration of their potential was provided by Timothy Wilson of the University of Virginia in Charlottesville. Back in 1982, he was trying to find a way to help new college students cope better with worries about their academic performance. Wilson's solution was inspired by attribution theory, which describes





"Our capacity often is unrealised as we are not in a position to take advantage"

how people account for events – say, whether they blame failures and setbacks on enduring facts about themselves, or on external factors.

When people look inward for the causes of their problems, it can puncture self-esteem and create a barrier to solving them. Wilson wondered whether getting students to attribute their struggles to their current situation, rather than facts about themselves, would unblock them. So he presented them with statistics showing that the majority of new students start with disappointing grades but do better over time. He also showed them videos of older students talking about their improving academic performance. Wilson found that the group's grades got better more quickly than those of students who did not receive these messages. They were also less likely to have dropped out by the end of the second year.

For a long time, this remained an isolated success. "Tim did this amazing study in the early 80s, then everybody forgot about it," says Dave Yeager of the University of Texas at Austin. "No one was doing field experiments." Instead, researchers focused on the basic psychological processes that govern our behaviour – work which laid the foundation for today's WPI research.

Some of the most influential work was done by Stanford psychologist Carol Dweck. Since the 1970s, she has been studying what drives people to persist in the face of difficulties. She found that much depends on whether people have what she calls a "fixed" or a "growth" mindset – that is, whether they see their abilities and personality as set in stone, or malleable. When people with a fixed mindset encounter challenges such as a difficult maths puzzle, they often conclude that they have reached the limit of their abilities and give up. "But if you think, 'hey, intelligence and skill can develop', then your whole attitude changes," says Dweck. "You want to take on the challenges that help you grow."

In other words, a fixed mindset is a mental block that stops us from

achieving something. And it can be reinforced or removed. Dweck's work also showed that praising successful children for being bright or talented nurtures the fixed mindset, whereas focusing on their hard work and perseverance fosters a growth mindset.

During the 2000s, Dweck began to explore whether promoting a growth mindset might help kids in school. In an influential 2007 study, she tested this idea among low-achieving 12 and 13-year-olds. Half of them were told about how the brain changes and learns, and how intelligence can be boosted; the rest learned about the brain, too, but with the emphasis on memory.

It worked. The "growth" group showed increased motivation in class and got better test scores. Significantly, those who endorsed a fixed mindset most strongly beforehand benefited the most.

Fixed and growth mindsets are now a common starting point for WPIs. For example, Yeager has applied them to bullying – not so much to stop the bullies, but to help victims cope better.

Growth mindset

Understandably, bullied kids often retaliate aggressively. In studies of students aged 10 to 14, Yeager showed that an intervention similar to Dweck's, in which kids learned about how the brain and personality change over time, reduced aggressive retaliation. "By teaching teenagers that people can change, it makes them feel less like they need to escalate things if they're bullied," says Yeager.

Another type of WPI has been pioneered by Stanford psychologist Geoffrey Cohen, this time aimed at reducing the achievement gap between white and black university students. Many social and economic factors underlie this gap, but there is also a powerful psychological driver: the stereotype that black people are less academically able than their white peers. For black students this can become a self-fulfilling prophecy:

WHY 'WISE'?

The name "wise psychological interventions" harks back to the "wise schooling" movement of the 1990s, which tried to be sensitive to racial diversity. That name, in turn, was derived from gay culture of the 1950s, which used "wise" to describe somebody who recognised the full humanity of gay people despite the widespread homophobia of the time.



"If you think, 'hey, intelligence and skill can develop', your whole attitude changes"

they often do worse on maths tests when surrounded by white students. This has been attributed to "stereotype threat", which creates anxiety and harms performance. (White students often underperform in the presence of East Asians, who are often stereotyped as maths whizzes.)

Cohen set out to design an intervention to close the gap. One proven strategy against stereotype threat is to get people to write about values that are important to them, a process called self-affirmation. When Cohen asked middle-school students to do this, he found that even a short session improved the grades of black students relative to controls, closing the achievement gap by 40 per cent. And two years later, after a few top-up sessions, the intervention was still having a clear effect. Cohen later applied the same approach to the achievement gap between men and women in university science courses.

Yet another kind of intervention boosts the sense of social belonging. When people go through big transitions in life – going to university, say, or moving to a new city – there's often a period when they are not sure they fit in. Members of minority groups are

especially vulnerable.

Cohen and Walton got first-year students to read a report summarising a survey of older students' experiences at university. The report described how they felt out of place at first, and how these feelings passed as they settled in and made new friends. Reading it not only improved the grades of black students, halving the racial achievement gap, but also increased their self-reported happiness and health. Remarkably, these effects persisted three years on, and much larger studies have replicated them.

All of this is evidence that WPIs offer a new and powerful way to approach difficult social problems, Walton says. "We typically approach such problems with the assumption that there's a lack of capacity, and we try to bolster that capacity. So we might think, schools are failing, we need to invest more in schools. But in many situations we actually have adequate capacity. And yet that capacity goes unrealised, as people are psychologically not in a position to take advantage."

Although many WPIs focus on academic performance, there have been experiments in applying them to criminality, teenage pregnancy,

relationship problems – even international conflict. Eran Halperin of the Interdisciplinary Center in Herzliya, Israel, has developed WPIs to reduce tensions in the Israeli-Palestinian conflict. He has shown that nurturing a growth mindset makes people on both sides more open to listening, more willing to compromise for peace, and more likely to forgive.

Not surprisingly, WPIs have attracted attention outside academia. In the UK, the Behavioural Insights Team (BIT) – a partly government-owned firm sometimes dubbed the "Nudge Unit" – is exploring their potential. "Nudges have been very successful in a number of areas," says Jessica Barnes, a senior adviser at BIT, "but we recognise there are a lot of complex issues that nudges are not necessarily going to address, so we're also interested in more intensive psychological interventions."

In September 2015, then US president Barack Obama launched the US Social and Behavioral Sciences Team, to explore ways to use nudges and WPIs. Similar units have been set up in Germany, Australia, Singapore, Finland and the Netherlands.

So when can you expect to be wised up? Even advocates of intervention admit that some questions need to be answered before WPIs can be widely rolled out. For starters, we need to know how easy they are to scale up so that it's not just a select few that can benefit. Early research suggests that WPIs delivered as online modules can reach a mass audience, but it's early days yet.

Researchers are also keen to avoid the hype and controversy that has surrounded nudges. They are at pains to point out that WPIs are not magic, and cannot help all the people all the time. "They address specific psychological sticking points, and if a person isn't stuck, then the intervention isn't necessary," says Yeager.

These caveats aside, psychologists are increasingly optimistic that WPIs can tackle any problem with a psychological component – in other words, nearly every significant social or personal challenge you can think of. "There are many problems that people have struggled with for generations," says Walton. "This is a new way to approach them." ■



YOU CAN HEAL YOURSELF WITH HYPNOSIS

We all hypnotise ourselves every day. Do it right and we could change healthcare, says Laurence Sugarman

You believe hypnosis can transform healthcare. How so?

Many problems we bring to our doctors have a psychophysiological component: irritable bowel syndrome, recurrent migraines, anxiety symptoms. And we know that people can somehow keep powerful medications from being effective.

Clinical hypnosis is about educating the patient to be a better boss of their body and mind. That is improving care.

So, what is hypnosis and how do you think it works?

My colleagues and I propose that hypnosis is simply a skill set for influencing people. It involves facial expression, language, body movement, tone of voice, intensity, metaphor, understanding how people interpret and represent things. It isn't something you're in, or that you do: hypnosis is something you use. It's not a therapy, it's a means to therapy.

In strategies like psychoanalysis or cognitive behavioural therapy (CBT), the most therapeutic influence tends to be the act of being heard. The skills that facilitate that are part and parcel of the influence of hypnosis.

Where does the hypnotic trance fit?

Trance is a process of intense learning. It happens when we change our minds in significant ways, when we become neuroplastic; we are thoughtful, we pause, change our breathing. There is a shift in the parasympathetic part of the autonomic nervous system – an intensified focus of attention and narrowed peripheral awareness. Trance happens when we are traumatised, and when we fall in love. There's no such thing as "hypnotic trance" as distinct from the trance of yoga or of prayer, for example. But part of the skill set of



PROFILE

Laurence Sugarman directs the Center for Applied Psychophysiology and Self-regulation at Rochester Institute of Technology in New York. He is a former president of the American Board of Medical Hypnosis and on the faculty of the National Pediatric Hypnosis Training Institute

hypnosis is recognising and facilitating trance, because it makes whatever you're learning more effective.

The popular conception of hypnosis is quite wide of the mark, then?

Hypnosis is widely attributed to the power of the hypnotist. Everything from the evil fictional character of Svengali to movies and the occult has contributed to this mistaken notion that somebody else can control our physiology – our minds. And certainly, entertainers who claim to use hypnosis can and do play on that myth.

People can be influenced into cults and violent religious movements, be depersonalised and become victims of abuse. If I have poor self-esteem and self-efficacy, I may let people use hypnosis to "overpower" me. But ultimately the power to change lies with the person who, as we say, "owns the trance". It still takes two to tango.

You're a medical doctor. How did hypnosis ever enter your radar?

I spent 20 years as a solo primary care paediatrician, and I was struck by how inadequate my training was for the behavioural and psychophysiological issues I encountered. All of my training was only to *do* things to help kids, whereas I saw a clear need to better help kids help themselves. This got me interested in hypnosis.

What convinced you it could make a difference?

I saw a little girl who was 8. She had a serious disease and needed an injection every week. Each time it was a very difficult process because she was so anxious and traumatised from illness and long hospitalisations.

I said, "I know it's scary to come here, I bet you would rather be somewhere

else." She was sitting on her mother's lap with her eyes closed. She said, "I would rather be home playing with my kittens." So I said, "Go play with your kittens, how do they feel, what do they sound like, how do they smell?" I kept talking her through and saying less and less and letting her fill in more and more. After it was done, she looked up and said, "Where's the shot?"

Now, do I think she really didn't know she got a shot? I think part of her knew, but part of her wanted the hypnosis to work, so she made it work.

How is hypnosis different from things like mindfulness meditation?

I may offend lots of people by saying that mindfulness meditation is an example of hypnosis – but it's what I think. In the West, it is used as a therapy to practise coping or decreasing stress. It can be really helpful when someone is sick and tired of having thoughts overtake them and needs to practise dropping out of them, for instance. But that's where it stops. It doesn't direct change. I think a lot more can be done.

How well can we tell whether hypnosis makes a therapy more effective?

One meta-analysis found that, of patients being treated for obesity, those receiving CBT with hypnosis had better results, even after long-term follow up, than those just receiving CBT. That is impressive because, the hypnosis aside, the therapy was so similar. A study of CBT for depression also showed more benefit for the hypnosis group. I expect more studies of this type.

Can we use hypnosis on ourselves?

We use it all the time. Most of our self-hypnosis is not very nice. Most of it is: "I suck at that, I'm not a very nice person, I'm lazy, I deserve this abuse, every time I do that I'm going to get a headache." If trance is this intense learning process, we use a lot of that plasticity to reinforce our ruts.

Clinical hypnosis is a way of helping somebody change their self-hypnosis, to understand what trance-formation looks and feels like, and use both the novelty and intensity of conversation to teach them to do their own trance.

Interview by Shanon Fischer

A blueberry a day...

Do “superfoods” have miraculous health-giving properties, or are they a rotten swindle? We are certainly swallowing the hype. In a recent survey of more than 1000 UK adults, 61 per cent admitted to buying a food because they considered it a superfood. Thirty per cent agreed that “superfoods are scientifically proven to have health benefits” and 14 per cent said they were willing to pay more as a result. Are we being ripped off?

Caroline Williams chews on the evidence



DESIGNPICS/INCRE/SHUTTERSTOCK

SUPERFOOD VS FOOD

When it comes to delivering the active ingredients thought to do you good, how do so-called **superfoods** stack up against ordinary fare? We compare 100-gram portions.

For nitrates, which can help lower blood pressure...

Beetroot 146mg

vs

Rocket

260mg



SOURCE: BRITISH JOURNAL OF CLINICAL PHARMACOLOGY, VOL 75, P 677

For Omega 3 fatty acids, good for a healthy heart...

This comparison is based on the amount of eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) your body gets (see page 30)

Chia seeds

1.8g



vs

Farmed Atlantic salmon

2.3g



SOURCE: USDA SR28

For glucosinolates, which may lower the risk of cancer...

Curly kale

100mg



vs

Brussels sprouts

236mg



SOURCE: BRITISH JOURNAL OF NUTRITION, VOL 90, P 687

KALE

Blended in smoothies, baked into crisps, blanched or raw in salads: once dowdy kale has become fashionable. Its main selling point is a family of sulphur-containing plant chemicals called glucosinolates that give all dark-green vegetables their characteristic bitter taste.

Glucosinolates are broken down in the gut to release glucose and isothiocyanates, which have been shown to stimulate enzymes whose job it is to eliminate cancer-causing chemicals. This much has been shown in animal research and it is supported by studies linking higher consumption of glucosinolate-rich brassicas

to a lowered risk of cancer in humans, particularly that of the gut and lungs.

Given that all brassicas contain similar stuff in similar amounts, however, kale is no better than white cabbage or Brussels sprouts. One analysis revealed that several varieties of cabbage contain as many glucosinolates as kale.

What's more, there are more than 100 different glucosinolates, and each gets broken down into a different isothiocyanate, so it is probably best to munch all kinds of brassicas. Be warned, though: boiling reduces glucosinolate content, so the crunchier the better.

VERDICT: Super, but no more than other types of cabbage.

GOJI BERRIES

Long revered in Chinese medicine, goji berries are said to pep your immunity, boost libido and more. What little research there is on them tends to focus on a group of chemicals called "*Lycium barbarum* polysaccharides", or LBPs. According to one review, they stop tumour growth, regulate blood sugar, protect eye and liver cells from free-radical damage and improve sperm motility. Yet it's not clear what LBPs are. Polysaccharides are long-chain carbohydrates, but in the goji berry literature, LBPs appear to include carbohydrate chains linked to proteins - which are not typically considered polysaccharides. What's more, there are no rigorous human trials measuring which components get into the bloodstream and what they do. So even if studies of LBP extracts turn out to be reliable, their relevance to you is far from clear.

The other big claim is that goji berries contain high levels of zeaxanthin, a compound linked to the prevention of age-related degeneration in eye cells. Catherine Collins, a dietitian at St George's Hospital in London, is not convinced. "Other foods that will have exactly the same effects are far cheaper," she says. If it's zeaxanthin you're after, you can get your fill from spinach, cabbage or yellow peppers. And although goji berries do contain more vitamin C than blueberries, you get roughly the same amount from strawberries or lemons.

VERDICT: Just a berry.

BLUEBERRIES

The blueberry is prized primarily for its ability to lower the risk of cardiovascular diseases. A 2012 study of 93,000 women, for instance, showed that participants who ate three or more portions of blueberries and strawberries a week had a 32 per cent lower risk of a heart attack than those who chomped berries once a month or less. The berries can't take all the credit, but the evidence is promising.

Such benefits are typically attributed to a compound called anthocyanin, part of a family of plant chemicals called flavonoids, found in particularly high levels in blueberries and red berries such as strawberries and raspberries. Alas, there's a catch: hardly any of the anthocyanins in berries get into the bloodstream, says

Gordon McDougall of the James Hutton Institute in Dundee, UK.

So the idea that blueberries flood your body with righteous compounds that roam around mopping up cell-slaughtering free radicals doesn't quite stack up. It's possible that it is not the anthocyanins that protect your heart, but the chemicals they are broken down into. These get into the bloodstream in far higher quantities than the original compounds, says McDougall.

There could be other explanations. Maybe some other component stimulates your own free-radical defences. Or perhaps anthocyanins act as benevolent gardeners for your colon microbiome, nudging it towards a healthier mix.

VERDICT: Super, though no better than many other berries.



CHOCOLATE

Everyone wants chocolate to be virtuous, but the evidence is flaky. The most commonly heard health claims centre on chemicals called flavanols, found in cocoa beans. Studies with cell cultures and rats have shown that cocoa flavanols increase production of nitric acid, a precursor to nitric oxides, which are known to relax blood vessels and regulate blood pressure. Human studies, on the other hand, have produced conflicting results.

A solid-looking 2012 review concluded that flavanol-rich chocolate, meaning the dark and bitter stuff, may slightly reduce blood pressure in the short term. But we don't know if the effects last. Duane Mellor at

the University of Canberra in Australia, who has spent years researching the health benefits of cocoa flavanols, is cautious. "We've got some statistical significance," he says. "Whether it is actual clinical significance, I'm not convinced."

The promise of cardiovascular benefits from chocolate has to be weighed against the fact that to make it, manufacturers tend to combine cocoa with large portions of sugar and fat. That's not to say that chocolate, especially the cocoa-rich stuff, is something you should avoid or feel guilty about - just don't think you can gorge on it as shortcut to keeping your blood pressure down.

VERDICT: Fine occasionally, but no health reason to gorge.



CHIA SEED

The ancient Maya used chia seeds for thousands of years to make everything from flour for tortillas to tea. Now they are a trendy superfood, often said to be a great source of omega 3s - fatty acids thought to reduce the risk of cardiovascular disease and depression.

Chia seeds contain roughly 17 grams of omega 3s per 100-gram serving. At first glance, compared with oily fish, that looks impressive: a 100-gram portion of farmed Atlantic salmon gives you 2.2 grams of omega 3s. Unlike salmon, however, the fatty acids in chia seeds come as alpha linolenic acid (ALA), which the body has to convert to eicosapentaenoic acid (EPA) and docosahexaenoic acid (DHA) to get the cardiovascular health benefits.

We don't do this conversion very well. It varies, but the median efficiency is 10 per cent, so the amount of EPA and DHA you get from 100 grams of chia seeds drops to 1.7 grams, fewer than from salmon. You also have to consider that to convert ALA, your body has to digest the seeds to extract the fats - and we all know that some seeds pass straight through.

For omega 3s, then, it might be better to smash up your chia seeds in a smoothie. Then again, if you're after soluble fibre to mop up bad cholesterol, whole seeds are the way to go. Two tablespoons provides around 30 per cent of your daily intake. So with chia seeds you can have your fibre and eat your omega 3s - just not necessarily in the same serving.

VERDICT: Good, but oily fish packs more omega 3s.

KIMCHI AND KEFIR

Kimchi is a Korean side dish made of fermented cabbage; kefir is a fermented milk drink from the Caucasus mountains in eastern Europe. These and other fermented foods have been around for centuries, only to suddenly receive acclaim as microbiome-balancing paragons of dietary virtue.

Some of their powers are put down to the fermentation process, in which bacteria partially digest the food, releasing a greater hit of nutrients. Indeed it seems to improve the availability of iron, essential for making red blood cells: one recent study in humans showed greater absorption of iron from fermented mixed vegetables than fresh ones.

The biggest health claim, however, is the supposed effects on your gut microbiome - the billions of bacteria that reside in your intestines, quietly regulating all kinds of bodily functions. The idea is that the fermentation process increases the numbers of beneficial bacteria naturally present in the food and, when you eat it, in your body.

Animal studies suggest that fermented foods might encourage a healthy mix of microbes in the gut. Adding kefir to the diets of mice, for instance, increased the population of beneficial bacteria like *Lactobacillus* and *Bifidobacterium* in their intestines and reduced potentially harmful ones.

However, John Cryan of University College Cork in Ireland, who studies the gut microbiome, urges caution when it comes to the benefits for humans. Fermented foods do look as if they could benefit gut flora, he says, but what this does for your health is not clear. "It's early days," he says.

VERDICT: *May be good for gut bacteria.*

BILL BOCH/GETTY



COCONUT WATER

When it comes to hydration, what could be better than water? The clear liquid tapped from young, green coconuts has been dubbed "nature's sports drink". But two recent studies comparing it with isotonic sports drinks and ordinary water found no difference in terms of how well they hydrated volunteers after vigorous exercise.

The claims for coconut water appear to rest on the idea that its higher potassium levels enhance water absorption. That doesn't stand up: according to another recent study, neither coconut water nor a potassium-rich sports drink scored higher on fluid retention than water. Besides, you shouldn't have any problem absorbing water so long as your diet contains adequate amounts of salt.

VERDICT: *No better than water.*

WHEATGRASS

Fans of the wheatgrass shot, the dark-green juice squeezed from the young shoots of wheat, insist that it will flood your tissues with oxygen. The story goes that chlorophyll, the compound that plants use to make sugars via photosynthesis, is structurally similar to haemoglobin, the protein in red blood cells that carries oxygen around the body. So as there is more chlorophyll in wheatgrass shoots than in other edible plants, you get more oxygen.

It's nonsense. Chlorophyll is found in similar concentrations in many green vegetables. More to the point, there is no evidence to support the idea that chlorophyll functions anything like haemoglobin. Even if it did, it wouldn't get into the bloodstream because chlorophyll gets broken down in the gut.

VERDICT: *Whole shot of nonsense.*



BEETROOT JUICE

No longer just soaked in vinegar and served from a jar, beetroot is now lauded as a blood-pressure lowering, metabolism-revving superfood. The main do-gooders in it are said to be nitrates. They are converted into nitrites by saliva and then pass through the stomach, where they are converted into nitric oxides - compounds that relax blood vessels.

Indeed, studies have shown that dietary nitrate brings down blood pressure and improves circulation. It might even jump-start your gym routine: one study found that a 500-millilitre glug of beetroot juice per day, containing 400 milligrams of nitrate, improves exercise performance, buying people an extra 90 seconds of intense exercise before exhaustion.

Maybe don't overdo it, though. The European Food Safety Authority puts the safe limit for dietary nitrate intake at around 260 mg per day for an average adult - that's equivalent to two whole beets or one 300 ml glass of juice. The main concern is that if nitrites combine with protein in the stomach, they could form nitrosamines, which may contribute to gastric cancers. The link is not proven, and adding vitamin C may prevent the formation of nitrosamines. Even so, Collins says it might be possible to have too much of a good thing. On balance, nitrates are a good addition to your diet and beetroot is a great source. As ever, though, there are plenty of alternatives: lettuce, rocket and other leafy vegetables are perfectly good sources too.

VERDICT: *Good stuff, just don't overdo it.*

The great breakfast myth

We've all been told that eating breakfast is a recipe for good health, but have we been lapping up a load of waffle?
Dara Mohammadi
investigates

ALOT of health advice is hard to swallow. But it can be made more palatable if it tastes like crispy bacon and lightly poached eggs, a buttery croissant or a steaming bowl of porridge... This is perhaps why the idea that breakfast is the most important meal of the day has stuck to our collective subconscious like an egg to an unoiled pan.

The health claims for breakfast are innumerable. It can boost your metabolism, leave you eating more healthily for the rest of the day, plus you'll have more energy and be less likely to put on weight, which is good news for avoiding heart disease and diabetes.

"The problem is that these benefits, although logical sounding, are largely assumptions based on observational studies and had never actually been tested," says James Betts, who studies nutrition and metabolism at the University of Bath, UK. "I was amazed when I started looking for evidence – I thought there would be a lot," he says. What was out there, though, didn't stand up to scrutiny. So he decided to find out for himself.

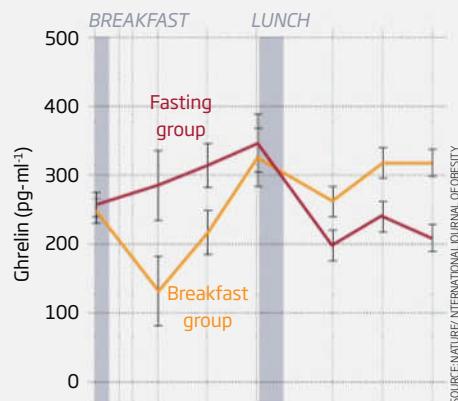
The concept of a healthy breakfast was probably first introduced at the turn of the last century by John Harvey Kellogg to promote his new breakfast cereal (see "The original 'health food'", overleaf). Despite these dubious beginnings, a body of research has since been published to support the idea. Studies show, for instance, that both adults and children who skip breakfast could end up at increased risk of type 2 diabetes. Other work

has found that eating breakfast cereals leads to a healthy BMI in adolescent girls and that teens who skip the meal are more likely to be overweight. So surely eating breakfast amounts to a simple and important public health message?

Not quite. There is one big problem – these and similar findings are based on observational studies, in which investigators watch people going about their normal life, without control groups. This means that other elements of the person's lifestyle – such as regular exercise or getting a good night's sleep – could truly be driving the health ➤

Hunger hormone

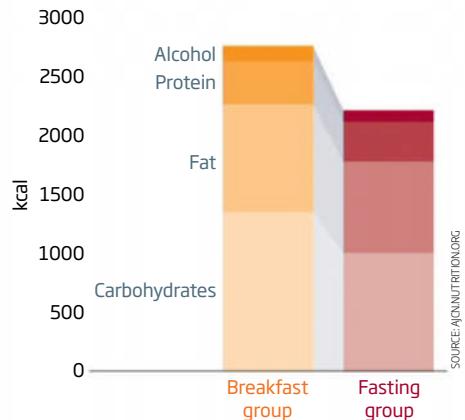
By lunchtime, levels of the hunger hormone ghrelin are similar whether you eat or not



SOURCE: NATURE INTERNATIONAL JOURNAL OF OBESITY

Breakfast binge

Breakfast eaters consume more calories over the whole day, especially in the form of carbohydrates...



effects. So are people healthy because they eat breakfast, or do they eat breakfast because they are healthy?

It's not a trivial matter. Given that so many countries are in the midst of an obesity epidemic, Betts thinks questioning the value of breakfast should ensure advice dished out by doctors is based on solid evidence. "As soon as doctors find out that an overweight patient skips breakfast they'll often tell them to make sure they eat it every day," he says. "But should we not know more about the effects? We try not to give any other health advice without evidence to back it up, so why are we more lax with breakfast?"

To separate the (Shredded) wheat from the chaff and determine what, if any, causal effect breakfast can have on health, Betts and his team decided to conduct a randomised trial. One group ate breakfast, while the other fasted and drank just water until lunch. Those who ate breakfast had to chow down on a whopping 700 calories or more before 11 am. The team then recorded a range of measurements throughout the day – either by monitoring participants in the lab or by having them keep their own records.

First, they looked at daily total consumption. Does breakfast really make people less likely to overeat at lunch or dive into the biscuit tin?

Contrary to accepted wisdom, skipping breakfast had little effect – those who fasted all morning ate more at lunch, but not enough to make up the 700 calorie deficit, which meant that the breakfast group ended up eating a fair bit more over the day (see "Breakfast binge", left). And eating breakfast didn't give people a much-touted metabolic boost either.

Bigger burn

The results also quash the idea that if you skip breakfast you'll be ravenous later on. In the lab the team took blood samples to measure ghrelin, a hunger hormone, and found something unexpected. Levels of the hormone were much the same at lunchtime, irrespective of whether breakfast was on the menu (see "Hunger hormones", page 25). "That might partly explain why those who fasted didn't overeat that much," Betts says. "But the bit that was surprising was that after lunch, ghrelin levels dropped in those who had fasted but stayed high in those who had had breakfast."

Despite some gentle cajoling, Betts refuses to coin the "Augustus Gloop" effect, in which the more somebody is used to eating, the

more they might want to eat later in the day. There's not yet enough evidence, he says. He is more confident about the team's finding that skipping breakfast did not affect fat levels or weight gain, which is corroborated by a much larger 2014 randomised trial. This all suggests that a doctor's advice to start the day with breakfast might be misguided.

So does breakfast have any benefits at all?

"Skipping breakfast does not affect fat levels or weight gain"

It turned out that the breakfast eaters had better control over glucose levels in the afternoon, an advantage that Betts was intrigued by, especially since we know that this is what goes wrong in people with type 2 diabetes.

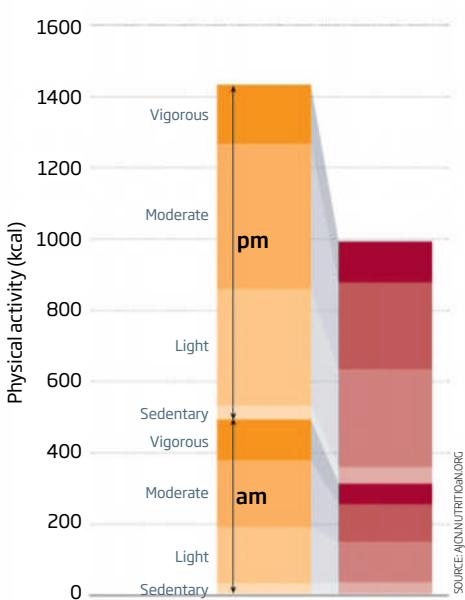
Other work backs up this idea. One study showed that children who ate breakfast every day, especially high-fibre cereal, were at lower risk of developing type 2 diabetes later on in life. "Our work and others' certainly show an association between not eating breakfast and an increased risk of later disease such as type 2 diabetes," says Peter Whincup at St George's, University of London, who led the research.

Even so, Whincup warns against over-interpreting data from these kinds of studies because they are observational and come with the usual caveats. Plus his research was based on asking children to remember what they had eaten, which is prone to errors.

Perhaps the biggest boon of breakfast is that those who indulge, while tending to eat more during the day, manage to burn off those calories later on – an effect that we didn't know about before. In their lab studies, Betts's team used heart rate monitors and accelerometers to measure movement, giving them the edge over past studies based on questionnaires alone. These would have missed lower-intensity activities such as unconscious movement or fidgeting, otherwise known as "non-exercise activity thermogenesis", or NEAT. And even light activity can make a big difference. The team found that calorie expenditure from low-intensity activities was significantly higher in breakfast eaters than in the fasters. They also burned on average several hundred more calories during the morning than their fasting counterparts (see "Bigger breakfast burn", left). Those who fasted just moved around less without thinking about it.

Bigger breakfast burn

...but end up burning more energy than those who fast – in particular through light exercise like fidgeting and walking around



"People who eat breakfast burn off the extra calories without even trying"



PETER MARLOW/MAGNUM

THE ORIGINAL 'HEALTH FOOD'

Breakfast wasn't always about a healthy start, you would just "break the fast" and replenish energy supplies after a long night's sleep. "Historically, if you had a hard day ahead of you doing manual labour on the farm, it made sense to refuel with a good breakfast. The idea of health didn't really come into it," says Louise Dye, professor of nutrition and behaviour at the University of Leeds, UK.

Then came the industrial revolution. Our days became less physical and the need for refuelling less obvious. "It was around the turn of the last century when Dr Kellogg popped up with his cereal, which really revolutionised the idea of breakfast as being healthy," says Kaori O'Connor, a social anthropologist at University College London.

Legend has it that John Harvey Kellogg, a Seventh-Day Adventist, invented his cornflakes because he thought that eating pure, wholesome food would stop people masturbating. That apart, as a doctor he also believed that the common health concerns of the day – digestion and regularity – could be improved by consuming the fibre in his cornflakes, says O'Connor. "Kellogg managed to take these free-floating health anxieties and embody them in a product," she says.

Both the product and the concept were

received very well. "People hadn't really had health food marketed to them before," says O'Connor. For women who had traditionally cooked a large breakfast for their family it was a godsend – the fact that it was healthier for their families took the guilt away from buying breakfast in a box. "It was such a successful marketing vehicle that others piggy-backed on to it."

Other staples of our breakfast routine, including orange juice and coffee, followed. The popularity of bacon for breakfast was allegedly the brainchild of Edward Bernays, the self-styled grandfather of public relations. In the 1920s, he was commissioned by the US pork industry to boost bacon sales. Bernays surveyed medical doctors and asked them one question: is a hearty breakfast preferable? The resounding answer was yes, presumably, says Dye, as a relic of the ideas of breakfast and refuelling from bygone agricultural days. Bernays used this fact in marketing campaigns and the popularity of bacon and eggs went through the roof.

"Let's not trash the benefits of breakfast all together," says O'Connor, "but it's safe to say that the idea that it is healthy in its own right was laid on a plate for us by marketing companies. And, by and large, we've gobbled it up."

Too excited about breakfast to sit down at the table

"It makes sense from an evolutionary perspective," Betts says. "Our bodies are strongly evolved to defend against weight loss, so if you've eaten fewer calories your body might compensate by doing less."

This adds another level of sophistication to our breakfast decision-making. We should chew over the idea every morning rather than unthinkingly reaching for the porridge – there might indeed be good reason to skip it, especially if you're stuck in a plane or conference all day without much chance to move.

Breakfast brain boost

But even if breakfast's reputation as the most important meal of the day is no longer secure, we shouldn't lay down our knives and forks just yet. "We'll need to find out about different types of breakfast foods: perhaps those rich in fats, carbohydrates or protein," says Betts. "And we didn't include caffeine in our tests, but maybe it could encourage greater physical activity even if you skip breakfast?"

There is also the question of whether missing breakfast takes a mental toll (watch our video at bit.ly/breakfastNS). Betts didn't measure mood or cognition, the effects most often mentioned – or moaned about – by colleagues who haven't eaten breakfast.

That question is hard to answer. Children who miss breakfast do not perform as well at school as those who eat it regularly, but that could be because the provision of breakfast is a marker of socioeconomic circumstance or stability at home.

In the absence of fake food, there's no placebo for the first meal of the day, which makes fair studies tricky. "If somebody turns up to a study and doesn't receive breakfast they might feel annoyed and expect to have a slump in energy," says Peter Rogers, at the University of Bristol, UK. "There's actually a suggestion that eating too much for breakfast could adversely affect you and make you sluggish – think about how you feel after Christmas lunch."

So next time someone preaches about the benefits of breakfast, you're perfectly entitled to shrug and walk away. "Most of us could do with eating less," Rogers says. "Given that it's probably the easiest meal to skip, maybe skipping breakfast occasionally could be that opportunity." ■

FAT LOT OF GOOD

Is eating more fat the solution to better eating, asks Clare Wilson

"**P**EOPLE have told me what I do is dangerous. They have walked away from me at meetings," says David Unwin, a doctor practising in Southport, UK. Unwin suggests to his patients with type 2 diabetes or who want to lose weight that they do the opposite of what official health advice recommends. He advises them to stop counting calories, eat high-fat foods – including saturated fats – and avoid carbohydrates, namely sugar and starch. Telling people to avoid sugar is uncontroversial; the rest is medical heresy.

But crazy as it sounds, Unwin has found that most of his diabetes patients who follow this advice are getting their blood sugar back under control, and that some are coming off medication they have relied on for years. Those who are overweight are slimming down.

This might seem like just another controversial fad diet, but a growing number of researchers, doctors and nutritionists around the world are backing it, and reporting their findings in peer-reviewed medical

journals. In 2016, the National Obesity Forum, a UK body for health professionals involved in weight management, made headlines when it overhauled its advice, telling people to ditch calorie-counting, low-fat foods and carbs in favour of fats.

The recommendations provoked a furious backlash from mainstream scientists and dieticians, but they should concern us all. If the advice is to be believed, starchy food isn't just bad for diabetes, it makes us fat and causes heart attacks. This is analogous to finding that smoking protects people from lung cancer, says David Haslam, an obesity specialist at the Lister Hospital in Stevenage, UK, and chair of the National Obesity Forum. "It is terrible," he says. "We have let people down."

For decades, standard dietary advice has been to shun fat and fill up on starchy food like bread, potatoes and rice. We are told this is good for our waistlines and our hearts, and is especially important for anyone with diabetes. Guidelines in the UK, the US and Australia, for instance, tell people to fill around a third of

their plates with starchy food (see "Food fight", right). When the UK government agency Public Health England revamped its "Eat Well Plate" in 2016, it cut added fats (such as oils and spreads) down to a mere 1 per cent of the recommended food intake.

Fat first came under suspicion when research early last century found that the arterial plaques that can lead to a heart attack contain the fatty compound cholesterol. Then came several studies showing that heart attack rates were higher in countries where people ate more fat, especially saturated fat from meat and dairy foods. Fat was also deemed the enemy of people wanting to stay slim, since it has over twice the calories, gram for gram, as carbohydrates and protein.

From the 1950s onwards, these ideas crystallised into official dietary guidelines, and the health-conscious started switching to leaner cuts of meat, low-fat milk and swapped butter for vegetable-oil based margarines. And they filled up on starchy carbs.

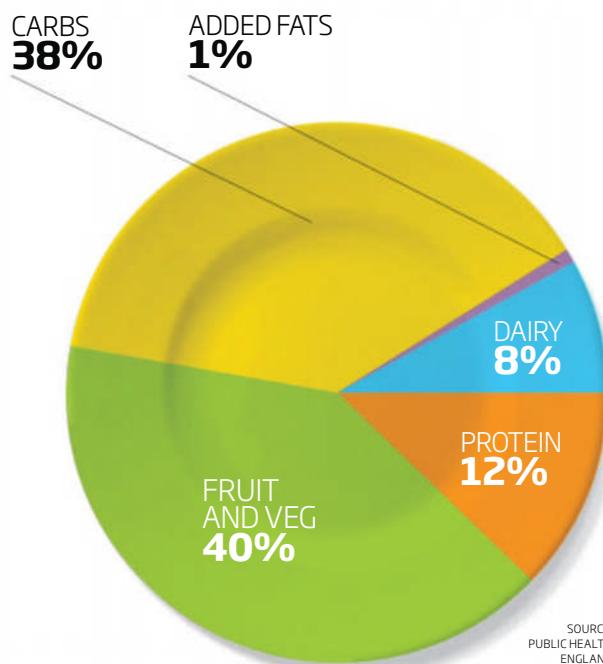
Yet average body weight has continued to ➤

Food fight

The standard nutritional "plate" suggests we get around a third of our daily calorie intake from carbs and almost nothing from added fats, e.g. oils and spreads. Proponents of an alternative high-fat, low-carb approach come up with very different advice for a sample day

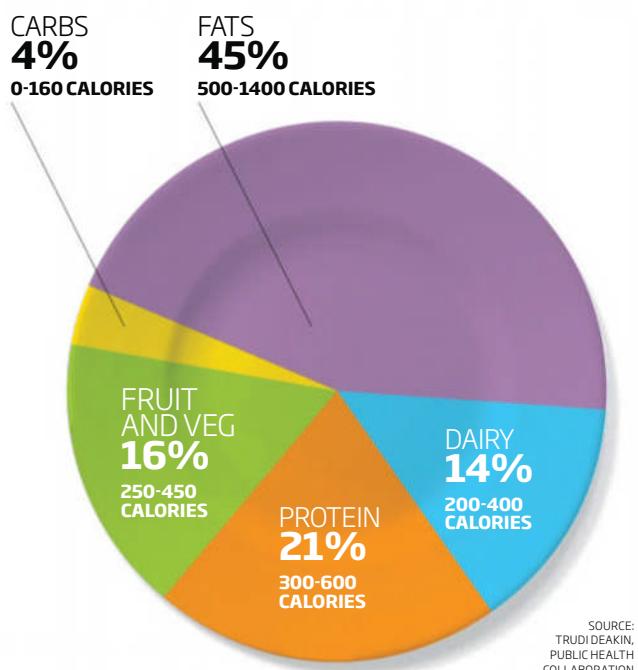
Standard plate : low fat

Recommends a daily total of 2000 calories for women, 2500 calories for men. Percentages add up to 99% because of rounding



Alternative plate : high fat

There is no overall daily calorie recommendation, only a recommended range of calorie intakes for each individual food group. For rough comparability with the low-fat plate, the percentages in the diagram are based on an average calorie intake from each group



Low-fat diet top tips

CARBS

- Avoid sugar
- Fill up on starchy carbs, especially wholegrain or higher fibre sources with less added fat, salt and sugar

FATS

- Avoid artificial trans fats found in processed foods
- Choose unsaturated oils for frying and spreading and use in small amounts
- Limit fat as much as possible to avoid weight gain

DAIRY AND ALTERNATIVES

- Choose lower fat and lower sugar options

PROTEIN

- Eat less red and processed meat
- Eat more beans and pulses

FRUIT AND VEG

- Eat at least five portions of a variety of fruit and vegetables every day

High-fat diet top tips

CARBS

- Avoid sugar
- Limit starchy foods like bread, potatoes, rice, pasta, cereals

FATS

- Avoid trans fats and processed, polyunsaturated vegetable oils such as sunflower, corn, soyabean
- Fill up on olive oil, butter, full-fat dairy and fats in meat
- Don't worry about calorie counting - the diet will make you feel full and prevent overeating

DAIRY AND ALTERNATIVES

- Choose full fat. Try different varieties of cheese

PROTEIN

- Try to have grass fed beef and free range eggs

FRUIT AND VEG

- Eat a mixture of fruit, vegetables and salad, at least 400 grams per day

climb, as have rates of associated problems such as type 2 diabetes, culminating in what is now arguably a health crisis. In the UK, US and Australia, around two-thirds of the population are either overweight or obese.

The orthodoxy was challenged when some dieters adopted the Atkins diet, which caused a sensation in the early 2000s. This urged people to shun fruit and veg and scoff meat, butter and cream. Doctors warned it couldn't work and all that saturated fat was a heart attack waiting to happen.

And yet, research showed otherwise. One trial directly compared 156 women on either the Atkins diet or a low-fat diet. After a year, those following Atkins had lost more weight, and their blood pressure and cholesterol profiles were, if anything, better than those on the low-fat diet. Another trial, which lasted two years, had similar results.

The idea that those with type 2 diabetes should ditch carbs has also been led by people defying medical advice. Unwin first learned of it when he called in a diabetes patient who had been missing check-ups. "Her blood tests were amazing," he says. "They seemed to show that she wasn't diabetic anymore."

This broke all the rules. Type 2 diabetes is supposed to be progressive and irreversible. It is the result of our cells becoming increasingly resistant to insulin, a hormone made by the pancreas to help with the uptake of glucose from the blood. The pancreas works ever harder until it cannot produce enough insulin to keep blood sugar levels under control. As a result, blood sugar gets too high after meals and this gradually harms blood vessels, leading to a range of nasty consequences such as foot amputations and heart attacks.

Newly diagnosed diabetics are usually advised to lose weight with exercise, and by eating less fat and more fibre, including bread, cereals and fruit and vegetables. But like most dieters, they usually don't succeed, and the majority need oral medication to control their blood sugar within a year of diagnosis.

Unwin's rebellious patient told him she began low-carbing after stumbling across a website that recommended it. As Unwin researched the idea, it started making sense. Diabetics are told to avoid sugar, but starch is basically long chains of sugar and is quickly digested into sugar in the gut.

Yet diabetics are told to eat starchy food just like everyone else to help them eat less fat. Fat is the bigger enemy because it leads to heart disease, says Louis Levy, head of nutrition science at Public Health England.

And even wholegrain carbs, which are

SLIPPERY SUBSTANCE

The idea of "good" and "bad" fats has come under scrutiny in recent years. The benefits of unsaturated fats, traditionally seen as good for the heart, may vary due to their omega-3 content – a substance it is thought could have anti-inflammatory effects. Then there's the fact that when most vegetable oils are heated, they form toxic compounds called aldehydes, which have been linked to heart disease, cancer and dementia. So you might be better off frying in butter than sunflower oil.

Many cherished beliefs about cholesterol have also turned out to be wrong. Too much cholesterol in the blood, especially a type called LDL cholesterol, can cause dangerous plaques to build up in blood vessels. But more recently we discovered that smaller LDL particles cause more plaques than large LDLs. And while eating saturated fat raises large LDL levels, small LDLs are boosted most by refined carbohydrates.

That's alarming because it suggests past research that used total LDL as a proxy for heart attack risk would be misleading – underplaying the dangers of eating processed carbs and exaggerating those of saturated fat.

recommended, cause our blood sugar to rise, albeit more slowly than their milled equivalents. A slice of wholemeal bread raises blood sugar the same amount as three teaspoons of pure sugar, according to research by Unwin and his colleagues. A jacket potato – archetypal healthy fare – is akin to eating 9 teaspoons of sugar (although how fast it is released depends on what you eat with it – fat or protein lowers the speed).

The sugar triggers release of insulin, which stimulates fat storage, and in the long term worsens insulin resistance. Eating fat and protein, in contrast, releases less insulin, and protein is the most filling food group, so will suppress appetite more.

People with type 2 diabetes are sometimes told to eat food with a low glycaemic index (GI), a measure of how quickly blood sugar rises. The faster the blood sugar rises, the harder it is for cells to take up glucose quickly

enough to avoid a blood sugar spike. But a strictly low-GI diet can end up being high-fat by default.

Startled into action, Unwin took the maverick step of offering weekly meetings on this dietary approach to his patients who had diabetes or were overweight. He put them on a less extreme version of the Atkins diet, telling them not only to cut down on starchy food but also to eat lots of non-starchy vegetables and the less sugary fruits, such as blueberries and raspberries. In place of carbs they should fill up on meat, fish, full-fat dairy products, eggs and nuts (see "Food fight," page 29).

Under control

It seemed to work. "They weren't hungry and every week they came back smaller," he says. Their blood tests showed improvements in glucose control, as well as blood pressure and cholesterol levels.

Unwin published the results from his first 19 patients in 2014. It wasn't a randomised trial, but there have been such studies in the US. In one study of 34 overweight people with type 2 diabetes, those who were placed on a low-carb, high-fat diet with no obligation to calorie count ended up with significantly better blood sugar control after 3 months than those following the low-fat guidelines for diabetes. Three times as many people on the low-carb diet were able to stop taking at least one diabetes medication, compared with those on the standard diet.

Unwin's unorthodox approach has not gone unnoticed. In 2016 he received a National Health Service innovator of the year award, partly in recognition of the savings being made at his practice, Unwin says. Their per-patient spend on diabetes drugs is about 70 per cent of the local average.

So is it time to overhaul official dietary advice? The National Obesity Forum led the charge with its 2016 report. But in an official statement, Alison Tedstone, chief nutritionist at Public Health England, called its contents irresponsible, saying the report was based on opinion rather than evidence and that it ignored "thousands of papers". Her colleague John Newton said it was at odds with the international consensus. And it also caused a rift within the National Obesity Forum, with a number of members unhappy about the report.

Critics of the idea argue that mainstream nutritional advice is based on decades of research, involving many hundreds of thousands of people, showing that a diet too

Sugarrush

Even typically healthy starchy foods can lead to a spike in blood glucose



Small plain baked potato

OR



153g serving of boiled long-grain white rice

OR



32g serving of cornflakes

all raise your blood glucose levels as much as 9 teaspoons of sugar



high in saturated fats is bad for the heart.

And yet, a body of literature has emerged to suggest that the question of fat might not be as straightforward as we once thought. For instance, one analysis of past studies found that diets lower in saturated fat are not significantly associated with less heart disease or stroke. Another found that the effects of reducing saturated fat depended on what people ate instead; there was a small benefit from replacing it with polyunsaturated fats, but no benefit from replacing it with carbs. The best kind of study is a randomised trial that alters people's diet to see how their health changes. Here too, there is conflicting evidence – some trials show a benefit from reducing saturated fat, while others indicate none or even the opposite.

A high-fat diet could also be concealing other aspects of lifestyle or diet, such as too much sugar or a lack of exercise, which may be the real culprits for heart problems.

It also seems fat is a more diverse food group than it first appeared. Oils from plants tend to be unsaturated fats, liquid at room temperature; we thought of these as "good", unlike saturated fat, mostly found in meat and dairy products and solid at room temperature. But studies suggest that dairy fats, which are saturated, do seem to protect people from type 2 diabetes and heart disease. Unsaturated fats too, are a mixed bunch (see "Slippery substance", above left).

The role of insulin resistance, the key problem in diabetes, also seems to be a bigger player in heart problems than we thought. One recent study found it is a bigger heart attack risk factor for men than high blood pressure, high cholesterol and being overweight. "We have been focusing on the wrong things," says Aseem Malhotra, a cardiologist at the Lister Hospital, who is a vocal advocate of low-carbing.

Still, many mainstream dieticians remain

"The question of fat might not be as straightforward as we once thought"

unconvinced. Julie Lovegrove at the University of Reading, who is a member of the UK government's Scientific Advisory Committee on Nutrition, says that while not all the studies show consistent findings, "a diet high in saturated fat is not optimal for cardiovascular health". Susan Jebb, professor of diet and population health at the University of Oxford, takes particular issue with the idea of not bothering to count calories on a low-carb diet, espoused in the new report. "Very few people manage to control their weight without some dietary restraint," she says.

Such conflicting advice might well leave many of us scratching our heads over what to

eat. Almost the only thing both sides agree on is that sugar is bad for you. If you tried to hedge your bets and avoid both fat and carbs, there would be little left. A more moderate approach is to limit just saturated fat, added sugars and refined carbs, leaving you more or less with an extra-oily Mediterranean-type diet, high in whole grains, fish, fruit, vegetables, nuts and olive oil.

This diet is higher in fat than the standard recommendations, but a large trial of a Mediterranean diet supplemented with extra olive oil or nuts found that either approach cut heart attacks by nearly a third over five years compared with the standard low-fat diet.

People with type 2 diabetes, who are most at risk of heart disease and weight gain, seem to be voting with their feet. Unwin published his diet advice on a free website and in the 6 months after its launch in November 2015, 110,000 people signed up, and over 80,000 people completed the 10-week course. Of 2500 who took a survey 6 months in, the proportion taking diabetes drugs had dropped from 70 to 60 per cent. Although this was not a randomised trial and the results need to be replicated, Unwin thinks it's a sign of what the diet can achieve without much input from health professionals. "The internet is democratising medicine, and patients have taught me so much," he says. "It's a new world – doctors should join in" ■

THE BLAME GRAIN





Wheat has been a staple for thousands of years but is now accused of causing all kinds of maladies.

Linda Geddes separates the facts from the chaff

GIVE us this day our daily bread.” Wheat was one of the first crops to be domesticated and for thousands of years it has been a staple food for a large swathe of the world. It is deeply engrained in our culture and consciousness. What could be more evocative of healthy goodness than the delicious smell of a home-baked loaf? So it comes as a shock to many to learn that wheat is under attack.

Wheat is toxic, addictive and makes you want to eat more junk foods, claim some. They say it causes food allergies, bloating and makes you fat. Others even blame it for various mental disorders. And many people seem to believe these ideas, often much to the annoyance of friends and family who have to cater for them. Demand for gluten-free food is rising rapidly, to the extent that many restaurants now promote gluten-free dishes on their menus. Eating gluten is frowned on in some quarters. “Here in LA, it’s comparable to Satanism,” joked US talk-show host Jimmy Kimmel.

Yet as Kimmel noted, most people can’t even say what gluten is. So what are the facts about gluten and wheat in general? Is it really the seed of all evil, or is this all much ado about nothing? The answer is complex. There is no doubt that some people – but only a tiny minority – must avoid gluten. For others who blame gluten for their gut-related woes, however, the problem may not be gluten but components of wheat also found in many other foods. And for healthy individuals, the benefits – or otherwise – of going wheat-free may depend partly on your genes and partly on what you eat instead. Wheat is not a squeaky-clean superhero, but neither is it the supervillain some claim.

Of all the constituents of wheat, gluten has been singled out by some as public-health enemy number one. Gluten is a composite of

two proteins, glutenin and gliadin, and it forms a network of fine stretchy strands when wet. This is what gives dough its elasticity and makes it so versatile, allowing it to be turned into everything from bread to cakes to pasta.

Gluten is found in other grains besides wheat, including barley and rye. Going truly gluten-free means excluding the vast number of foods containing these grains, and often things like oats, which are processed with the same machinery as wheat.

All this is entirely necessary if you have a serious condition called coeliac disease. It is caused by the immune system mistakenly producing antibodies against gluten that damage the hair-like projections called villi that line the gut, leading to malnutrition. Blood tests for the antibodies suggest that it affects as many as one person in 100, although many people have only mild symptoms and so are often unaware of their condition.

Far rarer are wheat allergies, which can involve one or more of a number of proteins. Symptoms appear rapidly if wheat is eaten or flour dust breathed in, or sometimes if people exercise soon after eating wheat.

What about those who don’t have coeliac disease or allergies to wheat proteins? Gluten is now being blamed for causing bloating, gut pain, headaches and lethargy in many people who do not have an immune reaction to it. The syndrome has been dubbed non-coeliac gluten sensitivity (NCGS), and there have been claims that up to a fifth of people have it.

But does NCGS really exist? Several small studies have found that some individuals do have gut-related symptoms when they eat wheat that often clear up if they change their diet. Peter Gibson of The Alfred Hospital and Monash University in Melbourne, Australia, was first to test the effects of gluten in a randomised, placebo-controlled trial – the gold standard for medical research. He recruited 34 non-coeliacs with gut symptoms that largely disappeared when they went gluten-free. He kept them on a gluten-free baseline diet, and also gave them bread and muffins that – unbeknown to the participants – either did or didn’t contain gluten. Those who ate the gluten-containing muffins reported a worsening in abdominal symptoms and tiredness.

This small study helped convince many doctors that NCGS was a genuine condition, but Gibson himself was not satisfied. “There’s no doubt that wheat is a major cause of bloating and abdominal problems,” he says. “The trouble is that wheat has more than just gluten in it.”



"Some people who think they are gluten sensitive may instead be reacting to certain sugars"

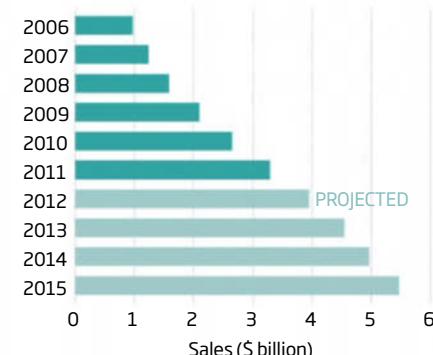
He wondered if the problem might instead be caused by members of a set of sugars that his group has dubbed FODMAPs (fermentable oligosaccharides, disaccharides, monosaccharides and polyols). So Gibson did another study involving 37 recruits with suspected NCGS. This time, however, they were put on a diet that was both gluten-free and low in FODMAPs. Then some had high or low amounts of gluten, or a milk-protein control, added to their diets. There was no difference between the three groups' response, Gibson's team reported, suggesting gluten is not in fact the root cause of their problems.

In other words, people who think they are gluten-sensitive might instead be reacting to the FODMAPs found in wheat. FODMAPs are poorly absorbed in the small intestine and so instead tend to be eaten by bacteria living further down the digestive tract, producing an abundance of gas. They also attract water, leading to bloating, flatulence, loose stools and worse in people with sensitive bowels.

Crucially, the various kinds of FODMAPs aren't just found in wheat, but in lots of foods including many fruits, vegetables and dairy products, so no one is suggesting remaining on a low-FODMAP diet permanently (see "Thinking of going gluten-free?", right). People who suffer when they eat lots of certain FODMAPs should be able to tolerate small amounts, because this is not an immune disorder like coeliac disease or wheat allergies. Many simply avoid cooking with onions, Gibson says, which are very high in fructans, a group of FODMAPs also found in wheat.

The science is far from settled. There may be a subset of people who don't have coeliac disease but who do get gut problems when they eat gluten.

Land of the gluten-free
US sales of products labelled as being gluten-free



including those in whole grains like wheat, are a leading cause of conditions including dementia, ADHD, anxiety and depression.

However, the evidence for many of the claims in the books, or their interpretation of it, is questionable. Take the claim that the spike in blood sugar caused by eating wheat and other grains triggers inflammation in the brain and thus Alzheimer's disease. One piece of evidence cited by Perlmutter is a 2013 paper reporting that even mild elevations in blood glucose in healthy individuals put them at risk of developing dementia.

Yet Paul Crane of the University of Washington in Seattle, who led that research, disagrees with Perlmutter's interpretation. "Our study says nothing about dietary sugar, dietary carbohydrates or dietary anything," Crane says. "What we studied was a five-year average of people's blood sugar levels. This is not at all the same as how much your blood sugar goes up or down after a single meal."

This is not to say that the glycaemic index (GI) of food – how quickly it releases sugar – does not matter. People who eat food with a low GI, which release sugars slowly, have a lower risk of developing diabetes than those who eat lots of highly refined, sugar-rich foods. And some researchers now regard Alzheimer's as a form of diabetes.

But there is no reason to single out wheat, or other grains, on this basis. The GI of wheat-containing foods varies and is typically lower than that of, say, cooked potatoes. What's more, your risk of getting

But of course, people with gut problems are far from the only ones going gluten-free. About a third of the US population say they would like to cut down on gluten or eliminate it from their diets, if one poll is to be believed. Some see it as a way of shedding a few pounds. Others just think a wheat-free diet is the healthiest option.

Where did this idea come from? Two bestsellers probably have something to do with it. In *Wheat Belly*, published in 2011, William Davis argues that the overenthusiastic consumption of wheat is the main cause of the obesity and diabetes crisis in the US. Meanwhile, in *Grain Brain*, published in 2013, David Perlmutter suggests that carbohydrates,

THINKING OF GOING GLUTEN-FREE?

If you have health problems that you suspect are linked to wheat, don't just go gluten-free. "You need to get tested to exclude the possibility of coeliac disease," says Gerd Bouma, a gastroenterologist at VU University Medical Center in Amsterdam, the Netherlands. The first step is to test for blood antibodies to gluten, and this will not work if you haven't been eating the stuff.

If you have abdominal problems such as bloating, and coeliac disease has been ruled out, the cause of your symptoms might not be gluten but one or more poorly absorbed sugars known collectively as FODMAPs (see main story). Wheat happens to be high in certain FODMAPs but so is a frighteningly long list of other foods and drinks, including onions, asparagus, peppers, apples, dried fruits, peas, honey, milk, ice cream, many sweeteners and beer. The good news is that

you don't need to cut them all out forever – instead the idea is to cut them out for a few weeks and gradually reintroduce foods to see which kinds of FODMAPs disagree with you.

"You learn which foods affect you and can adjust your diet accordingly," says Peter Gibson of The Alfred Hospital and Monash University in Melbourne, Australia. It's recommended that you get your doctor to refer you to a dietician if you want to try a low FODMAP diet but booklets and apps are available too.

If you are perfectly healthy but want to go gluten-free because you believe it will make you even healthier, just watch what you eat instead. Many off-the-shelf gluten-free alternatives are higher in salt and fat, for instance. They can also be bad for your bank balance.



Giving up gluten has become a trendy thing to do



disorders such as diabetes and Alzheimer's is likely to depend on a complex interplay between your genes, the number and form of calories you consume and how much exercise you do, not solely on whether you eat wheat.

Fattening and addictive?

But wheat is addictive, cry its critics. For example, Davis claims that wheat proteins break into fragments that act on opioid receptors in the brain, making us want more. "That's an extraordinary statement," says Gibson. These opioid-like peptides do exist, but whether they affect the brain in any way is unclear. And even if they do, proteins from milk, rice, meat and spinach all produce similar fragments, so again there is no reason to single out wheat.

What about the claim that wheat is particularly fattening? "Wheat is no more fattening than any other carbohydrate," says Gary Frost, who studies nutrition and dietetics at Imperial College London. "I think the reason wheat has got a bad press is just that it's a very commonly consumed cereal, so it's hardly surprising that if you start to miss it from your diet then you start to lose weight." Cutting out wheat, after all, means cutting out many high-calorie foods such as cakes and biscuits.

But swapping cakes and biscuits for fruits and vegetables is one thing. Swapping wholewheat bread for processed, gluten-free substitutes is quite another. A team in Spain examined the daily diets of 58 people with coeliac disease and found that, in general, they contained more fat and less fibre than those of people who do eat gluten.

That is bad because not only does eating

a high-fibre diet curb your appetite, it also reduces your chances of developing several cancers. And wheat, particularly wholegrain wheat, is a major source of fibre.

So eating gluten-free foods is not necessarily less fattening, nor even healthier in general. "People tend to think they are more nutritious, but in general they are low in fibre, higher in glycaemic response and more costly," says Julie Jones at St Catherine University in St Paul, Minnesota.

For many people, though, the issue is not how wheat stacks up against alternative foods. Instead, they have been convinced by the claim that humans did not evolve to eat a lot of carbohydrates. But this is a dubious argument for several reasons. Just because our ancestors ate lots of meat doesn't necessarily make it good for us. In any case, it is not at all clear that all our ancestors did eat lots of meat. Some ancient hunter-gatherers may have eaten a carbohydrate-rich diet, just as the hunter-gatherer Hadza people in Tanzania do today.

What's more, it may be that some populations whose ancestors ate a lot of carbohydrates have evolved to cope, just as the ability to digest milk as an adult – lactose tolerance – evolved independently in several parts of the world after the domestication of cattle. In 2014, Mario Falchi at Imperial College London and his colleagues discovered that people with fewer copies of a gene called

"It's hard to avoid eating wheat, but a healthy diet doesn't need to include it"

AMY1 are more likely to be obese than those with lots of copies.

This gene produces an enzyme found in saliva called amylase, which breaks down starch. Falchi thinks it might influence us in subtle ways, such as preparing the body for what we are eating. A 2012 study found that when people with many copies of *AMY1* consumed a starchy drink, their blood sugar levels showed less of a spike than when people with fewer copies drank the same. That suggests people with many copies are less likely to develop disorders like diabetes even if they eat lots of high GI carbohydrates. This is speculation, though, and in any case there's no simple test you can take to find out if you have lots of copies or *AMY1* or very few.

For some, though, avoiding wheat is not just about physical health. Gibson was struck by the fact that many of his patients chose to remain on a gluten-free diet even after he showed that their symptoms were not caused by gluten. "Most of them said they just felt better," says Gibson. It sounds like a classic example of the placebo response, but they might just be on to something.

When Gibson did another small double-blind, placebo-controlled trial in 24 people with irritable bowel syndrome, those given gluten – unbeknown to them – scored more highly on a questionnaire assessing levels of depression.

As ever, the results of such a small study have to be treated with caution. But then again, even if this and the many other claims about the evils of wheat don't stand up, there is no need to eat the stuff. It is hard to avoid eating wheat, but a healthy diet doesn't have to include it. So if it makes you feel happy, lose the loaf. ■



Fancy a drink?

At some point today the answer will be yes. The average adult drinks about 1.7 litres of fluids a day: water, tea, coffee, soda, milk, fruit juice and more. But our ideas of what we should be drinking are clouded by urban myths, wishful thinking and dubious health claims. Time to mix in some fact

WATER

YOU CAN'T NOT DRINK WATER – IT IS LIFE'S MOST ESSENTIAL NUTRIENT. BUT THAT DOESN'T NECESSARILY MEAN MORE IS BETTER

It's not called Adam's ale for nothing. Water was presumably what our early ancestors drank, to the exclusion of everything else. If you stopped drinking it now you would be dead within a week. It is the only nutrient whose absence is lethal in so short a time.

But how much you should drink is surprisingly contentious. It is common to hear eight glasses a day – about 2 litres – even if you don't feel thirsty. In 2002, physiologist Heinz Valtin of Dartmouth Medical School in New Hampshire tried to track down the source of this advice. The closest he came was a 1974 book that casually advised six to eight drinks a day – not just water but also soft drinks, coffee, tea, milk and even beer.

As for its scientific validity, Valtin found none. As the Food and Nutrition Board of the US National Academies of Science, Engineering and Medicine advises: "The vast majority of healthy people adequately meet their daily hydration needs by letting thirst be their guide". The only exception is some elderly people whose feedback mechanisms go awry, meaning they can become dehydrated without getting thirsty.

Generally, there is little to gain by doing more than just quenching your thirst. Water doesn't remove toxins from the skin, visibly improve your complexion or cure constipation. There is some support for the idea that drinking cold water makes you burn calories, and water with a meal does reduce overall calorie intake, perhaps because it helps fill you up or displaces calories from sugary drinks. But the overall influence of water on weight is far from clear.

There is a sliver of evidence that being well hydrated can protect against health problems including colorectal and bladder cancer, heart disease, hypertension, urinary tract infections and kidney stones. Good hydration makes it easier for the kidneys to extract waste, reducing wear and tear on them. Dehydration headaches do exist and water can cure them (although there are hundreds of other reasons why your head might ache), and drinking lots when you have a cold may loosen mucus, easing the symptoms.

Water may not be a cure-all, but the downsides of overdoing it are mild. Besides rare deaths through over-hydration among marathon runners and ecstasy users, the worst of it is that many people who regularly push the fluids too hard appear to be mildly hyponatremic – they have too little sodium in their blood. This is not a major problem, but has been associated with mild cognitive impairment and an increased risk of falling in older people.

Overall, though, "there are few negative effects of water intake and the evidence of positive effects is quite clear", according to a 2010 review.

Perhaps the most implausible claim of all has the strongest support: water can improve focus, at least among children. Several studies have found that having children aged 7 to 9 drink water improves their attention and, in some cases, recall. Perhaps children of this age are more prone to dehydration, which can cause a decline in alertness, concentration and working memory.

TAP OR BOTTLED?

For some, tap water is too clean, laced with chlorine-containing compounds used to sterilise it. For others it's not clean enough, teeming with nasty pathogens and traces of chemicals. Then there's the fluoride often added to it for dental health: decried as a Communist plot in 1950s America, it remains controversial in some quarters today.

Whether for those reasons or simple taste, many people prefer to buy bottled water. Either way, that could be a waste of money, in most parts of the West at least. Around 25 per cent of bottled water sold in the US is simply tap water from municipal sources. A large proportion of bottled water is chlorinated just like tap water - for good reason. Water chlorination is impressively effective at preventing serious diseases such as dysentery, cholera and typhus. Evidence that chlorination can produce carcinogenic byproducts or compounds that reduce male fertility is "inadequate", according to the World Health Organization, and the risk is extremely small compared with that from poorly sterilised water.

Tap water does contain traces of pharmaceuticals, toiletries and cosmetics, but the US Environmental Protection Agency says "There are no known human health effects from such low-level exposures in drinking water". As for fluoridation, there is no evidence that this causes any health problems except where accidents lead to over-fluoridation, which can cause vomiting and diarrhoea.

There is stronger evidence that the minerals in some bottled waters, especially sodium, can be harmful. And while the health benefits of mineral-rich waters have long been touted, the enormous variation between brands makes this impossible to test.

As for taste, that is also impossible to test objectively. But if it is an issue, just chill your tap water: it makes bad flavours much less noticeable.



SODA, SQUASH AND JUICE

WE LOVE TO SPICE UP PLAIN OLD WATER BY ADDING SOMETHING SWEET – WITH POTENTIALLY DISASTROUS CONSEQUENCES

Sugary drinks rot your teeth, and the more you drink, the more they will rot. Fizzy pop is generally assumed to be the worst. That is not because of dissolved CO₂ – it is a myth that sparkling mineral water is any worse for your teeth than the plain variety – but because of the combination of sugar and common flavourings such as phosphoric acid.

Their high sugar content means squashes and sodas deliver a huge calorie hit without filling you up: one standard can of a drink like cola provides more than the recommended daily amount of "free" or added sugar. That piles in excess energy that we store as fat. Those who regularly imbibe sugary drinks are more likely to be overweight, regardless of income or ethnicity, and consuming a can of

sweetened fizz or the equivalent a day increases the risk of type 2 diabetes by a quarter. Overall, this form of liquid sustenance has little to recommend it.

DIET SODAS

So, if the main problem with sugary drinks is sugar, eliminate that and you eliminate the problem, right?

Not so fast. Some studies indicate that diet sodas help with weight loss, but others find a seemingly paradoxical association with weight gain. Mice consuming artificial sweeteners can even develop glucose intolerance, a precursor to type 2 diabetes.

It is tricky to pin down cause and effect in human studies, says Vasant Malik, a nutrition scientist at



PLAINPICTURE

Harvard University: people who are already overweight may be consuming diet drinks in an effort to lose weight, skewing the stats. And the animal studies have been criticised as unrealistic, with mice or rats in some experiments consuming quantities of sweeteners equivalent to us gobbling a few hundred tablets a day.

But there are plenty of reasons why low-calorie sweeteners might not always have their intended effect. One is psychology: you had a diet cola this afternoon, so you can have an ice cream this evening. Alternatively it could be that the intensity of the artificial stuff, which can be 200 times as sweet as sugar, drives us to prefer sweet things, says Malik. Or perhaps sweeteners disrupt our gut bacteria, or our normal hormonal response to sugar intake. "As a result, the body doesn't respond as well when real sugar is consumed," says Susan Swithers at Purdue University in West Lafayette, Indiana, leading to weight gain.

A review concluded in 2016 that choosing diet drinks over normal sugary drinks can contribute to weight loss. But the uncertainty should give us pause for thought, says Swithers. "The reality is that no one should be drinking a sweetened beverage every day, whether it's regular soda or 'diet' soda," she says. "It's like candy in a can either way."

FRUIT JUICES

Pure fruit juice feels like a healthy alternative. It's 100 per cent fruit, after all, and contains good stuff that fizzy drinks don't, such as vitamins, minerals and antioxidants. The UK National Health Service says one small 150 millilitre glass of pure fruit juice counts towards your five-a-day.

But only one. Fruit juice is missing a lot that fruit has: the juice of one orange contains 0.4 grams of fibre, compared with 1.7 grams in an actual orange. And it is as sickly sweet as sweetened drinks. The World Health Organization recommends that the natural sugar in fruit juice should be lumped together with that added to food and sweetened drinks as free sugar, and advises strict limits on how much we should consume. Orange juice and Coca-Cola

contain roughly the same amount, and some juices even more (see "Sugar to go", below). That suggests pure fruit juices should carry the same health warnings as added-sugar drinks.

In truth, we don't know whether fruit juices are better or worse for you than soda, says epidemiologist Nita Forouhi of the University of Cambridge: other lifestyle factors such as income, diet, smoking and exercise that may differ between habitual juice drinkers and habitual soda drinkers make it hard to draw watertight conclusions.

A review by Forouhi's group and others in 2015 did conclude that added-sugar drinks, artificially sweetened drinks and fruit juices were all potentially associated with type 2 diabetes, but differing study designs mean the evidence for artificially sweetened drinks and fruit juices might be "subject to bias". In other words, the jury's still out.

SPORTS DRINKS

Sports drinks' main claim is that they improve athletic performance and recovery by replacing fluid, energy and electrolytes – sodium, potassium and chloride – lost during exercise. A review published in 2000 concluded that sports drinks probably do improve performance compared with drinking water. In 2006 the European Food Safety Authority agreed.

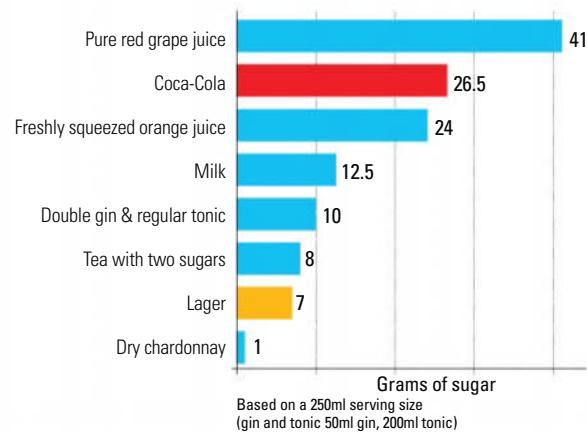
But most sports drinks also come with a stonking sugar content, and more recent studies have questioned earlier conclusions. An analysis published in the BMJ in 2012 found a "striking lack of evidence" for any claim related to sports drinks. They may help elite athletes, but are unlikely to do anything for ordinary people.

In the meantime, there's another competitor: low-fat chocolate milk. Its 4:1 mixture of carbohydrates and protein appears to be ideal for muscle recovery after a workout, and it is cheaper than most alternatives, too. "The research has been positive – most studies have found it to be just as effective or superior to an over-the-counter recovery beverage," says nutrition and exercise scientist Kelly Pritchett of Central Washington University in Ellensburg.



Sugar to go

The World Health Organization "strongly recommends" limiting consumption of free sugars to 50 grams a day, while advising a further reduction to 25 grams. Just a few drinks can take you close to the limit





PIANPICTURE

ORGANIC OR NON-ORGANIC?

Organic milk contains higher levels of omega-3 fatty acids than non-organic milk: it comes from cows that eat more grass, which is high in these acids. But even with this boost, total levels of omega-3s are still low in organic milk. And neither kind is allowed to have any traces of antibiotics.

Another common reason to go organic is fear about hormone levels in non-organic milk. All milk naturally contains hormones, but in areas where cows are treated with growth hormones - as happens in some US states but not in the European Union, Canada, Australia and New Zealand - non-organic milk may have higher levels of insulin-like growth factor, a hormone linked to increased risk of some health problems. But the US Food and Drug Administration concluded that it poses no health risk at the levels present in mass-produced milk.

MILK

IT'S A PLENTIFUL SOURCE OF CALCIUM – BUT MANY HEALTH CLAIMS FOR MILK AND ITS SUBSTITUTES DON'T STAND UP TO SCRUTINY

Milk is a richly nutritious mixture of water, proteins, minerals, vitamins, sugars, saturated fat and cholesterol. All mammals make it, but humans are the only ones to drink it beyond their early years. Should we?

Breast milk – or synthetic versions of it – provides the “perfect balance of nutrients” for babies in their first year, says Andy Bernstein, a paediatrician at Northwestern University in Evanston, Illinois. After that, full-fat cow’s milk is recommended as a good source of fat for brain development, dropping to 1 or 2 per cent fat milk from age 2.

But although programmes in the US and UK that gave milk to children in schools were associated with huge health benefits, it is not clear why. “We don’t know if there is something specific or special about milk, or if it is just the fact that these children are getting more calories, protein, nutrients in general,” says Andrea Wiley of the University of Indiana at Bloomington. A recent study of children in Kenya found that supplemental milk helped those with stunted growth catch up in height, but provided no benefits over a non-milk nutritional supplement for children developing normally.

For adults, the benefits seem even more dubious. There is no conclusive evidence, for example, that getting extra calcium from milk is vital for

“All mammals make milk, but only humans drink it as adults”

maintaining healthy bones or avoiding fractures. Other foods besides milk – “beans and greens”, largely – are also rich in calcium, and most researchers now argue that a generally healthy diet and plenty of weight-bearing physical activity is what keeps bones healthy.

And we should perhaps be careful not to overdo the white stuff. A Swedish study published in 2014 found that drinking three glasses of milk a day over an average of 20 years increased overall mortality compared with drinking just one – while showing that consuming fermented milk products such as yogurt and cheese reduced both fracture risk and overall mortality.

The authors of that study recommend caution in interpreting the results, though, as there were a number of potentially confounding factors they couldn’t control for. The fermentation finding is not fully understood either, says Amy Lanou of the University of North Carolina at Asheville, although it might have something to do with a reduction in the milk sugar lactose during fermentation. “If some of these effects are mediated by milk sugar, that may be a reason,” says Lanou.

SOYA MILK

If cow’s milk isn’t necessarily all that healthy, what about its most common substitute? Soya milk has a bit less fat than cow’s milk, but often comes pre-sweetened, counting towards your intake of free sugar. Its reputation for reducing harmful LDL cholesterol is overblown, too – even if you drank about eight glasses per day that would only equate to a 3 per cent drop in LDL.

Other supposed health benefits – preventing breast and prostate cancer, reducing risk of osteoporosis and hot flushes associated with the menopause – are ascribed to soya milk’s high levels of compounds known as phytoestrogens. These can mimic the effect of the hormone oestrogen or, in some instances, block it. But none of these effects has been convincingly demonstrated in trials, while a few studies have suggested consumption of soya milk may actually increase breast cancer risk.

COFFEE

MANY OF US SEEK LIQUID STIMULATION, AND CAFFEINE IS OUR DRUG OF CHOICE. IT'S PROBABLY NOT AS BAD A HABIT AS WE THINK

Coffee is no good for you – that's the received wisdom, at least. It is full of caffeine that's addictive and can make you bounce off the walls, give you headaches and disrupt sleep. Excessive consumption has been linked to heart disease and cancer. And although coffee increases alertness and focus, the effects are short-lived. Users quickly become tolerant: people who regularly drink coffee are no more alert on average than those who don't. For regulars, the morning brew merely reverses the fatiguing effects of caffeine withdrawal, bringing them back to a baseline level of alertness.

Sounds like one to avoid, then. But Kirsty Pourshahidi of the Northern Ireland Centre for Food and Health in Coleraine, UK, thinks that's overbrewed. "Having looked into it, I don't feel so bad having three or four cups of coffee a day," she says.

Pourshahidi has just carried out a review of the evidence, in work partly funded by the Italian coffee company Illycaffè. For a start, she finds few grounds to suppose that imbibing a moderate amount of caffeine is harmful. For an addictive substance, caffeine is surprisingly easy to kick, too: simply getting people to gradually cut their intake over four weeks is an effective strategy.

Beyond caffeine, coffee contains high levels of compounds called chlorogenic acids, known to slow the body's absorption of glucose. How this works isn't clear, but it backs up the observation that coffee drinkers have a lower risk of type 2 diabetes.

On the other hand, two oily compounds in coffee, cafestol and kahweol, do seem to increase "bad" cholesterol that clogs blood vessels – but most coffee we drink, including instant, doesn't contain much of either, says Pourshahidi. Espresso machines almost entirely get rid of them and French presses don't do a bad job

either. The thing to avoid is the boiled, unfiltered coffee popular in Turkey, Norway and Sweden.

Studies on coffee consumption and cancer typically find no correlation or a mildly beneficial effect, except among people who gulp down 40 or more cups a day and those who drink Turkish-style coffee. Even where coffee drinkers

"Coffee drinkers are no more alert on average than others"

appear to be at greater risk than non-drinkers, the studies generally fail to show a proportional relationship between the amount consumed and risk, suggesting some other factor is involved – perhaps that people who drink coffee also drink more alcohol or smoke more, says Pourshahidi. In 2016, the World Health Organization changed its stance on coffee from "possibly carcinogenic" to "no conclusive evidence". The sole caveat was that any hot drink – above 70 °C – increases the risk of oesophageal cancer.

So enjoy the odd coffee, but do yourself a favour: let it cool.

TEA

Tea drinkers are often bathed in smug satisfaction: unlike coffee drinkers, their beverage of choice full of life-giving, leafy goodness. Much of the buzz centres on flavonols, with a particular focus on green tea and its most abundant flavonol, epigallocatechin-3-gallate (EGCG). It boasts antioxidant and anticancer effects, at least when added to cells in a dish.

Time to pour some cold water. Although some studies have found that drinking green tea (and to a lesser extent, black tea) lowers the risk of breast, gut and lung cancers, a 2009

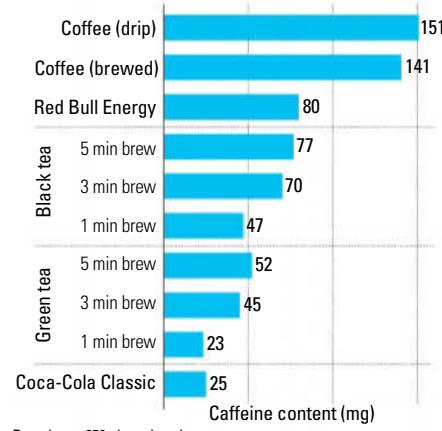
review of 51 studies involving a total of 1.6 million people concluded that the evidence was highly contradictory.

It is a similar equivocal story for other supposed benefits. Extracts of both green and black tea reduce blood sugar levels in diabetic rats and mice, and boost glucose metabolism in healthy human volunteers. Tea and its extracts may also reduce cholesterol and blood pressure in people at risk of cardiovascular disease, and animal studies suggest that catechins, compounds found in black tea, can inhibit enzymes that digest fat and starch and perhaps boost metabolism. Some or all of that might explain a small correlation between tea consumption and weight loss in overweight or obese people. So far so good, but the bad news is that the amount of weight lost was so small as to be irrelevant to health, and probably outweighed by other lifestyle choices.

Still, a nice cuppa is unlikely to do you much harm. One woman did lose all her teeth at 47 due to a fluoride overdose from tea, but she had been brewing up 100 to 150 teabags daily for 17 years. For most of us, tea's fluoride content and anti-bacterial properties actually protect our gnashers. A study of tea's potential as a mouthwash found that green tea killed just as many bacteria as a standard chlorhexidine-based version, and would probably work out cheaper. Black tea similarly fights cavities and stimulates the mouth's own antibacterial enzymes.

Charting hits

Your caffeine kick depends on what you drink, and how



Based on a 250ml serving size

SOURCE: USDA

SUPER-FLUIDS

MANY IMPLAUSIBLE DRINKS ARE TOUTED AS HAVING HEALTH-GIVING PROPERTIES. FEW OF THEM ACTUALLY DO

COCONUT WATER

Being potassium-rich, coconut water supposedly enhances your ability to absorb water during prolonged exercise. If that were true, though, it would also increase your risk of overhydration. In fact, studies show it is no better or worse at hydrating than a much cheaper beverage: water.

As yet there is no scientific verdict on other trending hyper-hydrating waters – including watermelon water, as endorsed by singer Beyoncé, and birch sap water, as endorsed by Nordic folklore.

BETROOT JUICE

Rich in nitrates that can relax blood vessels and improve blood circulation, there is some scientific support to the idea beetroot juice is good for you. But drink it in moderation: its sugar content is on a par with orange and other common fruit juices (see “Soda, squash and juice”, page 37). Too much nitrate has also been tentatively linked with an increased risk of stomach cancer.

WHEATGRASS SMOOTHIES

Wheatgrass contains a smorgasbord of vitamins and minerals, as well as chlorophyll, claimed by some to boost the production of red blood cells. But studies show it is unlikely to benefit you much more than munching green veg such as broccoli and spinach.

KEFIR

A fermented milk drink akin to yoghurt, kefir is prized for its supposed beneficial effects on microbes in our gut. Studies in mice suggest there might be a link – although it is too early to say whether there is an effect in humans, or how big it is.

URINE

Lost in the desert, you are far from any source of fresh water and your bottle is empty. What do you do? You know the drill: unzip your pants.

And not just there, if some have their way. From acne to anaemia via

“The myth that urine is perfectly sterile is just that – a myth”

obesity and various cancers, many are the ills that urine has been said to alleviate – seeing as it contains vitamins, minerals, proteins, enzymes, hormones, antibodies and amino acids your body has discarded.

For Joel Topf, a nephrologist at Oakland University in Michigan, though, that’s a clue to how useful the active ingredients really are. “The chemicals are not necessarily toxic, but they aren’t something that the body wanted to hold on to the first time,” he says. Not only that, but they are at concentrations far too low to be useful.

So, urine is disgusting and unhelpful, but harmless, right? Well, maybe not. One component of urine rarely mentioned by those who promote drinking it is phosphorus, a possible cardiac toxin. The myth that urine is perfectly sterile is just that, too – a myth. Drinking it could bring you down with all sorts of nasties.

Let’s seek advice from the real survival experts. When it comes to preserving precious bodily fluids, the US army’s 1999 survival field manual puts urine firmly alongside blood, seawater and fish juices in its “DO NOT DRINK” category. It’s not a cultural thing that we don’t like drinking urine, says Topf – it’s evolutionary. “Urine is waste, not medicine. Stop drinking your urine.”

AND FINALLY... ALCOHOLIC DRINKS

“Wine is the most healthful and hygienic of beverages.” So said that master of liquid health and hygiene, Louis Pasteur. With more than 100 studies confirming a link between moderate alcohol consumption – one or two drinks a day – and a decreased risk of heart attack or stroke, it is tempting to raise a glass to him and to that.

Stay that hand, though. A confounding factor in most of these studies is that people who drink in moderation also tend to share characteristics that lower heart-disease risk: they exercise more regularly, have a healthier weight, sleep better and as a general rule are more affluent than those who drink to excess or never drink at all (perhaps because they quit due to health problems).

Overall, there is no consensus on who, if anyone, might benefit from moderate

“There’s no consensus on who, if anyone, benefits from alcohol”

alcohol consumption, and by how much. Older people do seem to benefit more, but that could be because their overall risk of heart disease is higher. There is similarly no undisputed evidence that red wine arrests cognitive decline, as has been suggested.

Set these small and disputed benefits alongside the 3.3 million deaths that the World Health Organization attributes directly to alcohol consumption each year, and the fact it is classified alongside asbestos as a class 1 carcinogen, and things start to look that much less positive.

But let’s not go overboard. There’s a lot to be said for alcohol’s role as a social lubricant, and few studies connect moderate consumption with any significant increased mortality risk. One drink also makes you better at creative problem-solving. As with so much, the difficulty is knowing when to stop.

For more of the latest research on the effects of alcohol, go to <https://www.newscientist.com/article-topic/alcohol/>

CHAPTER THREE

HACK YOUR SENSES



ANDREW LYONS

Hear yourself happy

Want to feel instantly lively, slimmer, or more motivated? Try tweaking the noises your body makes. Corrinne Burns tunes in

AS A rule, I don't remove my shoes in public. But today I'm making an exception. Surrounded by engineers and psychologists, I pull off my Converse and step into a pair of rather ordinary-looking brown leather sandals.

I begin to walk slowly around the room, and that's when I experience the most peculiar sensations. The sound of my footsteps changes, and suddenly my lower legs feel lighter and longer. My knees feel looser, and I begin to raise them higher and higher as I walk. My walking speed increases until it's all I can do not to break into a trot. I feel slimmer, stronger, and full of energy. These are unlike any shoes I have ever worn.

Such footwear sounds fantastical, but these shoes are just one of a number of new experiments revealing how the noises we make have an immediate and profound effect on the way we experience our bodies, on our emotions and our behaviour. The trick here is



not in the shoes themselves, but in the way they change the sound of my footsteps.

This phenomenon raises the tantalising prospect that simply donning a particular pair of shoes or a headset could help us feel energised, more inclined to exercise – or just happier.

The discovery also sheds light on the way the brain builds your sense of self. This could have big implications for people who struggle with how it feels to live inside their bodies, not least those with chronic pain or psychological problems with their body image.

The sensation of inhabiting our own body is so familiar we barely give it a second thought. But over the last decade it has become clear what a complex construction this feeling is.

Much of what we know about it comes from studying the brain circuits of people subjected to the rubber hand illusion – one of the most well-established experiments into our sense of embodiment. In the classic version, a

rubber hand is placed on a table in front of a volunteer, in a natural-looking position, and the person's own hand is hidden from their view. Then they see the rubber hand being stroked, while their real hand is simultaneously stroked in the same way. The experience results in the person perceiving that the fake hand is their actual hand.

These experiments suggest that we carry a mental model of our body – how many limbs we have, for example, and where they are in relation to one another. This model is then constantly updated with sensory information from the outside world, and from special receptors inside the body that sense the movement and position of joints and muscles – called proprioceptors. In the case of the rubber hand, it is the combined visual and tactile input that convinces the volunteer's brain that the hand is in fact part of their body.

We know that much of this integration happens in an area of the brain called the right

temporoparietal junction. This area collects and processes information about body movement, and sensory information such as sight, touch and sound.

When it is disrupted using magnetic stimulation, people suddenly find it hard to figure out where their body ends and the outside world begins.

Variations of the rubber hand illusion have since shown that as long as enough information from different senses reaches the brain, it is surprisingly easy to change what people feel to be the limits of their physical form. With a bit of technology, it is even possible to fool someone into perceiving an entire other body as their own.

Personal soundtrack

These perception-skewing studies have traditionally relied on vision, touch and proprioception to understand the way in which the brain constructs this sense of an embodied self. For a long time, the role of one sense was widely overlooked. "Sound is a fundamental yet under-investigated dimension of body representations," says psychologist Manos Tsakiris at Royal Holloway, University of London, who has conducted much of the embodiment research. "For hearing people, there is a continuous, ever-present soundtrack to our bodily actions."

We use this soundtrack to infer information about other people: just hearing someone's footsteps hints at their size, for example. Ana Tajadura-Jiménez, who studies perception at University College London, is interested in the sounds we make ourselves. "What do they tell us about our own bodies?" she asks.

In trying to answer this question, she has found that hacking our hearing can have profound and surprising effects. In an early experiment, Tajadura-Jiménez's team at UCL's Hearing Body Project asked a group of volunteers to do a trial that involved tapping a desk while speakers played the sound of the taps at increasing distances. After each trial, participants were subjected to a touch test on each arm (see "Arm stretching illusion", page 45).

When the sound originated from double the distance away from the tapping, a curious phenomenon occurred – the volunteers significantly overestimated the distance between two touch points on the tapping arm. Their brain perceived that arm to be longer, even though they weren't consciously aware of it having stretched. ➤

In a similar experiment, blindfolded volunteers were asked to drop a ball, which was surreptitiously caught in a net. Instead of the true sound of the ball hitting the floor, a recording was played, with a varying time lag. Similarly to the arm experiment, the longer the lag, the longer they felt their legs to be.

Tajadura-Jiménez suspected that manipulating the audio feedback in this way disrupts the brain's internal model of the body by causing a mismatch between the input it gets from the different senses. Strange bodily sensations result, as the brain tries to account for the discrepancies.

These kinds of manipulations not only alter how we perceive the body, but can also affect behaviour. Touching surfaces generates sounds, however subtle. In another test, blindfolded volunteers stroked a smooth plastic board, but through a headset heard the sound of touching either sandpaper or velvet.

The sound they heard affected their actions – participants became hesitant to stroke the board when they heard sandpaper, but not when they heard velvet. (To experience this for yourself see the online version of this story here: bit.ly/NSsoundFX)

Slimming shoes

Tajadura-Jiménez wanted to know if it was possible to harness these peculiar experiences in more profound ways. This is why I find myself standing in my socks. A part of her team's most elaborate experiment yet, I am handed a pair of sandals fitted with microphones linked to a set of earphones. I don the shoes, put the earphones in, and begin to walk on the vinyl floor.

It is an unnerving experience. At first, I simply hear the unmodified sound of my footsteps. But then Tajadura-Jiménez filters the noise using an equaliser. Emphasising the higher frequencies mimics a lighter person's footsteps, causing them to sound higher-pitched, even slightly hollow. In a matter of seconds, I experience a sensation of lightness in my lower legs. And that's when I start to feel the other changes in my body too. The opposite effect also occurs – lower frequencies cause people to drag their feet like a heavier person.

What's going on? Tajadura-Jiménez thinks that what I experience is a conflict between two senses: hearing and proprioception. My brain, quite rightly, expects my body to be 156 centimetres tall and weigh about 55 kilograms. But thanks to the get-up, my ears pick up the sound of a considerably lighter



ELLIOTT ERWITT/MAGNUM PHOTOS

Tongue trick

As with sound, taste manipulations can have surprising effects on the way we experience the world.

In 2014, a team at the University of Oxford's Crossmodal Research Laboratory asked volunteers to stick their tongue through a hole in the side of a box, which was equipped with a strategically placed mirror. This made them see a fake, rubber tongue in place of their own.

Participants then watched as a cotton bud was stroked along the fake tongue while the same thing happened to their tongue. Seventy per cent of them perceived the fake tongue to be theirs.

Next, the volunteers saw a cotton bud get dipped in lemon juice and applied to the rubber tongue, while a water-soaked bud was simultaneously applied to their own. To the researchers surprise, a few participants reported a sour taste.

"It's the first time that vision has been shown to influence perception of an internal organ," says study co-author Charles Michel.

We already know that how food looks affects how much we like it. If we can make people perceive taste on a virtual representation of their tongue, Michel says, it raises an interesting question: "How much of our everyday experience of food is an illusion?"

You don't need to be in love to get an added spring in your step

person – and my brain updates my body representation accordingly, putting an added spring in my step.

This idea fits with one theory of how the brain works, called predictive coding. This depicts the brain not as a passive recipient of sensory information but a complex prediction machine, which makes sense of the world by forecasting the probability of various events occurring.

Those predictions are based on prior experience, but they are continually updated. This way of calculating how likely something is to happen is known as Bayesian statistics. The Bayesian model of the brain explains how we can instinctively work out, for instance, whether there is time to cross the road in front of an approaching car – we make a prediction based on past experiences, but the brain will update that calculation if new information comes in, such as the car suddenly accelerating.

Predictive coding is a compelling explanation of how these experiments work their magic. "If the sensory feedback you get is not what you were expecting, you update your predictions," says Tajadura-Jiménez. My brain

predicted that my footsteps would sound the way that they usually do. These shoes, though, provided unexpected sensory information, and so my brain quickly “corrected” its error, creating an illusion of lightness.

Tapping into these expectations could affect much more than the way we walk. Tajadura-Jiménez says people who try the shoes often report feeling happier. What's more, when participants are asked to adjust the size of a virtual avatar to reflect their body shape, after walking in the shoes, they consistently depict their virtual selves as slimmer than before.

The effects are temporary – it only takes a few seconds without the shoes to return the wearer to their original state. Still, such footwear could be just the ticket for anyone in need of an instant confidence boost.

Could they also help people with serious issues with their body image? Tajadura-Jiménez has teamed up with medics interested in how sound manipulations could help people with body dysmorphia to adjust their distorted body image. “We are

“Manipulating sounds changes the size people feel their waist to be”

finding that sound is affecting not just the perception of our body shape but our physical capabilities,” she says. “Understand these sounds, and we could change our feelings in a positive way.”

There's reason to think this group could be particularly responsive to interventions with sound and touch. People with eating disorders have already been shown to be more susceptible to tricks like the rubber hand illusion. And Tajadura-Jiménez's team has found that experimental sound manipulations can change the size volunteers feel their waist to be. People who were more concerned about their body shape felt the illusion more strongly.

These experiments suggest that you could consider body dysmorphia to be a disrupted sense of embodiment, says Anil Seth, who studies consciousness and identity at the University of Sussex in Brighton, UK – and that it might well be amenable to treatment with some of these new approaches.

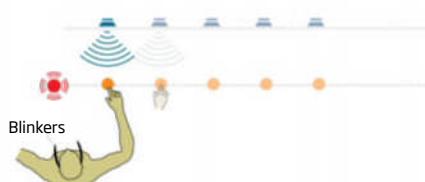
The findings clearly run deeper than the contours of the body – perhaps even to our fundamental sense of identity, he says. “I believe that our sense of self is at least partly

Arm stretching illusion

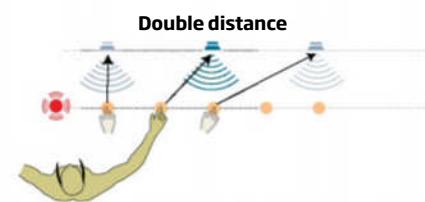
Manipulating sounds can trick your brain into thinking your limbs are longer than they are

A person taps a point (●) 10 times with their right hand in time with a flashing LED, and a hidden speaker amplifies the sound. Without leaving their seat, they repeat the taps at each point

Hidden speaker location matches tap location

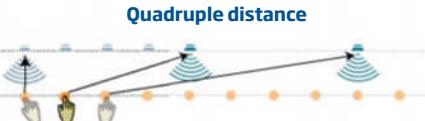


In the next trial, the speakers are placed at double the distance between the person and each tapping point. Before and after each trial participants were touched in two places simultaneously on their right arm and on their left



When the tapping sounds originated from **double the distance**, participants perceived the touches on their right arm to be significantly further apart than they really were

Their brain perceived the right arm to be longer



When the speakers were further away the illusion was broken

determined by the brain's inferences about the shape and physiological conditions of what it considers to be its body.”

So, change the shape, change the person? Work by Amy Cuddy of Harvard Business School and her colleagues shows that simply getting people to change their posture – even if they don't realise they have done so – can make them feel more powerful and, in turn, more likely to take risks. For instance, her team found that people who drive cars whose seats are designed to encourage a more expansive driving posture were more likely to park illegally.

In other experiments, when adults wearing a virtual reality headset were made to inhabit the body of a child, they started to identify more with childlike qualities in themselves, rather than adult ones.

This is an idea known as embodied cognition, whereby the way our body looks, feels and moves influences the way we think and behave. Tajadura-Jiménez wants to investigate whether her sound manipulations could be used to trigger similar responses, changing the way people think about themselves more fundamentally.

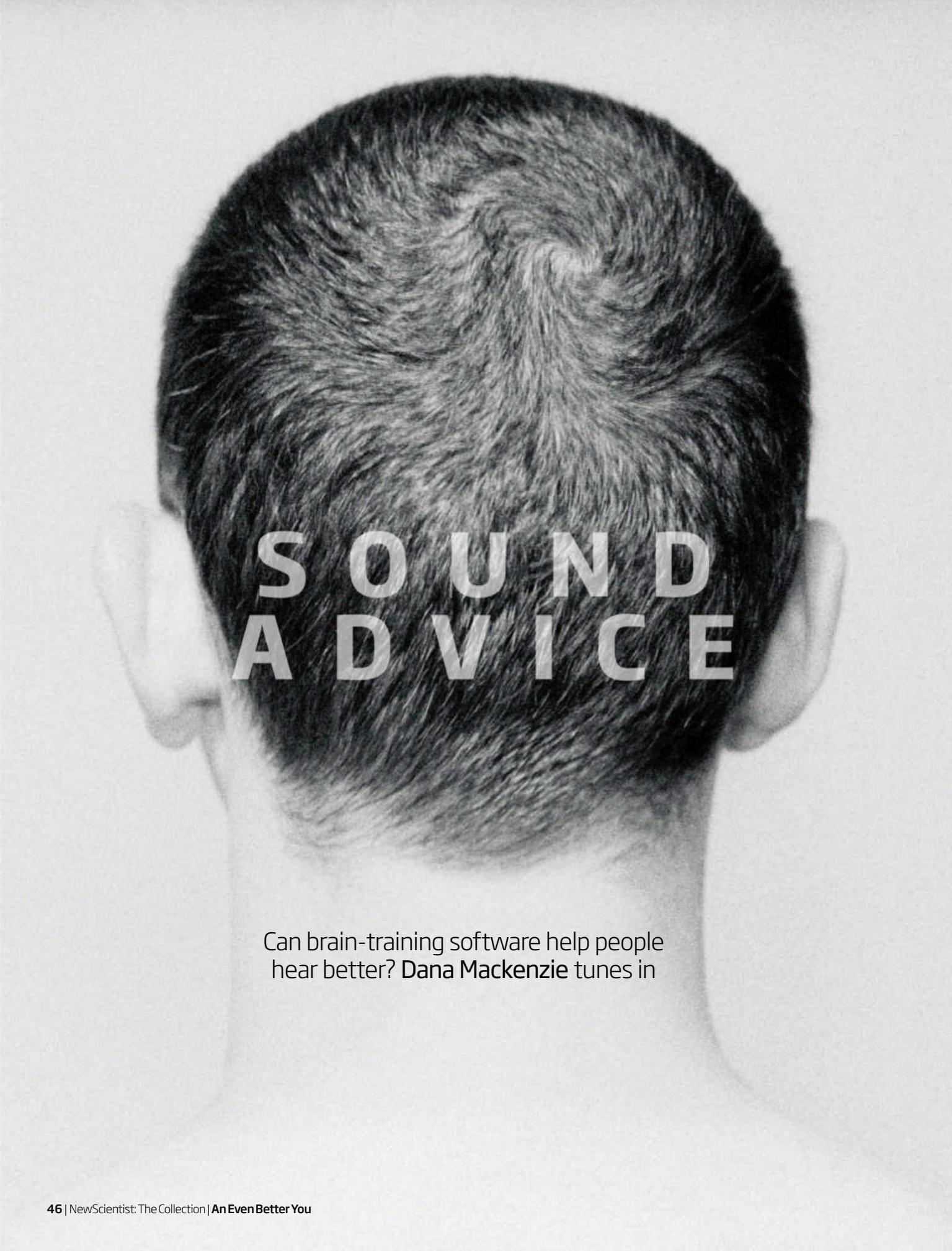
And she is now working with people who experience chronic pain. Feeling pain in one part of the body often leads to distortions in a person's sense of movement and positioning, leading to reduced awareness of their actual movement. For example, they tend to think their body is stretching more than it really is, and this makes it hard to carry out physiotherapy exercises. Some of their proprioceptors also switch to transmitting pain.

Tajadura-Jiménez and colleagues at UCL's Emotion and Pain Project and at the University of Genoa in Italy have developed an app that works as a kind of sensory prosthesis, giving people with chronic pain real-time information about their body movement and location. The hope is that it will help them to stretch further, and will reset their proprioceptors to accurately represent their body position. This might give them a better idea of their true physical capabilities and stop the proprioceptors from transmitting pain signals.

Another project is a separate app, which would allow people to modify the sounds their footsteps make, Tajadura-Jiménez says. The idea is that anyone can get the benefits of her sandals, “when walking or running, perhaps in the gym, to feel lighter and more motivated”.

This is the kind of thing that should appeal to makers of sports equipment, says sports engineer Steve Haake at Sheffield Hallam University, UK. “Something that enhances runners' perception would be very popular.”

From my short time in Tajadura-Jiménez's shoes, I would certainly agree. The feeling of lightness I experienced vanished as soon as I took them off, so I would be keen to have such a trick regularly at my disposal. The experience has also left me with a new-found appreciation of the role sounds play in forming my sense of identity. Walk a mile in these shoes, and you'll never feel the same again. ■



SOUND ADVICE

Can brain-training software help people
hear better? Dana Mackenzie tunes in

HAVE you signed the card for aunt Alice?", my wife asked one morning. But what I heard was: "Have you signed the contracts?" "There's a cross breeze," she told me when a gale blew through an open window. There's a what? A crossbow? A cross-breed?

Conversations like this are common in our household. I also struggle to hear people in a noisy room or over a bad phone line. I finally knew I needed help when my wife spoke to me from another room, and although I could hear her, I was unable to decipher a single syllable. She might as well have been one of the adults in the Peanuts cartoons, saying "Mwah-mwah-mwah..."

I am far from alone. At 56, roughly a tenth of people my age have the same problem – an impaired ability to hear speech against background noise. Add 10 years and it's up to 20 per cent. It's not as if somebody has dialled down the volume. We hear the sounds; we just can't pick out the words.

But here's the catch. I've had my hearing tested three times in the last decade, and the results always come back normal. "We call it hidden hearing loss, because it hides behind the audiogram that is the gold-standard test of hearing," says Charles Liberman, a neuroscientist at Massachusetts Eye and Ear Infirmary in Boston. It's also hidden because the problem isn't in the ears at all; it's in the most important hearing organ: the brain.

The idea that the brain is behind this kind of hearing loss opens up a whole new way of treating it. Instead of cranking up the volume with a hearing aid, why not train the brain to process the ear's signals better? A number of computer programs now promise to enhance the brain's auditory machinery from the comfort of your home. Curious and a little sceptical, I had to try it.

To understand how such an idea might work, let's start with what happens to our hearing as we age. We are born with about 11,000 hair cells in each ear. These delicate cells convert sound waves to electrical signals, but they are easily damaged by ageing and excessive noise. Hearing aids and cochlear implants are designed to treat this kind of

impairment, and they can be very successful.

But Liberman and his colleagues have turned their attention to the next step in sound processing – the auditory nerve fibres that pass the hair cells' signals to the brain. Their work has revealed that loud noises can cause a shocking amount of damage to these nerves (see "Silent epidemic", page 48). More specifically, it's the connections, or synapses, between the hair cells and the auditory nerves that are destroyed, a problem known as synaptopathy. The hair cells themselves remain.

Synaptopathy doesn't show up in audiograms because these only test the effect of hair-cell loss. "The whole domain of hearing assessment has systematically ignored the fact that the brain is a participant," says Michael Merzenich, a neuroscientist and creator of a brain-training program called BrainHQ. Perversely, the nerve fibres that are most damaged by noise are those we rely on to understand speech in a noisy environment – up to 90 per cent of these synapses can be damaged, yet you can still perform normally in a hearing test.

The loss of these connections means the brain processes sounds more slowly and samples them more infrequently, which makes it much harder to decipher different letters, especially those that sound similar. "We've called this problem by many names, but we've never really understood it," says Kelly Tremblay, an audiologist at the University of Washington in Seattle. "Liberman's work has for the first time provided an explanation. That opens the door to new treatments."

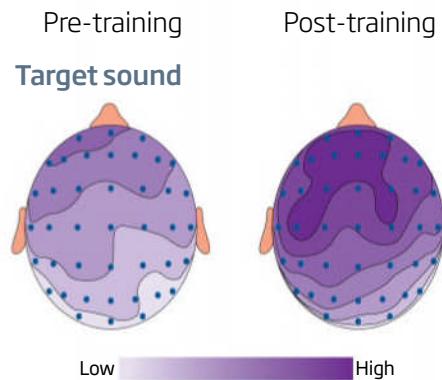
In particular, because the nerve and hair cells are still alive, it may be possible to persuade them to grow new connections. Liberman has managed to restore these synapses in mice using a drug called dexamethasone, although the side effects are still too severe for it to be used in people. Several pharmaceutical companies are also developing medications to restore hearing.

If, like me, you can't wait, there is an alternative.

The idea of brain training for better hearing

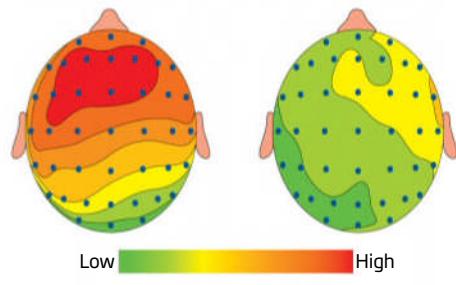
Hearing the difference

After 40 hours of using brain-training software, Dana Mackenzie showed improvements in his ability to pick out speech amid noise



Electrodes on the scalp show increased brain activity in response to target sounds after training...

Irrelevant sounds



...while his brain's response to non-target noise decreased

SOURCE: JOTIMSHRA/UCF

came to my attention in a 2013 paper by Nina Kraus and colleagues at Northwestern University in Illinois. They showed that people who did 40 hours of BrainHQ training over eight weeks had significant improvements to the first layer of auditory processing in the brain, which occurs in the brainstem. Their neural responses to sounds became quicker, and they became better at picking out speech in background noise compared with a control group who used general education software.

Intrigued by the promise of hard science to back up the concept, I got in touch with ➤



DAVID EULITT/KANSAS CITY STAR/MCT

SILENT EPIDEMIC

In 2014, fans of the Kansas City Chiefs American football team set the world record for the loudest stadium roar. At 142.2 decibels, it was louder than a 747 jet taking off. That's a dubious achievement. "They say 'wow, that was awesome, my ears were ringing for days,'" says Charles Liberman at Massachusetts Eye and Ear Infirmary in Boston. "I'm saying that's not awesome."

Your ears' short-term recovery when the ringing stops may fool you into thinking there is no permanent harm from loud sporting events, concerts and listening

to loud music on personal devices. But Liberman and his colleagues have shown there can be lasting damage to the nerves that transmit sounds from the ear to the brain. You might not feel the effects today, as it doesn't show up on standard hearing tests (see main story). But the nerve fibres may never recover and the damage will take its toll later in life, leading Liberman to call this a "silent epidemic". The World Health Organization estimates that 1.1 billion young people are at risk of hearing loss caused by unsafe listening practices.

Merzenich, who agreed to provide me with the same training exercises. Kraus, who has no connection to Merzenich's company, offered to perform the same independent before-and-after testing that she had done in her study.

After my initial tests, for two months I spent around an hour, five days a week, at the computer learning to pick out target sounds from others that sound similar, for example.

Much has been made in recent years of the idea that "brain-boosting" software may provide a mental workout that could fine-tune our neural faculties, but there have been mixed results under scientific scrutiny. What about hearing?

The very origins of the idea of brain plasticity – that the brain can rewire itself in response to how we use it – lie with the first cochlear implants that were tested in people in the 1980s. They were unexpectedly successful.

A cochlear implant delivers much less information to the brain than a healthy ear. When the implant is first turned on, this impoverished signal sounds very strange to the user. Yet after a year, people report that they can hear just like they used to.

That's because the brain adapts itself to the new information if it receives feedback. "Synaptic inputs strengthen if they contribute to getting the answer right," says Merzenich.

This rewiring only works if the brain knows when it's right. This might help explain the hearing improvements Kraus saw in her study. BrainHQ and similar programs are designed to be adaptive – the difficulty changes based on how someone is doing – and they provide immediate feedback.

After 40 hours of training, I returned to Kraus's lab for evaluation. I was particularly curious about the auditory brainstem response (ABR) test, because it looks at those very earliest stages of auditory processing in

"Just like your body, the auditory system needs regular exercise"

the brain. If you are looking for synaptopathy, that's where you will find it. Kraus also considers it a snapshot of overall brain health.

In my case, it's good news. My ability to perceive sentences in background noise improved substantially. Before training, I could only pick out target sounds if they were at least 1.75 decibels louder than the background (see "Hearing the difference", page 47), but after training I could pick out just sounds 0.5 dB louder. "It's as if the mixing board in your

brain has turned down the noise knob by 1.25," Kraus says. To put that in context, a 1 dB improvement increases intelligibility of approximately 10 to 15 per cent of the words.

The speed with which my brain processed sounds also increased by 0.26 milliseconds. "Although this doesn't sound like a lot, it is substantial. For a 56-year-old, this improvement gives you the neural timing of somebody almost a decade younger," Kraus says. It's this increase in speed that helps the brain recognise similar-sounding consonants, like "b" and "d".

Confidence boost

So my test scores improved significantly, but did this translate into real improvements in my day-to-day hearing? The main criticism levelled against brain training is that even when there are improvements in a test situation, the real-world effects can be disappointingly small.

I can say there was no "eureka" moment when my hearing suddenly improved. I still misunderstand conversations. And yet the training did give me confidence. I realised I had developed a learned helplessness, always asking "what?" when I didn't understand something. The exercises broke that cycle. During training you have to answer, and the software sets the difficulty so that your guess will be right more often than not. This gave me the confidence to guess in real life.

Whether this kind of improvement is enough to justify investing in auditory brain-training software is for affected individuals to decide. You will probably need to keep at it to maintain any gains, and not everyone will see improvements. But the confidence boost could be worth it.

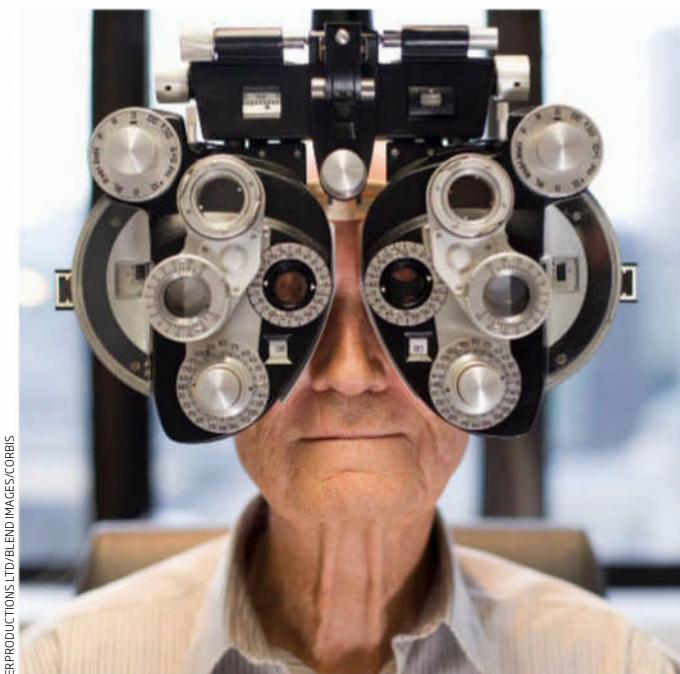
"I don't think we have evidence at this point to state that this will help everybody, so as a scientist I can't endorse it," says Tremblay. "But as a clinician, I think that if somebody feels they are gaining benefits from it, and it motivates them to work with their auditory system and become a better listener, then I would encourage that."

There may be cheaper and more enjoyable ways to work on that system, too. Kraus has found that musicians are protected from some effects of age-related hearing loss. In tests to pick out speech from background noise, musicians have the performance of somebody 20 years younger, probably because listening carefully to subtleties in music trains the same abilities.

Tuning in to different kinds of audio could also help. As Tremblay puts it, your auditory system, just like your body, needs exercise. "Whether it's books on tape, or a computer-based training experience, taking advantage of sound and using your own faculties is always a good thing." ■

Looking good

Glasses are far from the only way to see better, says Clare Wilson



ER PRODUCTIONS LTD/BLEND IMAGES/CORBIS

Not many of us have perfect eyesight, and we will all develop problems as we get older. Until recently, glasses or contact lenses were just about the only options. But as we've learned more about the eye, we've come up with some surprising ways to preserve or enhance vision, from changing what you eat to software that lets you read your smartphone without reading glasses.

SCREENS THAT DO THE FOCUSING FOR YOU

The lenses in our eyes get stiffer as we age, making it harder to focus on things that are close up. This is why people start to need reading glasses from their 40s onwards. Eventually, nearly everyone will own a pair. But it can be a pain putting on your glasses

every time you look at your phone, for instance, assuming you can remember where you put them.

Glasses work by partly focusing light before it hits the eye – so if you are looking at a screen, why not make it do the focusing for you? A team at the Massachusetts Institute of Technology has shown that plastic screen covers can correct for all kinds of vision problems – effectively, the screen wears the glasses. But rather than making plastic covers tailored to individuals' eyes, the team wants to exploit the ability of existing 3D screens to control the direction of light. The idea is that instead of the screen providing a 3D image, users could adjust the settings to "pre-focus" light as their eyes require.

Few handheld devices have 3D screens so far, but something similar can be done with software alone. "We know how the eye works

so we mathematically invert that and compute the image," says Daniel Aliaga, a computer vision researcher at Purdue University in West Lafayette, Indiana, who helped develop the idea. The software distorts images on the screen in such a way that it mimics the effect of a lens bending the light rays before they reach the eye. "It looks weird to anyone else but to you it looks sharp," says Aliaga.

The approach works with both text and images, he says, so with pre-focused screens people would no longer need reading glasses. The Purdue team's start-up, called CPrecisely, is developing apps that can modify the text on tablets, phones and computers. The first is a free alarm clock phone app.

"Imagine you're in bed and you want to see what time it is," says Aliaga. "Instead of searching for your glasses you just pick up your phone."

EAT YOUR GREENS

During the second world war, British propagandists circulated rumours that RAF pilots were such good night fliers because all the carrots they ate helped them to see in the dark. In reality the British were trying to keep their use of radar secret.

Yet it turns out that there is some truth to the idea that diet can affect our eyes. Retinal cells contain three yellow pigments – lutein, zeaxanthin and meso-zeaxanthin – which absorb near-ultraviolet light, protecting the eye from its damaging effects and reducing glare. These pigments are concentrated in the centre of the retina that produces the sharp central area of our vision, the macula. “It’s like wearing internal sunglasses,” says Billy Hammond of the University of Georgia in Athens. “It reduces the light intensity and absorbs scatter.”

We get these pigments from food, and the richer our diet is in them, the higher the levels in our macula. In theory then, people of any age could boost their eyesight by improving their diet or taking supplements. A small trial

of supplements, in which 36 people took a pill containing all three pigments every day for six months, yielded positive results.

The effect was big enough that people should have noticed the difference when coping with the glare of car headlights at night, for instance, says team member John Nolan, a nutrition and vision researcher at Waterford Institute of Technology in Ireland.

Nolan says boosting macular pigment levels should be even better than wearing yellow-tinted glasses for driving at night, as some people do, because such glasses block blue light from the whole of the retina. Extra macular pigment, by contrast, doesn’t stop the light reaching the retinal cells outside the macula, so peripheral vision is not reduced.

Nolan takes the supplements himself, and

thinks taking all three is important. Hammond, however, thinks it is best to get these compounds from your diet, by eating plenty of vegetables – kale, spinach and red peppers are among the best sources. Eggs are another. “We like things to seem like drugs, but you’d always be better off just eating some spinach,” Hammond says.

A diet rich in macular pigments could not only improve your sight, it might actually save it. As we get older the retinal cells in the macula often become damaged. As the disease progresses, people develop a blurred patch in the centre of their vision that gets worse. Over a quarter of over-75s have macular degeneration, making it the biggest cause of blindness in Western countries.

As there is no cure, the best approach is to detect macular degeneration early and try to stop it progressing. Telltale yellow spots appear in the tissue underlying the retina before symptoms appear. Trials have shown that people in the early stages of the disease who take supplements of macular pigments, vitamins C and E, and zinc are 25 per cent less likely to suffer deterioration in their vision.

“In theory, people of any age could boost their eyesight by improving their diet”

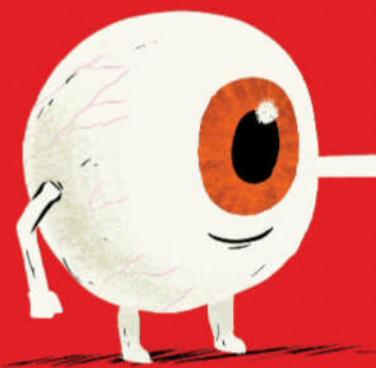


fig. Prefocused

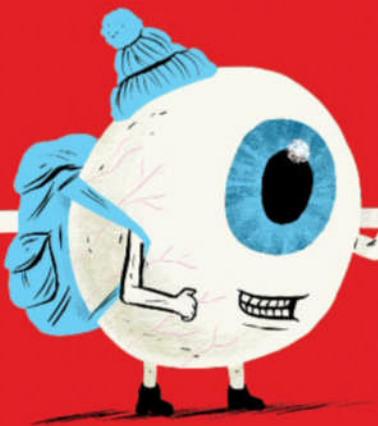


fig. Exercise



fig. Eat Greens

BETTER LENSES

The natural lenses in the eye tend to become cloudy in old age, with more than half of people over 80 developing the problem in at least one eye. It has long been routine to treat cataracts, as they are called, by replacing the lens with an artificial one.

The standard replacement lenses, however, can only focus light from distant objects, unlike the natural lens, which changes shape to focus on different distances. That means people still need reading glasses after a cataract operation.

Replacement lenses have been introduced that mimic the variable focusing power of the natural lens, meaning many people who have cataract surgery can dispense with glasses completely. "I've had 82-year-old patients who've worn glasses since they were 8," says Anne Sumers, an ophthalmologist in Ridgewood, New Jersey, and a spokesperson for the American Academy of Ophthalmology. "It's so exciting for them."

There are several designs. One type, for instance, is made in such a way that it has

different light-bending powers at different places within the lens. The brain somehow pays attention only to the light rays that give the sharpest image for the object you want to see and ignores the rest. "The visual cortex chooses the points of best focus," says Bruce Allan, a surgeon at Moorfields Eye Hospital in London. "Everything else is photoshopped out."

Cataract surgery is a no-brainer if you need it, whatever kind of replacement lens you get. However, there are also other kinds of implants designed specifically to replace glasses. One type is for people who are so short-sighted that they can't have corrective laser surgery as it would cut away too much of their cornea. Known as intraocular collamer lenses, these implants are inserted just in

front of the natural lens. "It's like putting spectacles inside the eye," says Allan.

Another kind of implant, called corneal inlays, treat the long-sightedness that comes with age, so you could throw away your reading glasses. But there have been reports of side effects so the jury is still out safety-wise.

GET MOVING

Doing eye exercises won't stop you needing glasses (see "Game on", page 52). But ordinary exercises like running might just save your sight as you get older.

Running or walking reduces your chances of getting cataracts, according to a massive study that followed over 40,000 people for six years. According to a smaller study, running also reduces the risk of macular degeneration – the leading cause of blindness in developed countries. The exact mechanism isn't clear in either case, but exercise is of course known to have a whole host of benefits. ▶

"Many can dispense with glasses entirely, even if they've worn them all their lives"



fig. Implants

fig. Play

DID YOU KNOW?

The latest in personalised medicine: eye drops made from your own blood. It might sound like a celebrity fad, but it is a bona fide treatment for people whose eyes do not make enough tears, leading to dry, sore eyes. In severe cases, ordinary eye drops may not bring relief as they lack the antibodies, growth factors and nutrients present in natural tears. The blood "tears" do.

Don't do headstands if you have glaucoma. This condition, which affects about 2 per cent of people over 40, is caused by raised pressure within the eyeball, and can lead to blindness. Tipping yourself upside down more than doubles the pressure inside the eye, and regularly practising such "inversions" during yoga has been linked with worsening glaucoma in several cases.

Things that aren't bad for your eyesight: watching TV, using computers and reading in dim light. "Reading in poor light is difficult and uncomfortable, but there's no good evidence it does you any harm," says Bruce Allan, a surgeon at Moorfields Eye Hospital in London.

Scared of laser eye surgery? It's actually safer than long-term use of contact lenses. The risk of laser surgery damaging the surface of the eye to the extent that you need a corneal transplant is about 1 in 3000. The yearly risk of a serious corneal infection from contact lenses is 1 in 2000. Daily disposable contact lenses are the least likely to trigger infection.

Gaming boosts some aspects of vision, but young eyes need time outdoors



GENE BLEVINS/REUTERS/CORBIS

Another common eye disorder is diabetic retinopathy, when the blood vessels of the retina overgrow or leak. This can damage the retina, affecting vision, and eventually lead to blindness. All the things that help prevent type 2 diabetes, such as exercise, also help prevent diabetic retinopathy.

People can also have the equivalent of a stroke within the eye if a clot blocks one of the blood vessels that feed the retina. Such "retinal vein occlusions" can trigger transient or even permanent loss of vision.

The best way to avoid one is to do all the things that prevent a stroke in the brain, says Anne Sumers, a spokesperson for the American Academy of Ophthalmology. Stay active, watch your blood pressure and cholesterol levels, and above all, don't smoke.

better at interpreting the signals it receives from the eyes. The main focus of research has been contrast sensitivity – how well we can discern things that are only slightly darker or lighter than their surroundings. It is important for reading in poor light, say, or driving at night.

There have been some apparently impressive results reported with training schemes involving Gabor patches. These look like blurry lines, and the exercises typically involve spotting ever-fuzzier lines that get harder and harder to distinguish from the background. One study suggests that older people, who tend to have worse contrast sensitivity, could regain similar abilities to those in their early 20s.

Several apps are on sale so you can try these exercises at home, but it's not yet clear whether they improve vision in real life or just make people better at detecting Gabor patches. Most eyesight specialists want to see more controlled trials done before they recommend their use. "It's probably too soon to know," says James Tsai, an ophthalmologist at Mount Sinai Hospital in New York, US.

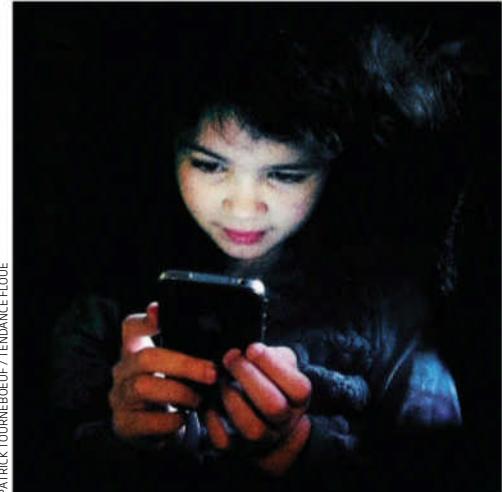
In the meantime, some of the strongest evidence that brain training can improve vision comes from studies of computer gamers. Daphné Bavelier, a neuroscientist now at the University of Geneva, Switzerland, first became aware of the effect after some students who were keen gamers scored more highly than expected on vision tests.

Her team has been studying this phenomenon ever since. They have shown that people who spend a lot of time playing

GAME ON

In his 1920 book *Perfect Vision Without Glasses*, William Bates claimed that doctors did not understand how the eye works and that anyone could achieve perfect vision by, for example, staring at the sun (do not try this at home!). His mad ideas remain popular to this day: countless books and websites still claim that "natural vision correction" can be achieved simply by doing eye exercises.

In fact, there is no evidence that any kind of exercise improves the eye's focusing powers, which is the cause of most vision problems. But there is evidence that the brain can get



action games have better contrast sensitivity than non-players. Not only that, but when they asked people who don't usually play these games to do so for 6 hours a week for nine weeks, their contrast sensitivity improved by 43 per cent.

The effect is strongest with so-called first-person shooters, which some claim increase violent behaviour. "It's the games that are ostracised," says Bavelier. For comparison, non-gamers who played *The Sims* for six weeks only improved by 11 per cent. However, it might be possible to create games that have

"Students who were keen gamers scored better than expected on vision tests"

the same effect as first-person shooters without the violence.

The people in her study were all in their 20s and already had good vision, so Bavelier doubts they would notice the effect on their vision in everyday life. Some of her volunteers spotted one result of the training, though: the screens of old-style cathode-ray tube monitors seemed to start flickering because their vision was now sharp enough to spot the pixels being refreshed. Fortunately, that side effect doesn't happen with modern LCD screens.

Bavelier thinks that computer-game-based brain training is most likely to produce meaningful improvements in vision in people

who already have problems, although her team has yet to demonstrate this. In theory, older people with declining contrast sensitivity stand to benefit most. The trouble is that most action video games are too fast for older adults, Bavelier says, but some researchers are creating games specifically for them.

Brain training is also showing great promise as a treatment for what's called lazy eye, where the brain ignores the input from one eye, often because of a squint in childhood. It affects about 3 per cent of the population.

The standard treatment is to put a patch over the good eye to force the brain to use the bad one, but children sometimes refuse to cooperate, leading to permanent vision problems. The brain-training approach involves playing the computer game *Tetris* through special goggles, so that one eye just sees the falling blocks and the other sees the shapes at the bottom of the screen they slot into. The game can be played only if the brain uses both eyes, working together.

In one study, after 10 hours of training, vision improved dramatically in the lazy eyes of 18 adults, equivalent to two or three lines on an eye chart. The biggest surprise was that adults were able to benefit at all, as patching does not work in children over 12, says Robert Hess, an ophthalmologist at McGill University in Montreal, Canada, who led the work. "There's no current treatment for adults," he says.

A commercial version of the training game, called *Dig Rush*, is now being developed for home use. It uses cheap 3D glasses to show different images to each eye.

IMPROVE YOUR CHILDREN'S VISION

Short-sightedness is becoming more common in most rich countries, and is skyrocketing in certain parts of Asia. In Singapore, for instance, 80 per cent of young adults are now myopic. So why the increase?

Myopia typically arises when the eyeball grows too long, causing light from distant objects to be focused in front of the retina rather than on it. Because the condition is more common among those who are more educated, the obvious conclusion is that the development of the eye can be affected by spending too much time reading.

But the reality is not quite that simple. Some studies have found that the less time children spend outdoors, the more likely they are to become short-sighted. Findings like these suggest that it is not book or computer work that is harmful per se. Instead, the problem may come from failing to look into the distance.

"A hunter-gatherer would have spent a lot of time seeing things at a distance – not 12 inches in front of their face," says Billy Hammond, a visual neuroscientist at the University of Georgia in Athens.

Not all researchers agree that looking at distant things is the key. Some think that the brightness or quality of outdoor light is what matters. But for now, giving children regular doses of the great outdoors seems to be the best bet for avoiding short-sightedness. And it has a whole host of other benefits too. ■

GROWING FAT TO GET SLIM

IS THERE REALLY SUCH A THING AS FAT THAT CAN MAKE YOU THIN? CHLOE LAMBERT PUTS THE IDEA TO THE TEST

GIVEN my predilection for peanut butter and ice cream, the offer of a scan to measure my body fat wouldn't normally fill me with excitement. But this is no ordinary fat map, and for once I'm hoping to have a lot of the stuff.

While normal white fat stubbornly stores excess calories on hips, bellies and thighs, over the last few years a picture has emerged of a different kind of fat – one which, paradoxically, might help us to lose weight. This is brown fat, which challenges all our assumptions about the fat in our bodies: it burns calories rather than storing them.

It was not long ago we discovered that brown fat exists and is active in adults. Since then, it has become the focus of

attention as a potential tool to help combat obesity and its related diseases. And the idea that there might be a way to burn through calories without the need to exercise is a tempting prospect for many of us.

"We all know you only need a modest change in energy balance to put on weight – eating one or two extra biscuits a day is enough," says Michael Symonds at the University of Nottingham, UK. "So if you could activate brown fat, or increase its activity, you could potentially reduce your body weight."

Symonds is one of a number of researchers working to develop behavioural, surgical and pharmaceutical therapies that might harness the power of brown fat, and some of these could be as simple as taking a cold dip in the pool or eating spicy food. So when the offer came to work with his team to try and give my own brown fat a boost, I had to give it a try.

What makes brown fat so interesting is its ability to burn food directly to produce heat, whereas energy extracted from food is usually stored first, then released during activity such as exercise. It can produce 300 times more heat per gram than any other tissue in the body. This is because brown fat cells have a disproportionately high number of mitochondria – the small energy producing structures in cells – which also gives the stuff its eponymous colour. These mitochondria are slightly different from those in other cells, too, because they contain a protein called thermogenin, or UCP1, which enables brown fat to turn energy to heat directly.

This furnace-like ability is vital for regulating temperature in some mammals and in babies, who are unable to shiver to keep warm. But initially it was thought to become defunct

WHEN GOOD FAT TURNS BAD

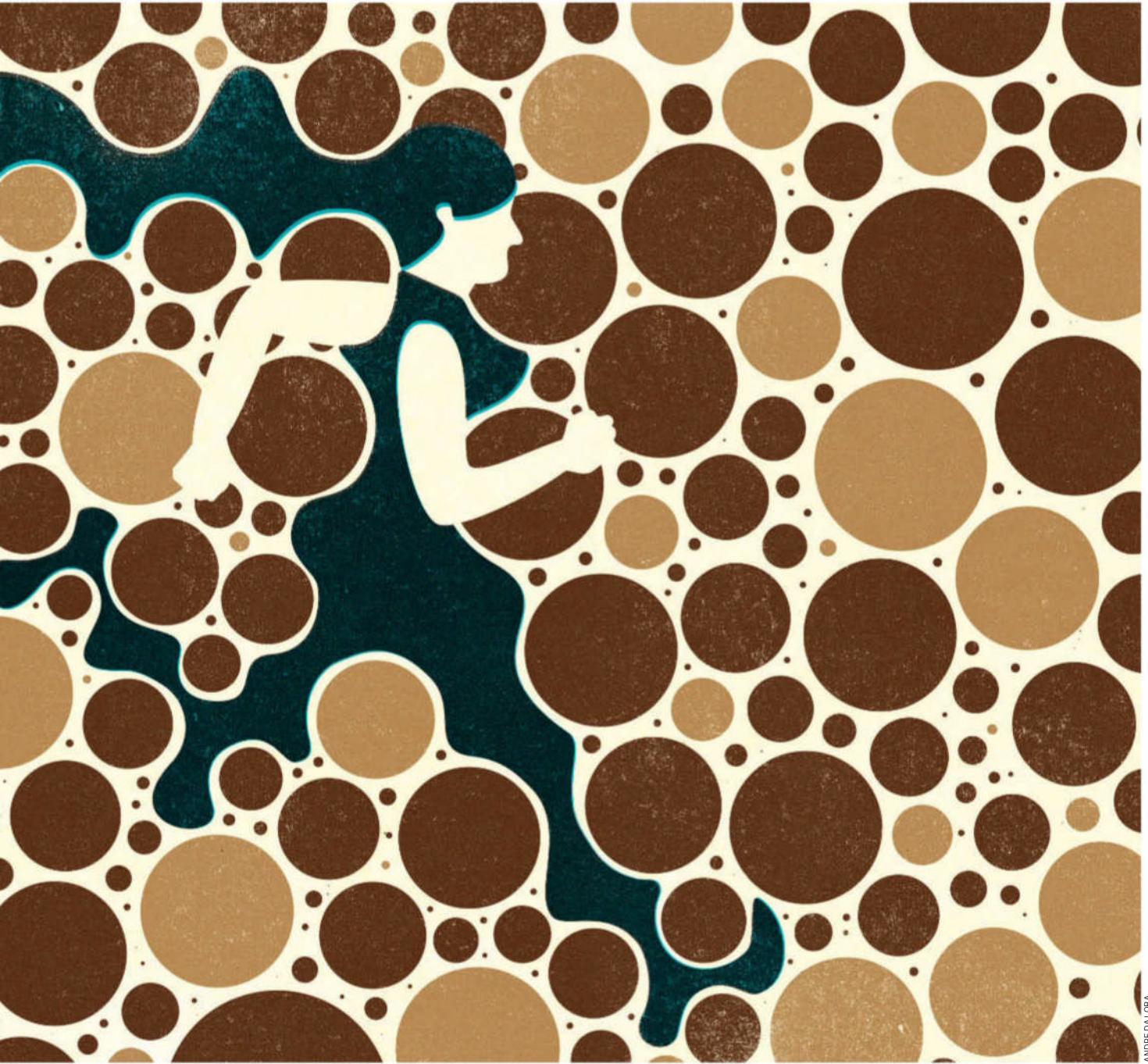
Switching on brown fat might help people to slim down (see main story), but switching it off could also be useful. Half of all people with cancer get cachexia, a condition causing extreme thinness, which also accounts for 20 per cent of all deaths from cancer. It now seems that brown fat is involved. Cancerous tumours cause white fat cells to turn into calorie-burning beige fat in mice. If the same is true in people with cachexia, it would explain why they lose weight even if they eat more. In 2014, a team at Harvard Medical School identified the protein that tumours release to cause this effect. When mice were treated with an antibody that neutralised the protein, their muscle mass and function were preserved. A similar antibody that works in humans is now being developed, and trials could begin within two years.

after infancy in humans. Then in 2009, several studies showed that brown fat was present and functional in adults in the neck, shoulders and around the spinal cord.

This discovery changed the question from whether adults have brown fat, to whether we can make use of it to help with weight control. "It was a eureka moment," says Symonds.

Although I'm not overweight, the idea of a fat that makes me thinner is certainly tantalising. The amount of brown fat each of us has varies, though. Slimmer people tend to have more of it, which might help explain why some people seem to burn through everything





ANDRE DALOBA

they eat, while others pile on the pounds.

So the first step is to find out how much, if any, of this “good” fat I have. Because brown fat is activated when the body is exposed to the cold, Symonds and his team have helped pioneer the use of a thermal imaging camera to detect it. The images clearly show two small glowing triangles at the base of my neck—hotspots of brown fat that get brighter when I plunge my hand in a bucket of cold water and the cells set to work (see image, page 56).

Because I have brown fat, Symonds says my best bet to try and burn calories the lazy way is to expose myself to the cold. When

animals are cold, they initially regulate their temperature by shivering. But after repeated exposure, shivering decreases while energy expenditure stays the same. Studies in rodents have shown that this is down to brown fat activity. If the same is true in humans, then regular cold exposure could help you adapt to the cold and burn calories in the process.

Evidence for this comes from an intriguing study conducted by the US army in the 1960s, which subjected 10 almost nude men to temperatures of 11 °C, for 8 hours a day for a month. Electrodes on their skin showed that, like rats, shivering decreased after about two

weeks, suggesting that their bodies had somehow adapted to the cold. The team concluded that another metabolic process was at work, although it remained a mystery.

Fifty years later, Anouk van der Lans at Maastricht University in the Netherlands and colleagues wondered whether brown fat was responsible. So in 2012 they recreated the study using PET scans and fat and muscle biopsies to measure brown fat activity, as well as monitoring shivering. After 10 days, brown fat activity had increased and the subjects were better at producing heat without shivering, so they shivered less. ➤

"BROWN FAT CAN PRODUCE 300 TIMES MORE HEAT PER GRAM THAN ANY OTHER TISSUE IN THE BODY"

They also found the cold easier to tolerate.

Encouragingly, in this study, a temperature of about 16 °C was cold enough to switch on the tissue. "Nobody thinks that getting so cold that you're uncomfortable is necessary," says Aaron Cypess of the US National Institute of Diabetes and Digestive and Kidney Diseases, an author of one of the 2009 papers.

But with just five days until my follow-up scan, Symonds says it won't hurt to get temperatures lower than that. So I keep the central heating at home off or on a low setting, even though it's just 4 °C outside. I drink iced water throughout the day, have a cool shower every morning and, for good measure, go for a swim in my local outdoor pool where the water is a breathtaking 3 °C.

How many calories can I expect to shed? Estimates vary hugely. One trial of Japanese men found that spending 2 hours a day in a 17 °C room for six weeks boosted brown fat activity by 50 per cent, and got rid of 5 per cent of their body fat. At the start of the experiment the men burned 108 calories during 2 hours in the cold, but this rose to 289 calories after doing it every day for six weeks.

That doesn't necessarily mean all those calories are burned by the brown fat itself – in studies that only involve short bursts of cold exposure, it could be down to other mechanisms like shivering. For example,

one study of volunteers with an average of 50 grams of brown fat found they burned around 300 extra calories a day when exposed to moderate cold for 30 minutes – but brown fat only accounted for 20 calories of this.

Despite the mixed results, those figures are encouraging enough for some people to make cold exposure part of their daily routine. "The mechanism of how it happens is important to understand, but for practical reasons, the result is what people care about," says Wayne Hayes, a NASA scientist who has created the Cold Shoulder, a waistcoat filled with ice packs designed to activate brown fat.

Cypess and others believe that brown fat could make a contribution to weight loss strategies with regular cold exposure. But what if you don't like the cold? There could be a tastier alternative.

BEIGE IS THE NEW WHITE

Capsaicin, a compound in chillies, seems to stimulate brown fat in a similar way. Mice fed capsaicin as part of a high-fat diet, for example, have increased metabolic activity and don't put on weight. This also fits with a small study in which 10 men who took capsaicin pills daily had greater brown fat activity in the cold and burned more calories after six weeks.

"Capsaicin is promising as it is natural, and relatively safe and inexpensive," says Cypess. "But we are awaiting the definitive experiment showing that a dose of capsaicin directly leads to activation of brown fat."

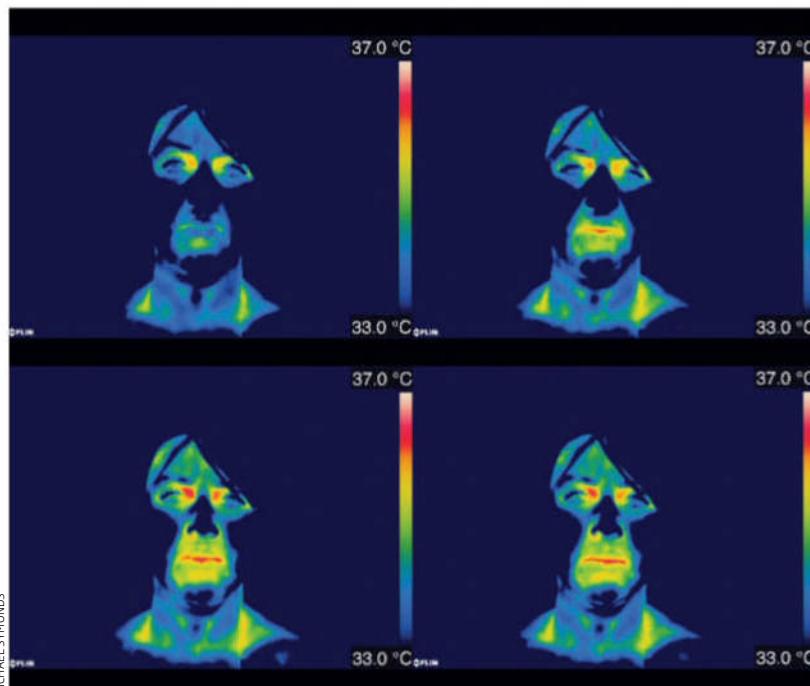
In the meantime, brown fat could have other benefits aside from calorie burning. It releases hormones that help regulate the metabolism of glucose and fatty acids, so might be useful to help treat diabetes and fatty liver disease. Humans and other animals with high brown fat levels have been shown to have better blood sugar and insulin regulation.

But there is a hitch: we have paltry amounts of brown fat and obese people have especially low levels. Stores also deplete as we age.

For that reason, arguably the biggest recent breakthrough in the field has been the identification of a third kind of fat, called beige fat. First described by Bruce Spiegelman at Harvard Medical School in 2012, beige fat has a different origin to classical brown fat, but it contains the same all-important protein, UCP1, which burns calories to generate heat. And while brown fat forms in tight pockets, beige fat is dispersed in white fat cells. Even better, it might be possible to transform white fat into the calorie-burning beige variety (see "Flavours of fat", right).

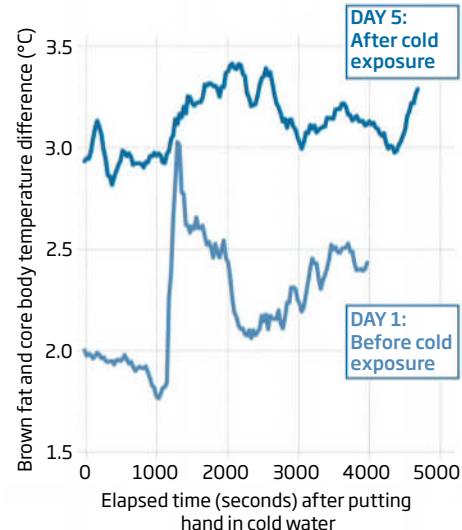
"With most experiments on brown fat you don't induce much new tissue, you just

Clockwise from top: Brown fat glows brighter as it becomes more active with time after submerging a hand in cold water



Chloe's brown fat boost

After 5 days of cold exposure, Chloe's brown fat was working harder – and burning more calories – as shown by the increase in temperature difference between her brown fat and core body temperature



activate it," says Ronald Kahn at the Joslin Diabetes Center in Boston. "With beige fat you get both an increase in the activity, and in the amount. So this is where people believe there are big therapeutic opportunities."

While most research has so far been in rodents, there is tentative evidence that humans too can turn white fat to beige. One way could be to throw off the duvet. Men who slept in 19 °C bedrooms with only bed sheets had 42 per cent more brown fat after four weeks, found Francesco Celi at Virginia Commonwealth University and colleagues. Glucose uptake increased in white fat, suggesting a rise in beige fat cells nestled within it. The men's insulin resistance, which is a key issue in diabetes, also improved.

Exercise might also help convert cells. Celi has found hints that a hormone called irisin, produced when muscles contract, stimulates white fat to produce beige fat cells, although the findings are still being debated. For good measure, I keep up my exercise routine, but switch indoor aerobics for a jog in the cold.

When I return to the lab after five days, Symonds's team finds that the difference between my core body temperature and my brown fat temperature had increased (see "Chloe's brown fat boost", left). "The fact that your brown fat temperature stayed the same even though your overall body temperature had cooled down, indicates that the brown fat tissue was more active, and having to produce more heat to keep you at a favourable temperature," Symonds says.

Then came the bad news: the brown fat boost didn't translate into any weight loss – in fact, I gained a kilogram. Symonds says it may be that brown fat needs to be activated for a longer period to see a change in fat mass. And although I tried to follow my normal diet, he suspects I may have compensated for the cold by eating more. In the sleep study, the boost in brown fat was reversed after the men spent another month sleeping in a warm room, which suggests you would need to make cold exposure a long-term fixture.

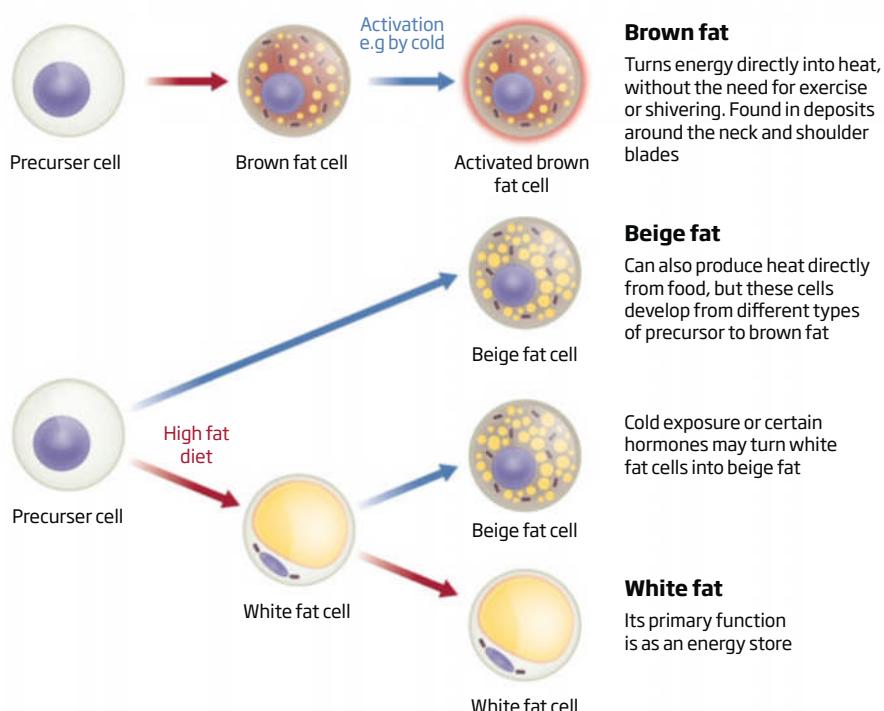
THIRD PILLAR OF WEIGHT LOSS

This highlights a big problem with thinking that boosting brown fat with cold exposure is an easy option: to some people, feeling cold is about as unappealing as slogging it out in the gym or living off salad. And our natural response to cold is often to eat more.

So a better tactic might be to find easier ways to simulate these effects. One hope is mirabegron, a drug developed as a treatment for an overactive bladder that also stimulates receptors on the surface of brown fat cells.

Flavours of fat

Fat isn't always the enemy when it comes to staying slim. Two types – beige and brown fat – can burn through calories, and animal studies show white fat can turn to beige



In 2015, a team led by Cypess found an increase in brown fat activity in 12 volunteers after they were given a dose of mirabegron. Their resting metabolic rate increased by 203 calories a day. And it works on brown and white fat. "Mirabegron causes white fat stores to break down, likely to be consumed as fuel by brown fat and other organs," says Cypess.

Another approach might be to convert white fat to brown in the lab and then re-insert it into the body. In 2010, Yu-Hua Tseng at Harvard's Joslin Diabetes Center took fat precursor cells from muscle and white fat tissue in mice and exposed them to proteins that influence development into brown fat cells. When they then injected them back into the mice, the treated cells developed into brown fat. Tseng's team has now identified the same mechanism in human fat cells.

A drug that mimics the effects of cold may not be far away either. A team at the University of California has discovered that in cold conditions the body sends signals to immune molecules called macrophages, which trigger browning of white fat to generate heat. Injecting mice with a dose of these signalling molecules activated the same immune response without the need to get cold, and the mice started

Brown fat

Turns energy directly into heat, without the need for exercise or shivering. Found in deposits around the neck and shoulder blades

Beige fat

Can also produce heat directly from food, but these cells develop from different types of precursor to brown fat

Cold exposure or certain hormones may turn white fat cells into beige fat

White fat

Its primary function is as an energy store

burning 10 per cent more energy.

Combining such approaches with cold exposure could increase brown fat's impact. It's likely that brown fat will become the third pillar of weight loss advice, says Cypess. "When you go to your physician, they'll advise you on eating right, exercising and keeping your brown fat healthy," he says. "And my hope is that if a person is uninterested in cold exposure they will be able to take a drug."

Until then, brown fat might not be the magic bullet so many hope. But it could be extremely effective for weight loss if used in combination with reducing calorie intake, says Kahn. Even a conservative estimate of burning an extra 100 calories a day would equate to losing around half a kilogram a month.

And with developments in thermal technology to monitor brown fat, Symonds is optimistic that screening for it could become routine. "It could provide an index of your metabolic health and tell you whether you are at risk of weight gain," he says.

As for me, the confirmation that I have brown fat, and can manipulate it, has been reassuring and I'll certainly be turning the thermostat down a few degrees in the winter. All the same, I won't be rushing back for another ice cold swim. ■

CAN YOU HAVE YOUR CAKE AND EAT IT?

Eat less and better, exercise more, stay off the booze, don't skimp on sleep, and live as virtuously and sustainably as possible. It's become a mantra for a good life – though most of us have trouble sticking to it.

But does that extra piece of charcuterie, that missed gym date (and the little white lie about it) or that cheap flight seeking sun and sangria mean you're a sinner? Find out which guilty pleasures you can get away with... and which ones you can't





In reality it's
not so easy to
spot a liar

LYING AND CHEATING

Whoever says honesty is the best policy is probably lying right there. Lying is a vital, smoothing part of the social fabric. We develop the skill young: most 3-year-olds will lie about not having peeked at a toy you told them not to look at. The average UK adult admits to lying 10 times a week – even if these tend to be little white lies, like inventing reasons for not answering a phone call.

These fibs are surprisingly easy to get away with. Contrary to popular opinion, there are no reliable “tells”, says Robert Feldman of the University of Massachusetts Amherst and author of *Liar: The truth about lying*. Shifty eyes or showing anxiety – behaviours commonly associated with lying – aren’t consistent indicators. And we are hopeless at detecting lies, for good reason. “Most of the time we assume that people are telling us the truth. It’s really cognitively exhausting to always be assessing whether other people are telling the truth or not,” says Feldman.

Even so, there are tricks we can learn. The best liars are “natural performers”, says Aldert Vrij, a psychologist at the University of Portsmouth, UK. They “naturally exhibit behaviours that observers associate with honesty, such as making eye contact, smiling and smooth speech lacking in ‘ums’ and ‘ers’, even when they are lying”, he says. Many successful liars also mask signs of thinking hard – and it seems

good-looking people are more likely to be believed when telling porkies.

As for taking lying to the next level – from creating Ponzi schemes to leading a double life – complex deceptions might be easier than you would imagine, Feldman says. Keeping secrets is part of being human, and we are adept at compartmentalising our lives, for instance having different personas at work and at home.

THE CLINTON EFFECT

Since telling white lies is so common, higher-level deception can become habitual for many people, says Feldman: “Think about all those people who are lying to their spouse, mostly by omission, and getting away with it.” And when a major deception is found out, some people manage to get off lightly – especially if they never came across as a paragon of virtue anyway. A good case study might be Bill Clinton, says New York-based psychologist Michael Shulman: his reputation as a “lovable rogue” helped him keep the presidency despite his transgressions.

We probably all lie much more than we realise. In one study, Feldman filmed students interacting with a stranger for 10 minutes. When he replayed the footage, the volunteers were surprised at how much they had lied – on average two or three times. When it comes to lying, the truth is we are already getting away with it.

Alison George

CHOCOLATE

There are worse sins than being a chocoholic. Much of the UK's chocolate industry was set up by Quakers trying to tempt people away from booze. Now we are hooked on chocolate instead. In the UK, each of us scoffs an estimated 7.5 kilograms every year.

Is that a bad thing? Dark chocolate has been branded a superfood, after studies showed eating 100 grams boosts heart-protecting antioxidants in the blood for several hours.

Milk chocolate, and even dark chocolate consumed with milk, doesn't have the same effect –

compounds in the milk seem to bind to the antioxidants and stop the body from absorbing them.

Weight for weight, milk chocolate has the downside of more fat and calories, too. The easiest way to deal with overindulgence is to exercise, but the effort might make you spit out your Mars bar. To burn off a standard-sized one, you would need to run up flights of stairs for roughly 20 minutes.

A shortcut to having your chocolate cake and eating it is to adopt a fasting diet, which typically entails eating just 500 to 600 calories a day for two days

of the week, and whatever you want the rest of the time. One study of more than 100 obese women found that dieting this way over six months led to the same weight loss as sticking to a more conventional calorie-controlled diet 24/7. And fasting led to greater improvements in blood-sugar control.

Still, severely cutting your calorie intake, even for a day or two, isn't for everyone. Most chocolate bars are about 30 per cent fat, so reducing that content without compromising the flavour might help. One way is

to replace some of the fat by an emulsion of cocoa butter and water. This method, pioneered by French gastronomer Hervé This, is practised by chocolatiers such as London-based Aneesh Popat. “Water, having no taste of its own, leaves the consumer to enjoy unadulterated pure chocolate,” he says.

Popat's delicacies are served up in Michelin-starred restaurants, but you can make your own low-fat version at home using agar. Just make sure you stash them in the fridge well before the craving hits. Catherine de Lange

INACTIVITY

Sitting is the new smoking. Sedentary lifestyles are being blamed for cardiovascular disease, diabetes and even some types of cancer, and the World Health Organization recommends that adults do two and half hours of moderate exercise or 75 minutes of intense exercise each week. Couch potatoes may scoff at this idea, and they are in good company: around half of people in the US, as well as 37 per cent of men and 45 per cent of women in England, fail to do even this modest amount. Often we blame lack of time. Is there an easier way?

"Any exercise is better than nothing," says Chris Easton at the University of the West of Scotland in Paisley, UK. "There's no question that any exercise you do leads to reduced risk factors for mortality."

One shortcut is high-intensity interval training, or HIIT. Its devotees claim you can get fit by exercising in short, intense bursts a few times a week, a "go hard, then go home" approach backed by numerous studies.

Some particularly encouraging research came from Richard Metcalfe, then at Heriot-Watt University in Edinburgh, UK, and his colleagues. They found that 10 minutes of leisurely cycling, interspersed with two 20-second sprints, three times a week, boosts cardiovascular fitness as much as more conventional routines. Participants didn't judge the workout as particularly arduous either, despite the strenuous sprints.

If even that sounds too much like hard work, some researchers have begun to question whether current exercise guidelines are overzealous. "I think you'll start to see a shift where the message will change to 'do something,'" Easton says. A study from the University of Utah found that sedentary people who took a stroll every hour for just



Live slow,
die young

LEFT: RENOLD ZERGAT/GETTY; RIGHT: CORBIS

2 minutes were 33 per cent less likely to die in the three-year follow-up period than those who just stood up for 2 minutes instead.

It also seems that the first 15 to 20 minutes of exercise bring the biggest benefits. One study of over 400,000 people in Taiwan found that those who did just 15 minutes a day in total – half the recommended amount – lived on average three years longer than those who were inactive (see diagram, below). The first 20 minutes of exercise are so effective that each session could add half an hour to your life. **Catherine de Lange**

RED MEAT

A succulent steak with creamy peppercorn sauce or a chunky burger laden with cheese. Could there be a better route to heaven (via a heart attack)?

Meat often gets a bad rap when it comes to health. When consumed in abundance, red meat probably does raise the risk of colorectal cancer and cardiovascular disease.

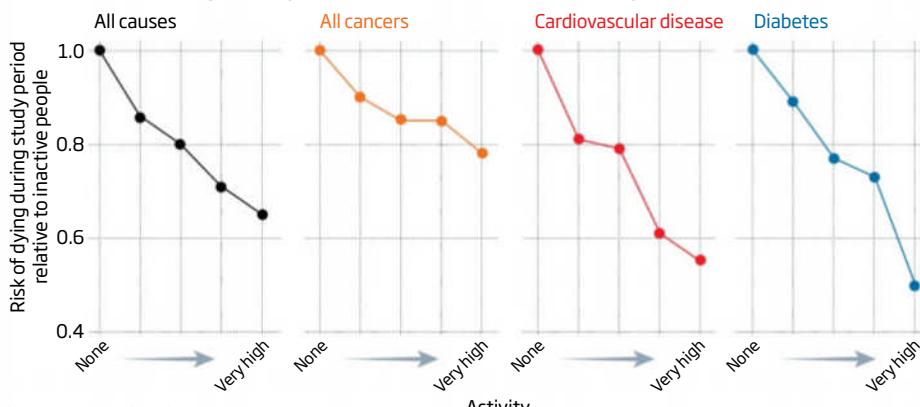
So what do you do if steak and blue cheese just happen to be your favourite flavour combination? Well, you might be on to a winner – it's just possible that adding dairy to your meat consumption might limit the damage.

First, it might help mop up some of the fat. France has one of the highest levels of cheese consumption in the world, yet one of the lowest levels of coronary heart disease. Some put this down to the fact that the French also consume a lot of vegetables, but several studies suggest that consuming cheese or milk causes a drop in the levels of "bad" LDL cholesterol in people's blood. "When you look at people who eat a lot of cheese compared to those who don't eat any, there's no difference in cardiovascular risk or diabetes – and if anything it tends to be beneficial," says Arne Astrup at the University of Copenhagen in Denmark.

One possible explanation is that the calcium present in abundance in cheese is binding to fatty acids and cholesterol in the gut, causing some of them to be excreted. However, giving people

A little goes a long way

An eight-year study of 400,000 people in Taiwan showed that even low levels of activity reduced the likelihood of death during the study period compared with complete inactivity



SOURCE: THE LANCET, VOL 378, P 1244



Meat is better with dairy

calcium supplements doesn't seem to have the same beneficial effect. It's also possible that certain bacteria or fermentation products in the cheese influence the balance of nutrients that are absorbed by the body.

SUPER SPUDS

Calcium consumption could also be a way to reduce the damage caused by another constituent of red meat: heme. This iron-rich substance plays a key role in transporting oxygen around the body, but free heme can react with DNA in the cells lining the gut and boost the risk of developing colorectal cancer.

Calcium seems to mop up heme and render it harmless; rats fed a heme-rich diet seem to be protected against its carcinogenic effects if calcium is added to their food. Sadly for steak-lovers, high levels of calcium react with protein, rendering meat hard and dry. Adding milk, cheese or yogurt to the meal might have the same effect, but it's unclear how much you would need to eat to negate heme completely. And high cheese consumption is bad for your waistline and so can bring health problems of its own.

What about vegetables? The EPIC trial, one of the largest investigations into the health effects of red meat, found that the early death risk was lower in meat eaters who reported consuming lots of fibre (abundant in many plant-based foods) than in

people who ate very little meat. Similarly, people benefit from eating cold potatoes with their meat. It appears that what is called butyrylated resistant starch, produced when potatoes are cooked and then left to cool, protects against DNA damage to gut cells and so may blunt red meat's association with colorectal cancer.

Then there's processed meat, widely considered more harmful than fresh on account of the nitrite preservatives used in its production. These can react with fats in the diet and produce other cancer-promoting substances. Here, too, fruit and vegetables may provide a solution as some of them

"Eating dairy with your meat might just help to limit the damage"

contain chemicals called flavonoids. Concentrated flavonoids are currently being investigated as an alternative to nitrites for preserving meats. "They stop microbes from growing and the meat has a shelf life which is acceptable to meat producers," says Gunter Kuhnle at the University of Reading, UK. "The idea is to help the food industry to produce meat where the links with colon cancer are at least reduced, or maybe not there at all." Linda Geddes

LATE NIGHTS

From burning the midnight oil at work to partying until the early hours, most of us have cut corners when it comes to sleep. That can have a serious impact on our ability to function. According to Charles Czeisler at Harvard Medical School, being awake for 24 hours will leave you with the same level of cognitive impairment as having a blood alcohol volume of 0.1 per cent, which would push you over the drink-drive limit in several countries.

The areas of the brain involved in attention, judgement and sensory processing are particularly hard hit. Accident statistics bear this out: traffic accidents peak in the early hours when the circadian drive for alertness is at a low, and our drive for sleep is the strongest. The impact on abilities depends partly on age; lab tests show that young people's reaction times suffer more than older people's after being kept up all night. Lack of sleep also affects the parts of the brain in charge of emotions and decision-making, and makes people more impulsive.

Can you counter such effects? Stimulants like caffeine can mitigate the effects of sleep loss, but a better strategy might be to catnap your way to a more coherent state of mind. "You can certainly offset the impact of sleep loss by strategic napping," says Judith Owens at Boston Children's Hospital. A short nap of just 10 to 30 minutes can improve alertness for 2 to 3 hours afterwards. A nap exceeding half an hour will have longer-lasting benefits, but is likely to leave you feeling even more groggy than before you nodded off, a phenomenon known as sleep inertia. An expert tip for avoiding that is to drink a cup of coffee just beforehand. The caffeine will kick in after about 20 minutes - in time to wipe away that hazy feeling when you wake.

Trying to get away with lack of sleep over the long term is much more risky. For one thing, its effects are much more insidious. Sleeping for 6 hours a night instead of 8 for two weeks, for instance, produces the same cognitive deficits as going 24 hours without sleep. But you may not pick up on it - people stop feeling as tired after the third or fourth day of sleep deprivation, even though their abilities are still deteriorating.

The effects of long-term lack of sleep are harder to get away with too, with elevated risk of diabetes, cardiovascular disease and some cancers. And if you have been repeatedly burning the candle at both ends, it can take weeks to recover, Czeisler says.

What about the idea that you can undo the damage with a very long recovery sleep? Probably not. "It's not like you can bank sleep," Owens says. "We don't know whether short sleep during the week and sleeping in at the weekends impacts people's long-term cardiovascular morbidity. But the evidence we have so far suggests that it's not a good way of dealing with it." Catherine de Lange

SCREEN TIME

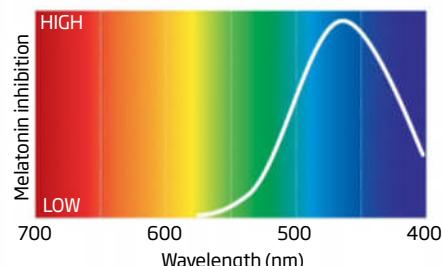
Text neck, *Candy Crush* thumb, iPad hand - the list of screen-related ailments is growing. Add in claims the internet is rewiring our brains, and the 4 or 5 hours a day we spend poking at phones and tablets starts to look like a health risk.

Most of these problems have a quick fix, though. Let's take the physical injuries. Text neck - looking down at a screen in your hands - puts strain on your upper back. Surgeon Kenneth Hansraj at New York Spine & Rehab Medicine claims that dropping the chin by 60 degrees is equivalent to making the spine support an extra 12 kilograms. And long periods spent jabbing and swiping or holding a tablet in an awkward grip can lead to stress injuries in the hands and thumbs. The compulsive playing of video games can also reduce pain sensitivity, meaning you could be damaging yourself without realising it. So keep your chin up and take regular breaks, regardless of how you feel at the time.

There are more subtle problems, too. Screens

Night light

Our phones and tablets emit plenty of blue light - the colour that most reduces production of melatonin, the hormone that makes us sleepy at night



SOURCE: JOURNAL OF NEUROSCIENCE, VOL 21, P 6405

are strong emitters of blue light, which inhibits the production of the sleep-promoting hormone melatonin (see "Night light", below left). So using them in the evening can shift our circadian rhythms out of whack, and even cause insomnia. In one study, Anne-Marie Chang and her colleagues at Harvard Medical School got volunteers to read from either an iPad or a book for four hours before bedtime over two weeks. When reading from the iPad, melatonin secretion was delayed by an hour and a half. The volunteers also felt more tired the next day compared with when they read books, and spent less time in REM sleep, which is thought to help us consolidate memories. The easiest fix is to switch off a few hours before bed, or use e-readers that don't emit blue light. If you must doze off to your favourite box set, reduce the brightness of your screen via your device's settings or a screen dimming app.

Screen time also tends to mean being inactive. In a study of 4512 people in the UK, Emmanuel Stamatakis at the University of Sydney, Australia, and colleagues found that those who spent more than 2 hours a day in front of a screen were more than twice as likely to have cardiovascular disease regardless of other common risk factors such as smoking, being overweight and social class. So try not to make screen time an additional reason to laze about.

And the impact on our brains? Kathryn Mills at University College London has reviewed studies to date and found no evidence that internet use has an impact on cognitive development. "Our brain is always changing: that's how it works," says Mills. "If all of a sudden you had to adapt to not having the internet, you would be fine." Douglas Heaven



POL FOTO/PMCA

BOOZE

If you like to end the night with tequila slammers, a pounding head could be the least of your worries. In the long run, drinking to excess risks harming your liver and other organs, various cancers and raised blood pressure.

Moderate drinking was thought to offer some protection against cardiovascular disease. One study found that a small drink every other day can reduce the risk of heart attack by a third, possibly because alcohol helps thin the blood. That study was in men, and more recent research suggests that the only people who might stand to benefit from light drinking are women over 65.

WEIGHING UP THE RISKS

Calculating whether your guilty pleasure pays is hard: statements about health risks and benefits can be tricky to wrap your head around.

With activities like motorcycling or skydiving, one way is to think in micromorts - a micromort being a one-in-a-million chance of dying then and there. This unit is useful for pursuits that could kill you on the spot, says statistician David Spiegelhalter of the University of Cambridge. "When you do these activities, you are going to be healthy unless you are dead."

For lifestyle choices that chip away at good health - eating to excess, or smoking - think instead in microlives. A microlife is a millionth of a life, and equates to about half an hour. Spiegelhalter reckons that, for regular smokers at least, every two cigarettes costs one microlife. "This enables you to make comparisons across broad ranges of activities using common units, and without having to use very technical units like person years lost per something, or hazard ratios," he says.

Let's weigh up skydiving against

riding a motorbike. Seven to 10 people die for every million parachute jumps, so that's 7 to 10 micromorts. On a motorbike, you'd do about 10 kilometres before reaching 1 micromort. So one skydive is like 80 kilometres on a motorbike.

Microlives are useful because of the psychological barrier we put up when considering the long-term health consequences of our actions. "It's all to do with the end of your life and people, especially young people, tend not to care so much about living an extra year being old and dribbly."

So the idea of the microlives is that this is happening to you now. You're ageing faster because of your behaviour," says Spiegelhalter.

Good habits can also improve life expectancy. Spiegelhalter has devised a microlife calculator (see right) which can help you see whether your good habits outweigh the bad. "The image is of course coming out of the gym and going to the pub," says Spiegelhalter, "which when I used to go to the gym is what I always used to do. But it's not to be encouraged." Catherine de Lange



Make it a half

If you find yourself dragged into a drinking game and want to keep your head while all about are losing theirs, is there anything you can do to ward off intoxication? There's nothing proven to help yet, but there's promise in a traditional Chinese remedy: an extract from the oriental raisin tree *Hovenia dulcis*. Known as dihydromyricetin (DHM), it binds to receptors for the neurotransmitter GABA, which in turn blocks ethanol's intoxicating effect, says Jing Liang of the University of California, Los Angeles.

SPRY AND DRY

Popping one DHM pill while drinking won't reduce your blood alcohol level, but should in theory reduce intoxication. It works in rats, says Liang, and people who take DHM while still under the influence of alcohol report improvements in concentration and clarity of thought.

A more natural way to soothe the liver is to give it a little holiday. "Dry January" is often touted as a way to get a health boost after seasonal indulgences, but there's little research to back this up. So in 2013, 14 *New Scientist* staff tried it out. Ten gave up drink for five weeks and saw an average 15 per cent reduction in liver fat, whereas the other four saw no change; too much fat in the liver can lead to liver disease. The abstainers' blood glucose and cholesterol levels also improved markedly. It seems a month on the wagon can offer fast, dramatic health effects.

If you have more money than brain cells left following a big night out, you could consider what is regularly touted as "the latest celebrity trend": pricey intravenous infusions designed to replace the fluids you lost the night before. Just like tequila, you might want to take that one with a pinch of salt. **Sean O'Neill**

Even so, there are things you can do to maximise the pleasure and nix the pain. If you wake up with the start of a hangover, trust your instinct and keep the curtains tightly closed. Analía Karadayian and her colleagues at the University of Buenos Aires in Argentina gave mice alcohol and then monitored their hangovers. Under normal day/night conditions, the animals took about 20 hours to get back to their normal levels of activity and coordination. But mice left to recover in total darkness were fighting fit in just 8 hours. "Hangovers can break the operation of our internal clock, so darkness could encourage recovery," says Karadayian.

ACCOUNTING FOR TASTE

Activity	Microlives
2 hours watching TV (sedentary)	-1
Smoking 2 cigarettes	-1
First unit of alcohol of the day	+1
Each subsequent unit (up to 6)	-1/2
First 20 minutes of physical activity	+1
Each subsequent 40 minutes (men)	+1
(women)	+1/2

PETER ROOS/PLAINPICTURE



Better than tomatoes

SUNBATHING

Only mad dogs and Englishmen go out in the midday sun, the song goes. Catching too many rays causes wrinkles and freckles at best, and deadly cancer at worst. And yet nothing feels quite as good on the skin as the warm kiss of the sun's rays. This feel-good factor - which may even elicit a response akin to addiction - might have evolved from our need for sunlight to make vitamin D.

What's a prudent person to do? The one thing nobody should try to get away with is sunburn, which not only hurts but has been shown to double the risk of melanoma, the rarest but most dangerous form of skin cancer. "All sun exposure causes cell mutations that may eventually lead to cancer, but sunburns exacerbate this effect," says Eleni Linos at the University of California, San Francisco. "It's a very intense dose."

How much sunning you can do in relative safety varies from person to person. "It really depends on your skin type," says New York-based dermatologist Michele Green. The darker the skin, the higher the concentration of melanin, a pigment that shields

"Nothing feels so good as the sun's warm kiss – but is it deadly?"

skin cells from the damaging effects of UV rays. "It is kind of like a natural sunscreen," Linos says. People with Mediterranean, olive-toned skin, for instance, are half as likely to develop melanoma than those with very pale skin.

To help you navigate the issues, there are wearable devices that tell you how long you can reasonably spend in the sun without protection to get a vitamin D boost. Then there's sunscreen: an SPF of 15 means the user can stay in the sun 15 times as long without burning.

Taking anti-inflammatory painkillers can reduce the risk of common skin cancers by around 15 per cent, but doing so regularly carries its own risks. A more tasty solar defence could be to eat tomatoes. A small study recently looked at the effect that eating 55 grams of tomato paste daily for 12 weeks had on how 20 women's skin reacted to UV exposure. "Those that were on tomatoes had increased sun protection in their skin," says Mark Birch-Machin at Newcastle University, UK, one of the study's authors. The key is the tomato's antioxidant properties, he says, adding that green tea and blueberries might have similar benefits. The foods are no substitute for sunscreen, however. "They just provide a little bit of extra protection," he says. Sonia van Gilder Cooke

DRUGS

If mind-altering substances are your thing, you're spoiled for choice. Besides marijuana, cocaine, ecstasy, LSD and mushrooms, a growing "long tail" of chemicals toast your oats in every conceivable way.

There's a reason why drugs have a reputation for being bad for you: they are. Yet at least 160 million people (and possibly twice as many) indulge at least once every year. So if you fancy a trip to an altered state, how best to get away with it?

The answer depends on what you mean by "getting away with it". You can't guarantee a safe experience. But an informed choice can give you the best chance of avoiding potential harm.

DOUBLE TROUBLE

Drug harms fall into two broad categories: those that affect you, and those that affect others. The personal ones include death, health problems (including mental health), accidents, addiction, relationship breakdown and legal trouble. Harms to other people include violence, financial problems, crime and environmental damage – both at home and where the drugs are produced.

One rule of thumb is that risks become more serious with repeated use. Take addiction, for example. According to the US National Institute on Drug Abuse, it can take only "a few" uses of a drug to become addicted to it, although the potential for addiction varies between drugs and people. Putting firm numbers on this is difficult, but a study

published in 2005 found that among a large cohort of people who tried cocaine for the first time, more than one in 20 were dependent on it two years later.

Perhaps the best guide to the harms comes from the UK's Independent Scientific Committee on Drugs (ISCD), which analysed 20 drugs on 16 criteria. It found the most harmful illicit drug to be heroin, with an overall rating of 55 out of 100, with crack cocaine on 54 (see "Is it worth the trip?", below). LSD and magic mushrooms are among the least harmful, and also carry the lowest risk of dependence.

Mixing drugs amplifies the risks. Taking cocaine with amphetamines or ecstasy, for example, raises the risk of acute toxicity over and above the sum of their parts. This also extends to nicotine.

And of course, most of these drugs are illegal in many places. As well as the potential for falling foul of the law, users often can't be sure what they are taking. Some nightclubs offer a testing service to analyse the contents of party pills, but on the whole the only "guarantee" is the word of the drug dealer.

When it comes to the benefit side of the equation, the picture is even less clear. Nobody has yet done an analysis taking into account the pleasure, fun and adventure that people seek when they take drugs.

All told, you might conclude that trying to get away with taking drugs isn't worth the risk. If so, this would also rule out a widely consumed and enjoyed substance that the ISCD rated as the most harmful drug of all: alcohol. **Graham Lawton**

SOCIAL SMOKING

Smoking is one of the worst things you can do for your health. Regular smokers shave half an hour off their life with every two cigarettes (see "Weighing up the risks", page 62). But what about social smokers, those who fancy the odd cigarette normally accompanied by a drink or two?

According to the British Heart Foundation,

"Occasional smoking is on the rise – can it really be that bad?"

there are 1.1 million occasional smokers in the UK. And a study of smoking in 31 US states found that the proportion of smokers who didn't light up every day is on the rise – jumping from 16 to 21 per cent between 1996 and 2001.

Occasional smokers tend to be categorised either as not smoking every day, or smoking an average of less than one cigarette a day. Can the health effects of such a habit really be that bad?

Some of the risks certainly pale in comparison to those of smoking 20 a day. Take cancer – the risks increase the more you smoke, says John Britton at the University of Nottingham, UK. "Every cigarette you smoke increases your chance of getting lung cancer, it's as simple as that." Each one causes irreversible structural damage, too. Fine particulate matter in the smoke causes damage to the lining of the lungs, the cumulative effects of which lead to serious breathing disorders.

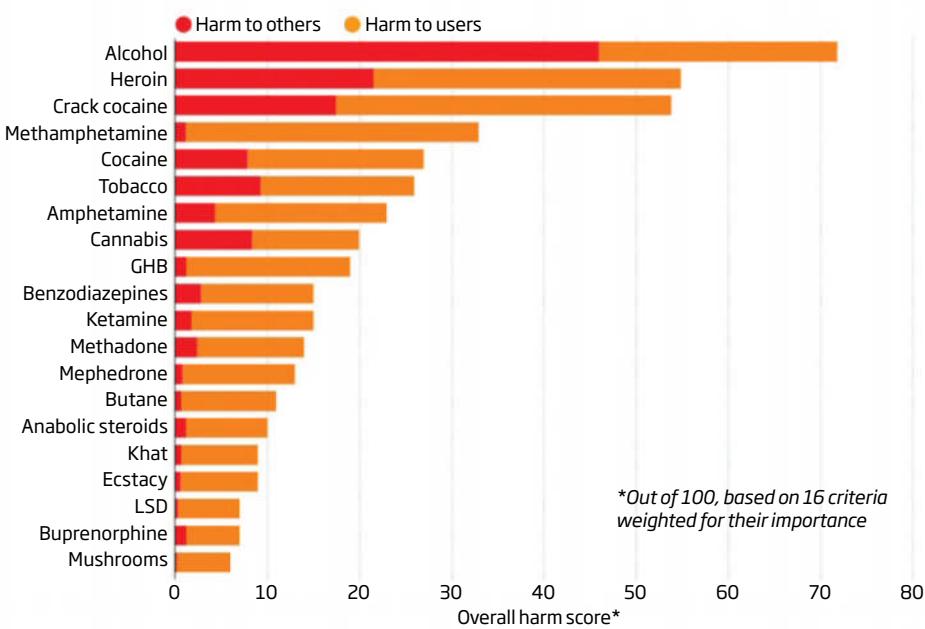
And any social smoker who thinks the harms can be undone by more virtuous habits, such as exercise, is kidding themselves, Britton says. "Doing more exercise or even stopping smoking will not reverse this damage," he says. "It's a complete fallacy that your lungs can somehow regenerate."

The news is even worse when it comes to cardiovascular disease and heart attacks – the biggest immediate risks for social smokers, says Robert West at University College London. "Unlike the risk of cancer or respiratory problems, which increase linearly with every cigarette smoked, the risk of heart disease is very non-linear, with the highest jump coming with the first cigarette and increasing gradually thereafter," he says (see graph, right).

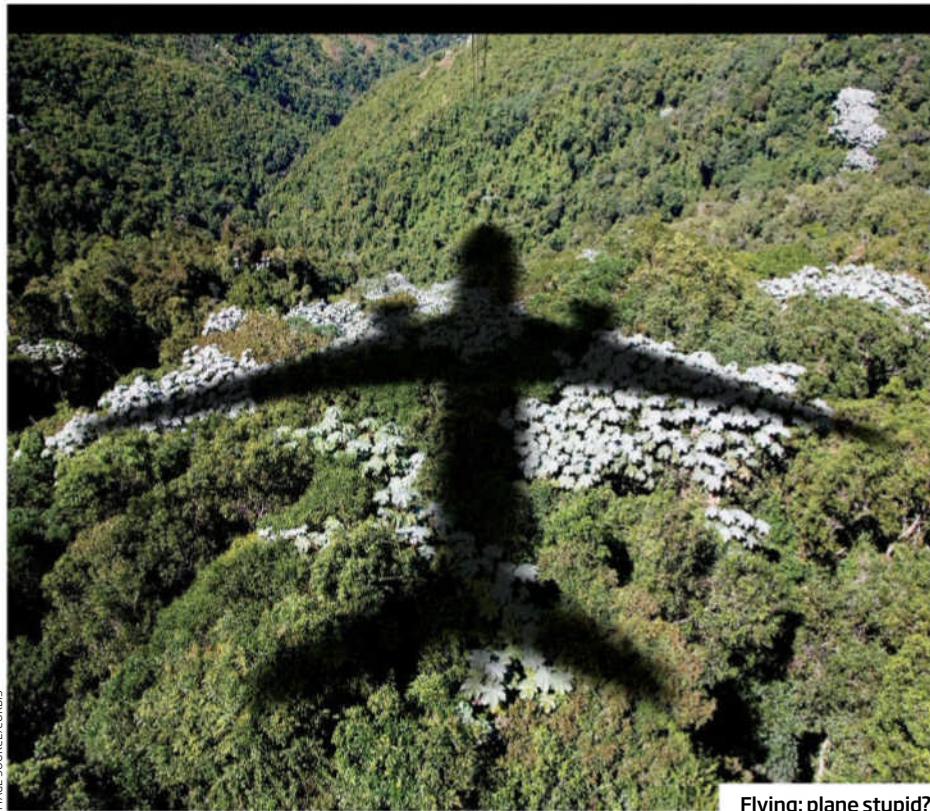
Intriguingly, smokers have been found to have better survival rates when admitted to hospital after a heart attack, or traumatic injury, compared with those who never smoked. This could be because some of the bad effects of smoking, such as over-activation of the body's inflammatory response, or causing platelets in the blood to form

Is it worth the trip?

The most dangerous drug isn't illegal



SOURCE: THE LANCET, DOLORG/DJCHV



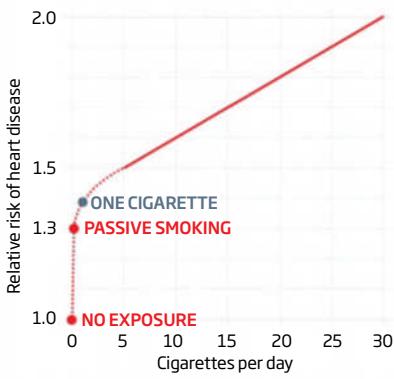
Flying: plane stupid?

clots, could be protective in a life-threatening situation. Clearly, though, this "smoker's paradox" is no reason to keep up the habit, and the mechanisms at work are still under investigation.

There is more practical good news though. Quit social smoking now, and you might be able to get away with a lot. Within a year your excess risk

Drag and drop

Smoking just one cigarette a day can increase your chances of heart disease by nearly 30%



SOURCE: BMJ, VOL 328, P 980

(relative to someone who has never smoked) of smoking-related heart disease will be halved. And by giving up before the age of 30, people can reduce the excess risk of dying of smoking-related causes by more than 97 per cent.

Recent research suggests quitting could also claw back some years lost to your lifespan. Among those who die of cardiovascular disease, smokers do so on average 5.5 years earlier than non-smokers. For ex-smokers, the gap goes down to 2.5 years – even if they quit as late as their 60s.

E'S ARE GOOD

Of course, quitting is often easier said than done. Even occasional smoking is addictive. Social smokers might not struggle to get through the day without a cigarette, but they tend to have a strong psychological addiction, triggered by certain situations. Even those who smoke fewer than one cigarette a day struggle to give up when they want to, with 65 per cent relapsing within six months of their quit attempt. Electronic cigarettes might be a good trick to deal with their situational craving, West says. "E-cigarettes are certainly less toxic than tobacco ones. We don't yet fully understand the long-term consequences, but in the short term, e-cigarettes are a good option – or at least a less bad option than cigarettes." Dara Mohammadi

FLYING

You've insulated your house and turned down the thermostat. You're eating less meat. You cycle to work. But a few times a year you fly.

In the UK, the average carbon footprint is around 10 tonnes a year, excluding flying – but a single round trip to New Zealand produces 12 tonnes of CO₂. Is flying ever going to be anything other than the greatest of green sins?

The short answer is no. There isn't much scope for making planes more efficient, and nor have efforts to develop alternatives to fossil fuel-derived kerosene got very far. The ethanol-powered Embraer EMB 202 Ipanema does run entirely on biofuel, but it's a single-seater used for crop dusting. Powering airliners with ethanol is problematic, not least because it freezes at normal cruising altitudes.

Flying cattle-class can help, because the more people crammed on a plane, the lower the per-person emission. But beyond this things get complicated. Planes burn fuel fastest during take-off, so you might think short-haul flights are worse. But the longer the flight, the more fuel is carried, and the more fuel is burnt to carry this fuel.

Claims that summer flights are better – because fewer heat-trapping contrails form then – are mired in uncertainty. Another suggestion is that flying during the day is better because contrails also reflect sunlight, compensating slightly for the heat they trap, but the difference may be negligible. As for taking less luggage, a jet can weigh 400,000 kilograms on take-off, only a tiny fraction of which is luggage.

So what about offsetting your emissions? The idea is that you pay a little extra to support projects such as installing solar panels or planting trees. But the quality of offset projects varies, says Anja Kollmuss, an independent environmental consultant based in Zurich, Switzerland. Most companies selling offsets claim their projects are "verified", but this is no guarantee of quality, Kollmuss says, nor that the projects in question wouldn't have happened even without your contribution.

When it comes to planting trees, say, what matters is that the trees survive for decades to come. If they die or are cut down, the CO₂ they locked away just ends up back in the atmosphere. "There are good offset projects out there," says Kollmuss. "But it is very difficult for consumers to identify them." Another option, she suggests, is that every time you fly you donate money to an organisation campaigning for action to prevent climate change.

Supporters of offsetting argue that it is at least better than doing nothing. But not even this is clear – opponents claim people who buy offsets may feel less guilty and fly even more as result. The bottom line is that if you can avoid flying, do.

Michael Le Page ■



Germ warfare

Tired of fighting over housework? Penny Sarchet dishes the dirt on how clean you really need to be

HATE housework," said the late Joan Rivers. "You make the beds, you wash the dishes, and six months later you have to start all over again."

If only. I can't stand a dirty kitchen sink, a grubby bathroom or cobwebs hanging from the ceiling, so I spend precious hours every week cathartically cleansing.

The doubts set in when I moved in with my boyfriend. It didn't take us long to discover that we're in opposing corners when it comes to housework – he's dirty but tidy, while I'm clean but messy. He suddenly had to deal with my clutter spread all over his dining table and sofa, while I nursed a growing preoccupation with the art of disinfection.

We have learned to live with each other. And my new position of compromise has led me to question some of my preconceptions. Is cleaner necessarily better? I'd heard in a vague sort of way that perhaps it's not; that an obsession with the elimination of germs might be behind many a modern malady. But what did the science say? I set out to see whether there might be such a thing as too much cleanliness.

We're bombarded with seemingly contradictory information about being clean. Good hygiene helps ward off countless infections and illnesses, that much is clear. But then there are the bacteria that turn out to be good for us; the whispers that some ingredients in our cleaning products might be hurting us; the hypothesis that too much hygiene is behind rising rates of allergies and other disorders.

On that last point, something definitely seems to be out of whack. More than 150 million people in Europe are thought to have allergies, a number that's rising. By the

2020s, half of all Europeans could have at least one. Food allergies are becoming more common, especially in children. Between 1997 and 2007, there was an 18 per cent rise in children who had one in the US – now nearly one in every 25. Then there is asthma. Between 1971 and 1991, the number of family doctor consultations for the condition quadrupled in the UK, while appointments for allergic rhinitis – inflammation of the nose in response to things like pollen and dust – more than doubled.

It was back in 1989 when David Strachan, then an epidemiologist at the London School of Hygiene and Tropical Medicine, first proposed his hygiene hypothesis. He suggested that modern lifestyles, with their lack of unhygienic exposure, mean we catch fewer infections in early childhood, and that this predisposes us to developing allergies.

Too much hygiene

Some of the evidence is fascinating. Children who grow up on farms seem to be healthier, as are children whose parents wash dishes by hand rather than using a dishwasher, and those who have a dog (my personal hygiene nightmare). But as a lover of cleanliness, the study that turns my stomach the most is a 2014 paper that found that children are less likely to develop precursors to asthma if, in their first year, they're exposed to particles from cats, mice and cockroaches.

Many of us have embraced the idea of a link between a little bit of dirt and good health, perhaps eager for an excuse to cut down on the housework. "This wonderful idea that we've become too clean for our own good, whatever that means, has just stuck," says

Can I stop washing?

No! Washing your hands with soap and water has been shown to cut the incidence of respiratory ailments and diarrhoea. Do it before and after cooking, before eating, after using the toilet, and after touching animals or rubbish. As for the daily shower, there is no evidence for claims that it is to blame for the rise in asthma and eczema. Children who wash daily seem to be healthier – and any bacteria you lose during washing are rapidly replaced.

Sally Bloomfield at the London School of Hygiene and Tropical Medicine.

There's just one problem: things probably aren't that simple. In recent years, thousands of studies have linked changes in the microorganisms living inside our bodies to everything from allergies and asthma to obesity, depression and Alzheimer's disease. This emerging understanding of what's known as our microbiome suggests that rather than there being a clear distinction between "clean" and "dirty", we have a complicated relationship with bacteria. Being exposed to some kinds is good for us, to others not. Figuring out which is which is difficult.

One thing is becoming clear – it's diversity that counts. A 2015 study of nearly 400 infants in Germany hinted as much, when researchers found no direct link between their chances ➤

of developing asthma or allergies, and their caregivers' personal and home cleanliness.

What did make the difference was their exposure to bacteria. Several studies show that healthier people tend to host a wider range of microbes. Western lifestyles may have adverse effects on this diversity, which was found to be 40 per cent lower than that detected in an isolated, traditional hunter-gatherer society. And while I can't help wrinkling my nose when I see a parent pick a dropped dummy off the street, suck it clean, and then hand it back to their child, a 2013 study found that these infants were less likely to develop asthma or eczema. The organisms in their saliva were also different from the ones inhabiting infants whose parents would never do such a thing, prompting the researchers to suggest that the protective effect is down to the transfer of beneficial microbes from parent to child.

There is also evidence for why living on a farm is so good at reducing allergies – the bacterial components in farm dust suppress inflammatory immune responses. This seems to indicate that the hygiene hypothesis is in need of revision. "It's not infections so much as exposure to a wide variety of bacteria that helps control the development of our immune systems," says Dennis Ownby, an allergy and immunology specialist at Augusta University in Georgia.

Mixed messages

When we are exposed to these beneficial microbes is also crucial, and the most important time seems to be early childhood. "It is probably very important to take children, starting at a young age, outdoors and let them play on the ground," says Ownby. So if you're old enough to be reading these words, I have some bad news. By the time we are adults, our microbiome may be largely set. According to current thinking, the cut-off is as early as 3.

So any suggestions that shirking the chores – or your personal hygiene – during adulthood could increase your diversity of good bacteria are spurious. After all, while we may lack a full understanding of which bacteria are good for us and how, we are more clued up on the ones that are unequivocally bad.

For example, there are about 17 million cases of food poisoning a year in the UK, caused by microbes including *Norovirus* and *Campylobacter*. Many cases are picked up in restaurants, but a study of 18 European countries suggests that nearly a third of food-borne outbreaks occur inside our own homes.



JULIETTE GUILLEMOT/PICTURETANK

Is the 5-second rule real?

Not even close. On contact with a surface, food picks up bacteria in less than a second. So should you eat it? If you've dropped it where dogs have been defecating, probably best not to. But if you're proud of keeping your kitchen floor so clean you could eat off it, it's probably no harm to put this into practice.

Should I wash food?

Raw fruit and vegetable yes – but chicken, no. Nasty *Campylobacter* bacteria are often found on chickens, and washing is likely to splash them further around your kitchen, giving them a ride to your mouth via your hands. Just make sure you cook the chicken through properly and disinfect preparation surfaces.

"I've seen houses that are absolutely, completely filthy," says Lisa Ackerley, a food safety adviser at the British Hospitality Association, who has gone into homes to swab for bacteria as part of her work. "It's easy to say we're too clean, but who's got the evidence?"

Filth has consequences. About 50 per cent of chickens in the UK carry *Campylobacter*, the country's most common cause of food poisoning, and the bacteria can easily transfer from the raw meat to your hands or a chopping board. Seen in this light, Bloomfield says, anything that encourages people to cut back on habits like handwashing is dangerous.

But while being too slovenly stands a good chance of giving us diarrhoea, neither do we want to be too clean. In particular, you might want to cut back on antibacterial handwashes and laundry detergents. Not only might some of these have less benefit in the home than advertised, there is some evidence they might contribute to bacteria becoming resistant to antibacterials and even antibiotics. There's also growing concern about indoor pollution connected with overzealous use of certain household products (see "Would it kill you to do a little cleaning?", opposite).

Right, so being too dirty could hurt me, but so could being too clean. What's a girl to do?

Should I vacuum?

It depends. Regular vacuuming with a high-filtration machine is recommended for people who have asthma, or an allergy to dust mites or other indoor substances, or who don't want any judgement from visitors. If none of this applies, the dust bunnies won't bite.

The good news is that there might be a science-approved hygiene sweet spot. Bloomfield and Ackerley are among a growing group of experts who advocate "targeted hygiene". This has been a well-known strategy since the 1950s, says Bloomfield, but it was limited to hospitals and industries like catering, pharmaceuticals and cosmetics – anywhere it's important to "identify critical points for transmitting infection".

The suggestion is that targeted hygiene should be the strategy behind everyone's basic housework. "It's still important to be hygienic in the places and at the times that matter," says Bloomfield. But instead of striving for a sterile home, we need focus only on removing harmful bacteria, from important surfaces, at critical times.

Most of the cleaning should focus on doorknobs, light switches and the bathroom – anything we touch a lot. It's also crucial to thoroughly clean everything you use while cooking. That includes all surfaces, chopping boards and utensils that come into contact with raw meat, as well as unwashed dirty vegetables, whose bacteria can give you food poisoning just as raw chicken can. The most important advice is to wash your hands, after cooking, before eating and after using the toilet.

But beyond that? Well, Joan Rivers fans can take heart: cleaning the walls, floors or the furniture really can wait six months. If you're not allergic to dust mites, vacuuming is entirely optional. And you can forget about making the bed – especially if you're allergic to dust mites. Mites need a humid atmosphere to survive, so leaving the covers open in the morning might help to kill the beasts.

It all seems great news for my relationship: as long as I can encourage my boyfriend to be clean in the right places, I needn't fear for my health. And in return, I can take comfort ➤

WOULD IT KILL YOU TO DO A LITTLE CLEANING?

There's increasing evidence that the chemical mixtures we use to clean our homes create indoor pollution. "Most of our exposure to hazardous pollutants occurs indoors, and a primary source of these pollutants is our everyday consumer products," says Anne Steinemann at the University of Melbourne in Australia.

This includes air fresheners, shampoos, soaps, scented candles, laundry detergents and cleaning products. There is no legal requirement for these products to list all their ingredients, and while the compounds they contain may each have individually been tested for toxicity, we don't know how dangerous they become when mixed.

Ironically, many of the pollutants seem to come from ingredients to make the products smell clean and fresh. When fragrance compounds like limonene and other terpenes get into the air, says Steinemann, they can react with ozone to generate compounds such as formaldehyde, which is carcinogenic.

How we build modern homes compounds the problem. "What we've done to our housing is to seal it to prevent energy loss," says Stephen Holgate at the University of Southampton, UK. The problem is worst in the most efficient homes. "Ventilation is very low, and chemicals can accumulate in the air and dust."

Cleaning products aren't the only source of pollutants – paint, wood resins and chemical treatments on soft furnishings like carpets contribute too – but we clean our

homes far more often than we refurbish them.

Steinemann suggests switching to edible cleaning substances such as vinegar, bicarbonate of soda and lemons. Air purifiers are no help; they remove large particles of allergens, such as dust and pet hair, rather than small fragrance chemicals.

GREEN AIR

If you can't bear knocking off on the cleaning, one solution might be the humble houseplant. We've known for more than a decade, thanks to NASA research into crewed space flight, that plants can absorb organic chemicals like benzene and formaldehyde from the air. In 2016, a team tested how well five common houseplants remove mixtures of organic compounds from the air of a sealed chamber. The winner turned out to be *Guzmania lingulata*, a type of bromeliad often seen in offices, which could absorb high amounts of each of the eight substances tested.

But a single sad perennial in your living room isn't going to do much. "In a house where you've got chemicals that are quite toxic, even to plants," says Holgate, "I doubt it will make much of a difference."

At the last count we had 16 plants in our flat, but I take his point. Until NASA furnishes the specifics, Holgate suggests opening the window. "It's rare to see houses with windows open today. In the old days, ventilating your house was an everyday activity, but that doesn't happen in the UK any more."

THE UPSIDE OF CHAOS

There might be a “sweet spot” for how much cleaning you need to do to maintain good hygiene (see main story), but the evidence for how much mess is good is thinner on the ground.

Some studies suggest that surrounding yourself with meaningful objects helps you define and connect with your home – but too much clutter can get in the way of cooking, cleaning and freedom of movement.

But trouble with clutter might go beyond safety hazards. Evidence suggests that working women who describe their homes as cluttered or unfinished have stress hormone patterns that may be less healthy. Other studies have suggested a link between disorganised, cluttered homes and worse health in children.

But the most frequently cited research shows that the tidiness of our surroundings influences our behaviour. You may have heard that tidier desks encourage healthier snacking, while messier desks make you more creative. These claims are based on a 2013 study that invited participants to do a range of activities while sat in either an ordered or disordered room. Its findings suggested that people behave more conventionally when in a tidy environment – more often picking the option labelled “classic” on a menu, for example. And those sat in messy rooms came up with more creative ideas – in this instance, new ways to use ping-pong balls.

In short, the research provides ammunition for both sides – those of us who struggle to defend our messiness and the ones urging better organisation. Converts to Japanese lifestyle guru Marie Kondo’s decluttering guidelines may tell you that a tidy home is a less stressful one. But I’ll see your Kondo and raise you one A. A. Milne, who said that “one of the advantages of being disorderly is that one is constantly making exciting discoveries”.



FOOD AND DRINK/REX/SHUTTERSTOCK

that being tidy might not be the be-all and end-all either (see “The upside of chaos”, left).

Beyond the basics, it seems there is one big thing we can do to improve our health beyond worrying too much about the state of our homes: leave them more often. “We don’t spend enough time outdoors,” says Bloomfield.

Preliminary findings hint that spending more time doing social sports and other outdoor activities can help restore a healthily diverse microbiome. Exposure to soil may be key, says Ownby. “We all end up ingesting between 50 and 60 milligrams of soil a day,” he says. Gardeners get about twice that amount.

It’s all quite pleasingly wholesome and old-fashioned: boost your health by getting out in the open air. Use cleaning products, but not so many that your home fills with pollution, and open the windows after you do.

We’re trying to put it into practice. It’s certainly nicer to spend time in a well-aired flat, and I now eye air fresheners and antibacterial soaps – not to mention the recent proliferation of antibacterial air fresheners – with suspicion. I’m even seeing pets in a new light. The thought of having a dirty animal in my home used to fill me with dread, but I’m

Does the washing-up really need a rinse?

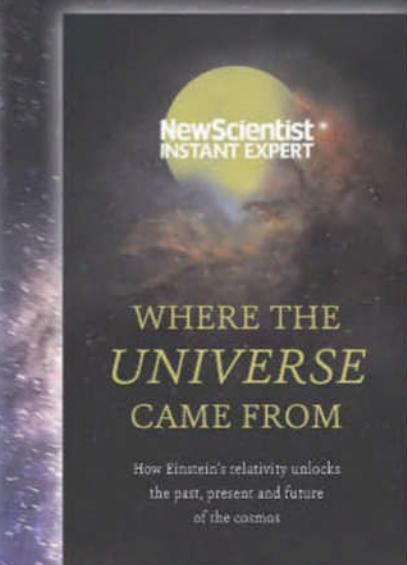
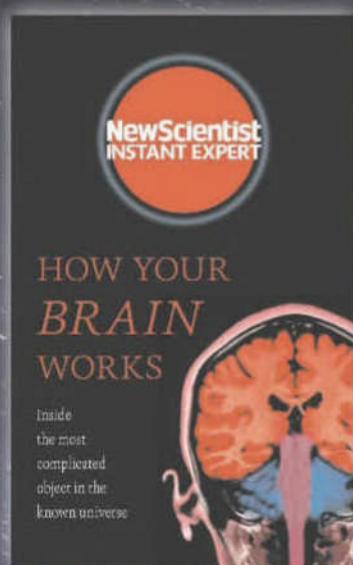
Absolutely. Detergent and soap don’t kill bacteria – they simply help detach dirt and germs, meaning they’re still there on the surface. If you simply wipe your dishes with cloth and detergent, all you’re doing is wiping the microbes around. So rinse with plenty of water, preferably hot.

beginning to revise my views, much to the delight of my dog-loving boyfriend.

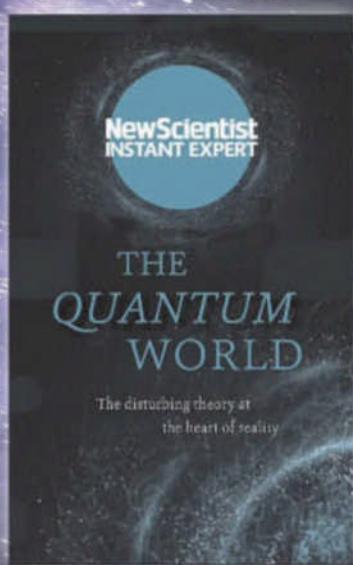
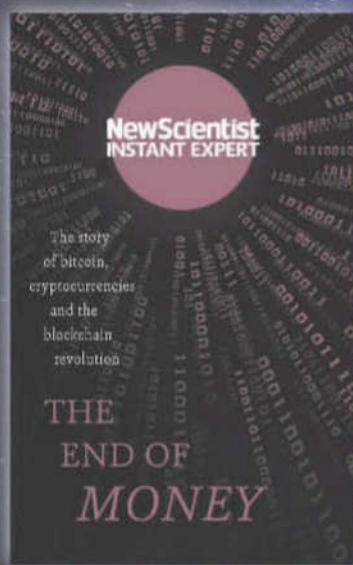
But despite what the studies say, I’d still really like to get a dishwasher before too long, and no microbiome hypothesis is likely to change my mind there. In the words of one of my friends, who is pretty unequivocal about her own household preferences: “Anyone who tells me I need to handwash all my kids’ dishes can get bent.” ■

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MARCH 2017



APRIL 2017



Sunshine's vitamin-making talents are even more vital for our bodies than we thought, finds Emma Young

Sunny D

IT IS an annual ritual, as reliable as the spawning of frogs or the return of migrating birds. On the first sunny, warm day following winter, pale-skinned denizens of the high latitudes slough off excess clothing and expose their blanched bodies to the sun's rays.

Most of us love sunshine. Yet the standard health advice tells us to cover up and slather on the sun cream for fear of developing skin cancer. That is still good advice, but the latest research suggests that sunshine – or rather the vitamin D it generates – may be more essential for health than we previously recognised.

Most people are familiar with the idea that extreme vitamin D deficiency causes rickets, a softening of the bones that can bow and distort them. It's also known that even a moderate lack of vitamin D can boost the risk of fractures. What's new is the idea that vitamin D is not just about bones. Mounting evidence indicates that if we don't get enough of it, we could leave ourselves more susceptible to infections, increase our risk of autoimmune diseases such as multiple sclerosis and type 1 diabetes, and even raise the risk of certain cancers.

All that suggests a rethink of official advice about how much vitamin D is enough. "The UK guidelines have traditionally been targeted at trying to prevent rickets," says Julia Pakpoor, a vitamin D researcher at the University of Oxford. "Higher doses – perhaps five times higher – are almost certainly safe, and more beneficial." Time to get out in the sun?

We get vitamin D in two ways: by eating it, and by exposing our skin to the ultraviolet B (UVB) rays in sunlight. Technically, vitamin D made in the skin is a hormone, as a vitamin is defined as an organic compound that the body cannot produce in adequate quantities. Cells in the outermost layer of skin, the epidermis, make a substance called 7-dehydrocholesterol, which reacts with UVB light to form a

precursor of vitamin D. Our kidneys convert this into the active form, which binds to receptors in the intestines and bones and helps regulate levels of calcium, a crucial building block of bone.

Along with the kidneys, various types of immune cell can convert vitamin D into its active form, and many also possess vitamin D receptors. The first hints that vitamin D might play an active part in the immune system came as early as the 1960s from studies of multiple sclerosis. MS is characterised by the immune system attacking the fatty sheaths around nerve cells in the brain and spinal cord. Epidemiologists noticed that cases seemed to cluster at high latitudes, where people were exposed to less sunshine. "At first, the link seemed kind of improbable," says George Ebers, a neurologist at Oxford. "But gradually, there has been more and more data to support the notion that it has something to do with sunshine."

In 2011, a group led by Steve Simpson at the University of Tasmania, Australia, combined the results of hundreds of studies investigating MS and sun exposure, and concluded that the trend is real, with a few exceptions. Scandinavia, for instance, has far fewer cases of MS than its latitude should predict – but then Scandinavians eat a lot of oily fish, a food packed with vitamin D.

There could be other explanations for this clustering. People living at higher latitudes might have other genetic predispositions that would boost their MS risk, although the team controlled for one such gene variant. But studies of people living in Iran have bolstered the idea that sun exposure is directly involved. From the 1950s through to the 1970s, Iran was a country heavily influenced by the fashions and culture of the West. With the Islamic revolution of 1979, however, that changed. ➤



PABLO BERNASCONI

"Young adults with low vitamin D are about twice as likely to develop diabetes"

Men dressed more modestly and women covered their bodies almost completely, so skin previously bathed in sun was suddenly in darkness.

There is no MS data from before the revolution, but the period 1989 and 2006 saw an eightfold rise in cases, to nearly 6 per 100,000 people. "This is a very high, rapid rise," says Pakpoor, especially for such a sunny country. "It must be because of an environmental risk factor, and one that is specific to Iran, because this isn't something we've seen across the Western world," she says. "The only thing I can think of is the revolution."

Protective effects

That's still only a highly suggestive correlation, but there is other evidence. In 2014, Alberto Ascherio of the Harvard School of Public Health published data from people with the earliest symptoms of MS, suggesting that those with lower levels of vitamin D in their blood were more likely to develop full-blown symptoms, and to have a poorer prognosis. Ascherio has also reported that young adults with low vitamin D are about twice as likely to develop type 1 diabetes as those with higher levels.

It's not yet entirely clear how vitamin D might protect against autoimmune diseases. From his own work on MS, Ebers suspects vitamin D may enhance the ability of immune

cells to distinguish between foreign material and the body's own cells. Other research hints at a link with the blood-brain barrier, the protective layer that prevents certain harmful chemicals and cells from reaching the brain. A study of mice given an MS-like disease suggested that one kind of immune cell was unable to cross the barrier and mount an attack against nerve cells if the animals' diet was supplemented with vitamin D. When these supplements were stopped, the cells started appearing in their brains.

Whatever the answer, it seems the immune benefits don't stop with autoimmune conditions. Vitamin D also seems to ramp up the body's defence against viruses, including those responsible for causing flu and colds. Possibly it increases the production of natural antimicrobial substances by various cells, including immune T-cells and cells lining the respiratory tract. The research is still young, but these findings suggest that low levels of vitamin D may be one reason why we are generally more susceptible to infection in winter, when there is less sunshine – although other factors that affect viral survival, such as temperature, humidity and the gloppiness of the protective mucus in our noses, could also be in play.

So how much vitamin D should we really be getting? There is currently no agreement on the optimal level. UK and US government guidelines focus on getting enough vitamin D to build healthy bones and teeth, and suggest



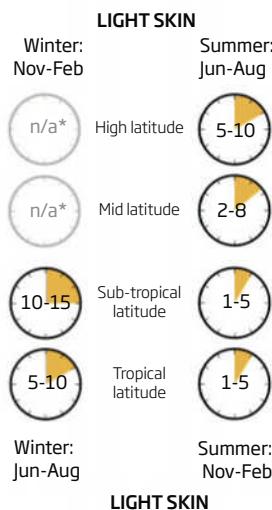
Sunshine could be a drug not just for healthy bones, but for a healthy immune system too

the aim should be around 20 nanograms per millilitre of blood. But for a strong immune system we may need more. The Endocrine Society, a medical organisation dedicated to the study of hormones, says it could be anywhere between 30 and 100 ng/ml.

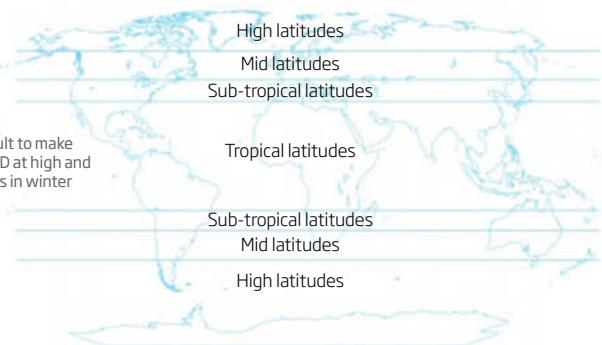
Even assuming 20 ng/ml is enough, if you live at latitudes above around 35 degrees – north of San Francisco, Seville and Seoul or south of Melbourne, roughly speaking – the chances are that you're deficient in vitamin D

How much sun?

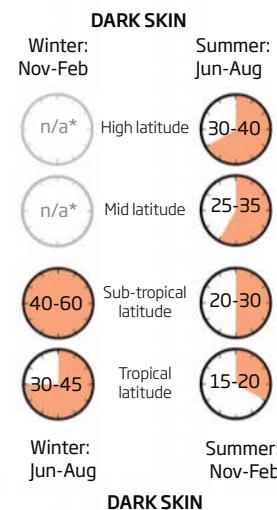
The number of minutes you need to spend in the sun to get your daily dose of vitamin D varies by the time of the year, your skin colour and where you are



NORTHERN HEMISPHERE



SOUTHERN HEMISPHERE





for at least some of the year. Between November and March (or June to August in the southern hemisphere), the angle of the sun means that few UVB rays hit Earth at high latitudes, making it very difficult to synthesise vitamin D in skin. Neither can you stockpile enough vitamin D to tide you over the winter months, as bodily stores typically dwindle after around 30 days.

One study of white Britons found that in winter and spring, around half have vitamin D levels below the recommended UK figure, and 15 per cent are deficient year-round. The risk is even greater for people with darker skin living

DON'T BE MODEST

How much sun is too much? While sunbathing until your skin burns is clearly going too far, evidence is emerging that covering up too much could be counterproductive. People living in sunnier low latitudes are less likely to develop certain cancers, including breast, prostate and colorectal cancer, than those in more northern climes.

Why is that? The presence of receptors for vitamin D on a range of tumour cells suggest they respond to it, and vitamin D is known to influence the expression of genes that regulate cell growth. Studies on animals also show that vitamin D can slow tumour growth, and even encourages certain types of malignant cell to commit suicide. Once again, it seems the sunshine vitamin is at work.

at high latitudes, who need more UVB exposure to make the same amount of vitamin D. Few people have levels low enough to cause the adult equivalent of rickets. But given how even a small deficiency increases the risk of bone fractures, and growing evidence for the role in our immune system, should we be doing more to get more?

Fear of skin cancer means many people are understandably keen to cover up during the summer months, and even moisturisers and make-up now often contain sun protection. That's despite growing evidence that more sun exposure could reduce the risk of getting other cancers – a positive effect also attributed to vitamin D (see "Don't be modest", below).

The good news is that, unless you are housebound, it should be easy to get enough vitamin D on a sunny day without getting a dangerous dose of sun. A fair-skinned person in the UK need only expose their face and arms to the midday summer sun for 10 minutes to generate more than twice the amount they need for the whole day, while a dark-skinned person would need closer to 40 minutes (see diagram, below left). Apps and gadgets have also appeared recently that calculate how long you should stay in the sun at any given time and location to get enough vitamin D while not getting burned.

But the sun doesn't shine every day, and we can't all go outside when we want. What if it's cloudy or you're stuck in an office? Dense cloud and shade roughly halve the amount of vitamin D you synthesise, while glass blocks it almost entirely. UVB rays also dwindle in the early morning and evening, even though UVA rays continue to penetrate. Sunbeds provide lots of UVA exposure, but very little UVB.

Supplement your sun

So can you eat your way to vitamin D health? UK and US guidelines suggest adults need the equivalent of between 15 and 25 micrograms of vitamin D per day from all sources combined, including the sun and diet. A 100-gram packet of smoked salmon would get you there, as would three 160-gram tins of tuna. But if you don't eat a lot of oily fish, it's unlikely you'd meet these requirements through diet alone (see "How to get your daily dose", above). In the US, where milk is supplemented with vitamin D, the average intake from diet is around a third of the recommended dose. In the UK, where this is not common practice, the figure is lower.

That leaves vitamin D supplements as a possibility. The UK National Health Service

HOW TO GET YOUR DAILY DOSE

Each of the following will provide you with 15 micrograms of vitamin D – the daily dose recommended by the US Institute of Medicine

0.5 tablespoon of cod liver oil

88 g smoked salmon

10 tablespoons of margarine

15 eggs

15 bowls of fortified cereal

2.8 kg

already recommends supplements for children, and suggests that certain groups of adults should take around 10 micrograms of vitamin D per day. These include pregnant and breastfeeding women, those aged 65 and over, and people who "aren't exposed to much sun". It also points out that dark-skinned people are at greater risk of vitamin D deficiency, though it stops short of recommending supplements.

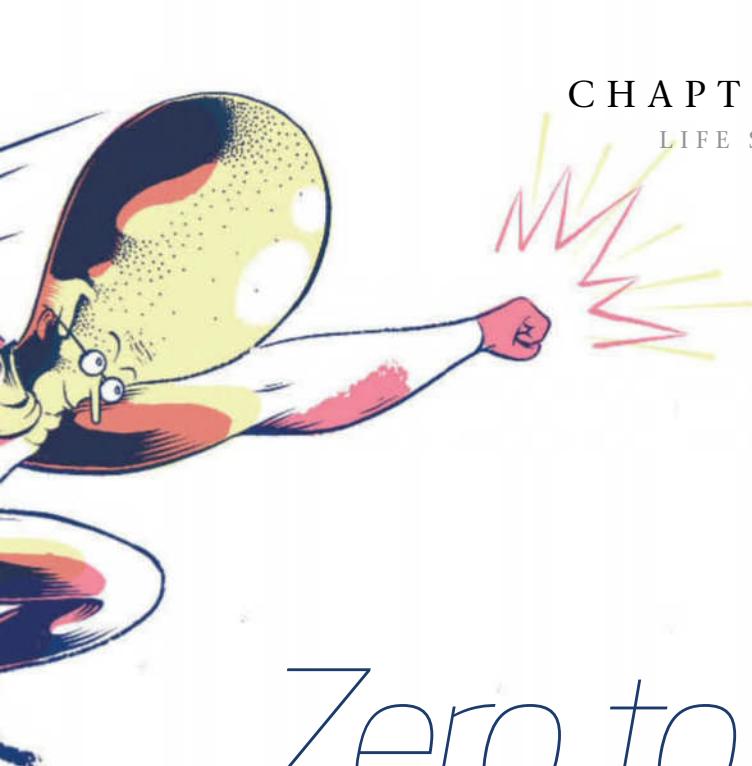
Taking supplements is not risk-free. You can't overdose on vitamin D from sunshine, as any excess made by the skin is degraded. But ingesting too much vitamin D can cause high blood calcium levels, which can damage the kidneys – although it's unclear at what dosage this becomes a genuine concern.

Some think there is a case for much more widespread use of supplements, at higher doses. Official advice in the UK is to take no more than 25 micrograms of vitamin D per day in supplement form, while the US Institute of Medicine suggests an upper limit of 100 micrograms. "That's what I take," says Pakpoor.

Such higher limits could become the norm, both to help healthy people get enough, and also to help treat a growing number of ills. Clinical trials are under way in which vitamin D supplements are being given both to people with cancer and multiple sclerosis to see if they have an effect. Early results suggest it might ease the symptoms of MS.

A stroll in the sun is always a joy for body and soul. But as we learn more about the sunshine vitamin and how it works, it seems that our cells are glad of its benefits, too. So get out there and enjoy – like all things, in moderation, of course. ■





CHAPTER FIVE

LIFE SKILLS

Zero to *HERO*

A touch more self-confidence can make all the difference. But can you really fake it to make it? William Lee Adams investigates

JOHN BARGH may be a professor at Yale, but even he occasionally needs to pump himself up before facing a lecture hall full of students. "I'll sometimes listen to Led Zeppelin," he says. "When you have a performance situation and you have to get psyched, music is great."

Confidence is something we tend to regard as coming from within, but Bargh, a social psychologist, is one of many researching how subtle influences – from music to how we walk – can affect it. It's an idea that has grabbed the public imagination: a lecture by Amy Cuddy of the Harvard Business School, entitled "Your body language shapes who you are", is the second most watched TED talk ever, with over 40 million views and counting. Cuddy recommends striking superhero-style "power poses" to buoy self-assurance in advance of high-stakes situations: her research suggests that doing this can improve performance significantly.

Not everyone may feel comfortable adopting a Superman stance, but nonetheless

the appeal of "fake it till you make it" is obvious. Who wouldn't want to vanquish self-doubt by straightening their back? The question is whether it really works. "You cannot trick your brain into thinking you are actually physically strong and big when in reality you might not be," says Joseph Cesario, a psychologist at Michigan State University in East Lansing. So who's right, and are there really secrets to confidence?

Body over mind

It has long been thought that everything we think, feel and do comes from the mind – the font of a fully conscious and largely immutable personality. But since the 1970s, psychologists have been exploring how various stimuli might unconsciously influence our thoughts, emotions and actions, shaping us without our even knowing. Over the years, researchers have identified a slew of examples. Exposing people to words related to money, such as "stockbroker",

for instance, apparently makes them more eager to take part in a lottery.

And it's not just words that may have an effect. One notable study by Bargh suggested that holding a warm cup of coffee makes people more likely to judge others as warm. Similar research has hinted that tensing your muscles increases willpower, eating sweet things can make people take a rosier view of a potential romantic partner, and donning a doctor's coat may make people pay attention longer.

But the field is not without controversy. More recently, high-profile studies have been criticised as being not replicable, including one by Bargh that found people slowed their walking pace after hearing words associated with the elderly, such as "bingo" and "Florida". But researchers have succeeded in replicating some important findings, and they seem to suggest that we may, to some extent, be shaped by our environment and bodily attitude much more than we imagine.

Confidence is a natural focus for this sort ➤

of research. It can have an inverse relationship with performance: the Ancient Greeks invented the word hubris for a reason, and studies have shown, for example, that incompetent individuals are much more likely to overestimate their skills than competent ones. But in many important situations, such as public appearances and academic assessments, confidence can affect performance no matter how skilled the person is to begin with.

This phenomenon was highlighted in the mid-1990s in well-known experiments by Claude Steele, now at the University of California, Berkeley. He found that African Americans performed less well on a test when it was billed as a measure of intellectual ability. He called it "stereotype threat", hypothesising that simply mentioning intelligence activated stereotypes in the test-takers' minds about themselves, namely that they are less academically able. Other groups

role models," says Latu.

Why should these stimuli, and the state of mind they impart, be powerful? One answer might lie deep in our social primate minds. Having a low social status makes us worry, and worrying takes up cognitive capacity. That's likely the mechanism behind Steele's theory of stereotype threat. "We are so anxious not to confirm the stereotype that we end up confirming it because we do not have enough cognitive capacity to put into the task," says Latu.

People who have low status, whether among friends or at work, must constantly monitor the highly ranked members of their group and respond to their actions. This additional cognitive burden makes it more difficult for them to stay focused on personal goals and planning. Almost everyone is susceptible to this: studies have shown you can manipulate how well people do on a task just by making them a "superior" or "subordinate" in a game beforehand, or by exposing them to disempowering words like "obey". Feeling empowered, by contrast, makes people more optimistic and quick-witted.

As you might suspect, there can be downsides to social power – it may drain away empathy and make people less likely to take another person's perspective. But in many situations, power-related traits might help performance by making people more likely to think abstractly, take risks and make the first move in competition or negotiations.

Accept this at face value, and the question becomes one of how people can achieve that sense of confidence. Studies suggest it's not just about studying hard or improving skills. It may also involve less obvious things.

Primed for power

One of those is our bodies. Cuddy's research, for example, found that people who prepared for a speech by standing with hands on their hips and shoulders thrown back got better ratings from evaluators. She also found that people who adopt more confident poses produce more testosterone, which boosts motivation and risk-taking, whereas those that take up insecure poses produce more of the stress hormone cortisol. And Johannes Michalak at the University of Hildesheim in Germany, has shown that depressed people sitting in a slumped posture remember more negative words from a list than those asked to sit up straight.

There are yet other ways of manipulating confidence. Joris Lammers of the University

"Women speakers were rated higher if female role models were present"

seem susceptible to similar dynamics. Women exposed to gender stereotypes, for example, perform less well on mathematics tests.

Steele's studies show how we can be subconsciously susceptible to influences that are pervasive in society, creating hurdles that some groups may have to overcome. But if subconscious cues can hurt performance, can they be used to help it too? In a 2013 paper, social psychologist Ioana Latu, then at the University of Neuchâtel in Switzerland, and colleagues recruited about 150 male and female students to give a speech in front of a virtual audience. They found that men spoke longer – a standard indicator of confidence – and were rated more highly by an independent panel.

But the researchers tweaked the experiment for some participants by putting a photo of either Hillary Clinton, Angela Merkel or Bill Clinton in the back of the virtual auditorium. It made no difference to the men, which Latu speculates could be because people in powerful positions, as men have often traditionally been, may be less influenced by outside information. But it made a difference to the women: the female students talked significantly longer and were rated more highly when exposed to the images of Merkel or Hillary Clinton. "The gender performance gap disappeared in the presence of the female



JON BUCKLE/EPIC SPORTS/PA

All about that bass

From Serena Williams to Michael Phelps, athletes across sports share one ritual: pumping themselves up with music before a race or match. But which type of music is best? Dennis Hsu, a self-styled "sports geek" at the University of Hong Kong, wanted to find out.

He and his colleagues selected 31 pieces of music from genres including heavy metal, punk, reggae and hip hop. They then had undergraduates listen to excerpts and rate how powerful, dominant and determined each made them feel.

The students rated *We Will Rock You* (Queen), *Get Ready for This* (2 Unlimited) and *In Da Club* (50 Cent) as the most empowering. Least empowering were *Because We Can* (Fatboy Slim), *Who Let the Dogs Out* (Baha Men), and *Big Poppa* (The Notorious B.I.G.).

Those tunes reflect a range of genres, so what was it about them that had an effect? The researchers suspected the secret was in the bass. They found that raising its level made participants feel more empowered; lowering it had the opposite effect. "With bass, people hear power and dominance," Hsu says.

It's important to use music sparingly, however. "The easiest analogy is coffee," he says. "Your first drink has a strong effect, but if you keep drinking you need more to have the same effect."



It's claimed that powerful body language can shape your outlook, and even your neurochemistry

to prime themselves. "When a person does it intentionally and with awareness, that is a different process to how it happens naturally – kind of like a tennis player consciously trying to do everything right on their serve and having it all fall apart," Bargh says.

Some have questioned how big an effect body language really has. In a 2013 study, Cesario and Melissa McDonald, also at Michigan State, looked at whether people's behaviour in a gambling game was more influenced by posture or the situation they imagined themselves in. They asked undergraduates to adopt a typical power pose: standing at the head of a table, with head upright. Then they had them envision a scenario in which they were either in charge (an executive at their desk) or submissive (being frisked by the police). Other students imagined the same scenarios while in a submissive posture.

Cultural taboos

The researchers found that those who imagined scenarios of power took more gambling risks, while those who imagined they were submissive were more cautious. Physical orientation seemed to have no effect. The upshot, according to Cesario, is that context matters: if you're lower on the social totem pole, no amount of power posing is going to make you forget it.

There are also potential cultural barriers. "I can't picture people I know from Korea feeling comfortable doing these poses," says Korean-born Lora Park of the University at Buffalo in New York.

To look at the influence of culture on body language, Park asked American and East Asian students to adopt three expansive positions: hands-spread-on-desk, sitting upright and feet-on-desk. All the students demonstrated a greater sense of power in the first two positions. The third, however, was a step too far for the East Asian students. "The expansive feet-on-desk posture was perceived as being the most violating of East Asian norms of collectivism and modesty," Park says.

Intangible and often ephemeral, confidence is clearly a complicated thing. Grasp at it, and it may disappear. Harness it, and you may overstep the mark. Unravelling its secrets might help to right some of society's wrongs. In the meantime, it may simply be worth considering how subtle influences shape how you feel about yourself. Park's advice on the subject is simple: "Stand tall but don't put your feet up." ■

of Cologne in Germany, for example, has found that people who were made to write about a time when they felt powerful before going for a mock business school interview were much more likely to be offered admission by independent judges than those who wrote nothing. The worst performers were those who wrote about a time when they felt powerless.

One study suggests why these sorts of exercises might work. Researchers at Northwestern University in Evanston, Illinois, scanned the brains of 24 women during a maths test after putting them through a written exercise similar to that used by Lammers, reinforced by a role-playing task that gave them a high or low social role. Compared with those primed to feel disempowered, women who had been put in a powerful state of mind not only scored better

on the test but made more use of parts of the brain associated with concentration rather than cognitive interference.

It would be natural to hope that making people aware of these findings might help to redress inequalities and perhaps even provide a magic bullet for improving performance. But questions remain about how effective these various techniques really are and how long any benefit lasts. Michalak warns against jumping to conclusions. "The effect would be relatively short," he says. "But if you can train patients to change their posture or way of moving, I think it can have a more lasting effect."

There's another potential pitfall. Participants in psychological studies aren't aware of what outcomes the researchers are interested in – they don't know that they are being primed. This is a potential hurdle for people who want

Why am I here?

Having a purpose to what you do could help you live longer – and better, finds **Teal Burrell**

SOMETHING to live for. This simple idea is at the heart of our greatest stories, driving our heroes on. It is the thread from which more complex philosophies are woven. As Nietzsche once wrote, “He who has a why to live for can bear almost any how”.

As human beings, it is hard for us to shake the idea that our existence must have significance beyond the here and now. Life begins and ends, yes, but surely there is a greater meaning. The trouble is, these stories we tell ourselves do nothing to soften the harsh reality: as far as the universe is concerned, we are nothing but fleeting and randomly assembled collections of energy and matter. One day, we will all be dust.

One day, but not yet. Just because life is ultimately meaningless doesn't stop us searching for meaning while we are alive. Some seek it in religion, others in a career, money, family or pure escapism. But all who find it seem to stumble across the same thing – a thing psychologists call “purpose”.

The notion of purpose in life may seem ill-defined and even unscientific. But social studies are pinning down what it is, and how it affects our lives. People with a greater sense of purpose live longer, sleep better and have better sex. Purpose cuts the risk of stroke and depression. It helps people recover from addiction or manage their glucose levels if they are diabetic. If a pharmaceutical company could bottle such a treatment, it would make billions. But you can find your own, and it's free.

The study of how purpose influences our

health largely began with Viktor Frankl, an Austrian psychiatrist who survived four Nazi concentration camps. He noticed that some of his fellow prisoners were far more likely to survive than others. “Woe to him who saw no more sense in his life, no aim, no purpose, and therefore, no point in carrying on. He was soon lost,” he later wrote. After the second world war, Frankl dedicated his work to understanding the role of purpose and developed a therapy based on his findings.

Beyond happiness

Today, researchers define purpose as a sense of direction in life – a long-term goal set around one's core values, that makes life worth living, and shapes daily behaviour. It is a component of broader measures of subjective well-being or happiness (see “How do you measure purpose?” page 82), in which there has been a surge of interest in the past two decades. That's why, in 2012, then United Nations secretary-general Ban Ki-moon commissioned the first ever *World Happiness Report*, which has been updated annually since.

Measures of happiness can reflect broader social issues such as inequality, but when researchers look at the individual elements that make up well-being, they find purpose on its own has a unique influence on health.

Of course, teasing out whether it is actually purpose itself, and not the fact that purposeful people may exercise more or eat better, can be difficult. But over the past 10 years, the findings about the health benefits of

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CARLO GAMBARI



purpose have been remarkably consistent – revealing that, among other advantages, alcoholics whose sense of purpose increased during treatment were less likely to resume heavy drinking six months later, that people with higher purpose were less likely to develop sleep disturbances with age, and that women with more purpose rated their sex lives as more enjoyable. These findings persist “even after statistically controlling for age, race, gender, education, income, health status and health behaviours”, says Victor Strecher, a public health researcher at the University of Michigan in Ann Arbor and author of the book, *Life on Purpose*.

In an analysis of 7000 middle-aged people in the US, even small increases in sense of

purpose were associated with big drops in the chances of dying during a period of 14 years. A study of more than 9000 English people over 50 years old found that – even after adjusting for things like education, depression, smoking and exercise – those in the highest quartile of purpose had a 30 per cent lower risk of death over nearly a decade compared with those in the lowest quartile. Other studies show higher purpose cuts risk of heart disease by 27 per cent, stroke by 22 per cent and Alzheimer’s disease by half.

The only reason purpose isn’t a top public health priority, says Strecher, is because it somehow feels too vague or ephemeral. “It’s not a construct that feels scientific enough,” he says. “If this were a physical issue or a new drug or a gene, you would see lots of funding going into it.”

Some of the scepticism has to do with concerns that purpose is merely a stand-in for opportunity in life, or wealth. Indeed, in one analysis, Patrick Hill, now at Washington University in St Louis, did find that people with a stronger sense of purpose tended to have more money to begin with, and earn more over the period studied.

HOW DO YOU MEASURE PURPOSE?

To determine whether purpose affects health and longevity, you first have to measure it. To do this, many researchers turn to a set of scales developed in the 1980s by the psychologist Carol Ryff at the University of Wisconsin in Madison.

Ryff’s scales measure six different aspects of well-being: autonomy; environmental mastery (the feeling of being in control in your everyday environment); personal growth; positive relations with others; purpose in life and self-acceptance. For each item, people read a series of statements, and select one of six responses ranging from “strongly disagree” to “strongly agree”. These types of scales are often used to assess national levels of well-being.

For purpose, the statements include things like, “My aims in life have been more a source of satisfaction than frustration to me”, or, “In the final analysis, I’m not sure that my life adds up to much”.

Higher scores are based on stronger agreement with purposeful statements such as: “Some people wander aimlessly through life, but I am not one of them”, and disagreement with remarks such as: “I live life one day at a time and don’t really think about the future”.

People who score in the bottom 25 per cent are considered to have low levels of purpose. A person with a high degree of purpose – someone who falls into the top 25 per cent – is characterised as someone who “has goals in life and a sense of directedness, feels there is meaning to present and past life, holds beliefs that give life purpose and has aims and objectives for living”.

Health benefits

But a 2007 Gallup poll of 141,000 people in 132 countries found that, even though people from wealthier countries rate themselves higher on measures of happiness, people from poorer nations tend to view their lives as more meaningful. Shigehiro Oishi at the University of Virginia in Charlottesville, who analysed the poll data, suspects this is in part because people in developing countries have more concrete things to focus on. “Their goals are clearer perhaps: to survive and believe. In rich countries, there are so many potential choices that it could be hard to see clearly,” he says.

Could it be that purpose is just another term for religious faith? Oishi’s study did find that nations with the highest ratings of meaning in life were also the most religious. And religious people do tend to report having more purpose. But efforts to disentangle the two have revealed differences. Religiosity doesn’t predict a lower risk of heart attack or stroke, for example. And certainly many non-religious people have high levels of purpose.

In fact, few of us rank on the very low end of the scale. “We tend to focus on the utter meaninglessness of the world,” says Samantha Heintzelman at the University of Virginia. But, “for the most part, people feel like their lives are pretty meaningful”.



So how does that meaning, that sense of purpose, actually improve your health? In part, it may be because greater purpose makes people more conscientious about maintaining their health. But Steven Cole at the University of California, Los Angeles, thinks there’s more to it. “If people are living longer, there’s got to be some biology underpinning that,” he says. Cole has spent years studying how negative experiences such as loneliness and stress can increase the expression of genes promoting inflammation, which can cause cardiovascular disease, Alzheimer’s or cancer.

In 2013, Cole examined the influence of well-being instead. He focused on two types: hedonic, from pleasure and rewards, and eudaemonic, from having a purpose beyond self-gratification. These two aspects were measured by having participants note down their well-being over the previous week, how often they felt happy (hedonic) or that their life had a sense of direction (eudaemonic), for example. Although scoring highly in one often meant scoring highly in the other and both



Full circle: having goals that benefit others may provide particularly strong benefits for you

chronic stress, causes harmful inflammation. "There may be something saying 'be less frightened, or less worried, anxious or uncertain,'" says Cole.

That something could be a brain region called the ventral striatum, an area activated when people are told to focus on things of value. Cole has found that people with more activity in this area show similar patterns of gene expression to those with high levels of eudaemonic well-being. Focusing on something positive and bigger than yourself may activate the ventral striatum, which can inhibit areas like the amygdala, which usually promotes the stress response. Another indication of this comes from research showing that higher scores on a scale of purpose correlated with less amygdala activation.

And one study indicates that people with higher eudaemonic well-being have both increased activity in the ventral striatum and lower levels of the stress hormone cortisol. "Things that you value can override things that you fear," says Cole.

An alternative theory for how purpose could affect biology is by preserving telomeres, caps on the ends of chromosomes that protect DNA from damage, but that shorten with age and stress. A study on stress reduction through meditation has found that it could defend telomeres. But close analysis showed that the benefit was down to a change in sense of purpose, not the meditation directly: the greater a person's purpose became, the more of the protein telomerase they had to protect their telomeres.

Because of findings like these, some researchers think purpose should be more of a public policy priority, shifting away from traditional measures of economy like GDP, and narrowing the focus of happiness campaigns. Doing this would reduce early mortality, give us better overall health and cut the need for medical help, says Michael Steger at Colorado State University in Fort Collins.

It may also help us all get along. Hill has found that people who report higher levels of purpose are less distressed in situations where they are in the minority. It makes sense: people on a mission must accept that achieving their aims requires getting along with others. "Whether goals are focused on helping others or not, it's very rare that our life goals don't involve others at all," he says.

This is all well and good if you're already



ALEX WEBB/MAGNUM

correlated with lower levels of depression, they had opposite effects on gene expression. People with higher measures of hedonic well-being had higher expression of inflammatory genes and lower expression of genes for disease-fighting antibodies, a pattern also seen in loneliness and stress. For people scoring highest on eudaemonia, it was the

"If people with purpose live longer, there must be some biology underpinning that"

opposite. "There were surprises all around," Cole says. "The biggest surprise being that you can feel similarly happy but the biology looks so notably different."

Cole suspects eudaemonia – with its focus on purpose – decreases the nervous system's reaction to sudden danger that leads to faster heart rate and breathing and surges of adrenaline. Over-activation of this stress-response system, as you see with

brimming with direction, but how can people boost their sense of purpose if it is lacking? There are several different strategies. As the study on telomeres indicates, meditation can have an effect. And other research has shown that eudaemonic well-being is strengthened by carrying out random acts of kindness. Cole has found that having a purpose that benefits others may be particularly helpful. But striving for something that isn't necessarily constructive, like climbing a mountain, may be enough to create the health-boosting biology he sees in his studies.

To identify or strengthen your sense of purpose, Steger suggests starting small, by focusing first on making work more meaningful or becoming more invested in relationships. Strecher recommends setting a different purpose for each of four domains in life – family, work, community and personal – and acknowledging that your focus will shift between them over time, and the goals themselves can shift too.

Purpose pills

Strecher recommends considering what you would like to be said about you at your memorial, or to identify people you would like to emulate. He is also developing an app called Jool that he hopes can eventually serve as a kind of "purpose pill". Users begin with an assessment, and then get encouragement and guidance as they go on. It is being tested by companies to help employees hone their sense of purpose – and boost productivity.

There are also more formal therapies that foster purpose and meaning in life for people with conditions such as depression. For example, Dolores Gallagher-Thompson at Stanford University in California, has found that cognitive behavioural therapy can promote meaningfulness. She encourages patients to consider their legacy and how they might provide a good example for children and grandchildren.

Purpose isn't a fixed entity – it waxes and wanes with changes in life. Many people experience a drop in purpose following retirement, for instance, but can regain it by engaging in the community, helping others and remaining sociable. And, as Hill found, the health effects of purpose are apparent whether someone is 20 or 70. "To me, that's evidence suggesting that whenever one finds a purpose it can still imbue benefits," he says. In other words, it's never too late to start seeking the meaning of life. ■

Force of habit

If you master your brain's autopilot system, you can make a habit of whatever you want, finds Teal Burrell

I'M STARING down at my fingers on the keyboard with some shame and disappointment. I expected them to look different by now. When I set out to write about habits, I vowed to break one of my own – biting my nails. The gnawed tips remind me what everyone knows: old habits die hard.

Just why habits are so hard to make and break is a long-standing mystery. Even so, the prospect of mastering our habits has such appeal that plenty of theories about them have evolved. Accepted wisdom suggests, for instance, that it takes 21 days to form a new habit or get rid of an old one.

Unfortunately, there's little by way of evidence to back up such notions. But that is starting to change. With advances in neuroscience, it is now possible to peer inside the brain as it goes about its business, which means for the first time we are building an accurate picture of just what happens to brain circuitry when a habit is formed. We've even figured out ways to switch habits on and off with the flick of a switch.

The first challenge in understanding habits is getting to grips with what one actually is. In the vernacular, we might refer to habits as anything from brushing our teeth to bad table manners or smoking.

Scientifically, habits are defined fairly broadly as actions performed routinely in certain contexts and situations, often

unconsciously. Once a habit is formed, you might think of it like initiating a program that runs on autopilot, making our actions more streamlined.

This process plays a vital part in making our everyday lives easier: imagine if you had to give your full attention to brushing your teeth or the commute to work every time you did it – life would become exhausting. "So much of our lives actually wind up being our habitual behaviours, that alone is amazing," says Ann Graybiel,

"Forty per cent of our daily behaviour is habitual, freeing up the mind"

a neuroscientist at the Massachusetts Institute of Technology. In fact, as much as 40 per cent of our daily behaviour is habitual, according to Wendy Wood, now at the University of Southern California, who tracked student behaviour to see how much of it fell into this kind of mental autopilot. She found that when students were engaged in well-practised behaviours – such as driving, exercising or brushing their teeth – they were often thinking of something else, allowing them to ruminate and their mind to wander.

All this makes sense from a practical perspective, but it also suggests that something changes in the brain when a conscious action turns into a habit.

This is one of the questions Graybiel is studying in her lab. Much of her work involves monitoring the brain activity of rodents and primates as they learn new activities and then repeat them until they eventually become habitual.

One of the first things her lab discovered was to do with an area of the brain called the striatum, a region important for movement, mood and reward. After a rat learns to navigate a maze and begins to follow the same route out of habit, brainwaves slow down in this part of the brain. Graybiel suspects that this slowing down indicates the creation of the habit, probably because the brain activity in that region has become more coordinated and efficient.

In another study, when monkeys were rewarded after looking at a series of dots, they soon learned the optimal strategy – the quickest way to look at every dot and get a juice reward the fastest. Again, after a certain point, the firing of the cells in the striatum became more coordinated as the monkeys' behaviour shifted to habit.

Importantly, the studies showed that cells within the striatum fire in this way at the beginning and end of a behaviour, as if



signalling when the autopilot program is turned on and off. Graybiel has seen this time and again in her studies of rats and monkeys. "By the time they really learned the habit, a lot of the neuronal activity had moved over to occurring at the beginning and the end of the whole behaviour, as though to package it, to mark the onset and offset of behaviour," she says. You might think of this as the brain's equivalent of putting the habitual action between brackets. Graybiel calls it "chunking", as a homage to psychologist George Miller's ideas about how it's easier to remember lists of things if you "chunk" them together into discrete blocks. If you were interrupted while reciting a phone number, says Graybiel, you would

"Willpower comes in limited supply, and gets used up during the day"

probably have to start over, because you only know it as a full thing.

This chunking of habits is what allows us to avoid wasting valuable brain power on simple activities. But it also has a downside: it makes breaking bad habits incredibly difficult.

The problem comes from assuming that we are always goal-directed, motivated people when we actually don't have conscious access to our habits, says David Neal, founder of Catalyst Behavioral Sciences, a consulting firm specialising in understanding consumers' decision-making and habits. For instance, I think I bite my nails to relieve stress, and can stop if I want to; in truth, I bite my nails without realising it. Simply wanting to stop isn't enough, because habits are unconscious impulses, firmly wired into our brains.

Understanding this could contribute in other ways though. The striatum helps to chunk habits, but Graybiel also suspects the involvement of a small brain area called the infralimbic cortex. Previous studies found that when animals had this brain area removed, they either abandoned their habits or acted in more goal-directed ways.

Because neurons within the infralimbic cortex change their firing pattern as habits are formed and broken, Graybiel decided to target the region with optogenetics, a precise technique that allows neurons to be turned on and off with flashes of light. When the region was deactivated, the habit was immediately disrupted; the rats no longer

followed their usual route. With time, the rats formed a new habit of running in the other direction, until Graybiel thwarted them again with another flash to their infralimbic cortex. When she did, they reverted back to their original habit.

This raises the intriguing possibility that targeting this area could help us break bad habits (see "Pathological habits?", below right). But optogenetics hasn't been tried on the human brain yet. Transcranial magnetic stimulation – which applies small electrical currents to the outside of the head – is one alternative, and it is already being studied for treating addiction. Deep brain stimulation – in which an implanted electrode is used to activate a certain brain region – is another option. It is used to treat depression and Parkinson's disease. Studies on obsessive-compulsive disorder, which is associated with very persistent behaviours, have been mixed.

Still, right now, that doesn't help my nail biting, or another aspect of habit that I was especially curious about. I wanted to know: does the brain distinguish between habits that we want to keep and ones we are trying to ditch? And so I resolved to keep a gratitude journal every day, to help me stop taking things like the ability to run for granted.

Some evidence about how the brain processes good and bad habits comes from another of Graybiel's experiments, set up to mimic the bad ones. Rats learned to navigate a simple maze – turn left for chocolate milk,



COREY HENDRICKSON/AURORA PHOTOS

say – until running this route was engrained. When given chocolate milk laced with a chemical that made them sick, the rats still ran the same route, despite having no desire for chocolate milk anymore. They couldn't help it – it was habitual.

Studies of willpower also build on the idea that the brain doesn't discriminate between good and bad habits. Willpower, it seems, comes in limited supply; the more we use it during the day – to resist the office doughnuts, to go to the gym when we'd rather not – the more it gets depleted, which means we're more likely to give up on later attempts.

Fortunately, our reserves are restored overnight, so we start with a fresh supply each day, says Richard O'Connor, a psychotherapist and author of the book *Rewire*. But when it is in short supply – in times of stress or exhaustion, for example – we fall back on our habits, whether good or bad. As my deadlines get closer, my nails get shorter. And it's perhaps not surprising that during exam weeks, students find that habits like unhealthy snacking, increase. But good habits, like reading more or exercising, also increase.

This is because there are two competing systems in the brain, says Neal, who studied the students during exam weeks: a goal-directed system and a habit-forming one. "The goal-directed system is expensive to run; it takes effort and lots of mental resources." When it gets tied up, as during a week of exhausting exams, the habit system



PABLO DEL RIO/SOTERLO/GETTY

A hard habit to break, even when you want to stop...



Resist, resist... but if at first you don't succeed keep trying until it's a habit

acting more habitually, pressing for food even when full. And when the area was activated, they became more goal driven.

Gremel has distinguished between the different parts of the brain responsible for both systems in mice: goal-directed behaviours rely on the orbitofrontal cortex and a medial part of the striatum (which is analogous to a region called the caudate in

"There are individual differences in how the brain is wired for habits"

kicks in. But, he says, "the habit system has both good things in it and bad things in it. So you get kind of a boost across the board."

"People fall back on whatever habits are strongest," says Wood. She conducted a study in which people who had been trained to eat healthy foods ate less chocolate even when their willpower was low. Chocoholics, on the other hand, ate more of it when their willpower reserves were depleted.

What makes one habit stronger than another? Most habits start off as goal-directed behaviours: you want a cleaner bedroom, so you make your bed each morning; I wanted

to be more grateful, so I started a journal. But if done often enough, they become automatic, performed unconsciously. And this switch between the two can also be seen in the brain.

Christina Gremel, now at the University of California, San Diego, taught mice to press a lever for a sugary drink in either a goal-directed way (only when they were hungry) or a habitual manner (every time they entered a particular room).

Next, Gremel used optogenetics and chemical methods to disrupt certain brain areas. When a region called the orbitofrontal cortex was inhibited, the animals started

humans) while habits rely on a lateral part of the striatum (the putamen in humans).

The results hold up in experiments on people too. Sanne de Wit at the University of Amsterdam in the Netherlands examined differences in how often people make "slips of action", falling back on habits when they don't intend to, like driving towards work when they meant to drive to the grocery store. In the study, people learned to play a computer game for a monetary reward. Then the rules of the game were changed. Those who were more prone to slips of action would continue to hit the buttons they were used to, even if it lost them money. When their brains were scanned, these people had stronger connections between the putamen and cortex compared with people who were better able to remain goal directed (to adjust to the new rules and keep earning money). The more goal-directed people had stronger connections between the caudate and cortex.

So there are individual differences in how our brains are wired for habits. To some, the key to making and breaking habits is understanding these differences. "You look at all the advice we're surrounded by: do it first thing in the morning, start small, give yourself a cheat day... They all work sometimes for some people, but they don't work all the time," says Gretchen Rubin, author of *Better Than Before: Mastering the habits of our everyday lives*.

O'Connor agrees: in his book, he identifies factors that may lead to bad habits: a tendency towards excessive risk-taking or perfectionism, for example. Like Rubin, he stresses that the first step to better habits is gaining self-knowledge and insight into your personality, triggers and ingrained responses.

We also know that habits are triggered by certain cues or contexts. Indeed, it could be ➤

PATHOLOGICAL HABITS?

Biting your nails might be impolite and unsightly, but it's not life-altering or life-threatening. But where do bad habits become more of a problem?

"We don't yet know how our normal habits and habitual behaviours relate to the very insistent behaviours present in addiction and OCD," says Ann Graybiel at the Massachusetts Institute of Technology. There's evidence that people with obsessive-compulsive disorder, Tourette's syndrome or drug abuse problems have disruptions in neural circuits between the cortex and the striatum, which are both involved in habit formation (see main story).

Research has found people with OCD to be more vulnerable to "slips of action" - unintentionally executing habitual behaviour. And a study found that anorexia might also be an extreme form of habit; the people with anorexia in the study had stronger neuronal activity in the dorsal striatum, an area that helps regulate habits.

With drug use, however, it gets more complicated, because the neurotoxicity of drugs also affects the brain. So while having a strong propensity for forming habits might make you more likely to become addicted, the drug itself might make you more prone to falling into habit traps.



YUJIRO TADA/GETTY



SOPHIE CHIVET / AGENCE VU/CAMERA PRESS

And repeat: do something enough and changes in the brain make it effortless

these cues that kick off brain signals that tell the striatum to “open brackets” and begin that autonomous behaviour. We are driven to do certain things in certain environments. Neal and Wood studied this by having people watch videos in a cinema or a conference room. In both settings, the participants were given either freshly popped popcorn or week-old popcorn. People who were used to eating popcorn at the cinema ate more of the stale popcorn in that setting, even when they admitted it wasn’t very good. But in the conference room, they didn’t eat as much. The context was essential.

So the next step is coming up with a well-defined plan based on such cues. I wanted to write in my journal at the end of each day, so I put it next to my bed. Before I turned out the light, I’d write.

“People who form such simple concrete plans are generally much more effective,” says de Wit. Having specific rules also makes it easier to make good choices, even when your willpower is low.

Clean break

The link between habits and our environment is also why the best times to break habits or create new ones are when we go on a trip, change jobs or move house. Wood studied students’ habits before and after transferring university and found that they changed habits like how much they watched television or went to the gym, for better or worse. The context got disrupted, allowing new habits to form.

And even small changes to routine can help – like the cue to put my diary by my bed. “Those little disruptions to the

environment actually make a big difference. It’s surprising,” says Neal.

For my nail-biting, working out a way to break the cue was harder: I needed my fingers to type. Neal suggested painting my nails, to disrupt the sensory experience. It worked, for a bit.

But after about a week of painted nails, the polish chipped and I removed it. I promised to repaint them soon, but, before I even realised it, I had bitten them down again.

Another tip is not to worry about little slip-

HOW TO MAKE OR BREAK A HABIT

SCHEDULE IT Figure out when you’re going to perform a new habit and make it part of your day. Consider tying it to something you already do: for instance flossing after you brush your teeth, eating an apple with lunch, going to the gym on your way home from work.

BE SPECIFIC If you want to eat fewer sweets, determine rules to take the choice out of it, such as never eating the treats at work or only eating them if it’s a certain day of the week.

GO EASY ON YOURSELF Gretchen Rubin, author of *Better Than Before*, says guilt and shame don’t work: “People who do better are the people who show themselves compassion.”

START NOW The beginning of a new week, month, or year can be a popular motivator for changing habits but as Rubin notes, “usually the best time to start is now”.

BE PATIENT Some habits take a long time to make or break (see main story).

ups like this. A University College London study that followed about 100 people as they tried to form new habits found no long-term consequences to slipping up for a day here or there. So if you diet for a month, but then fall off for a day, don’t take that to mean you’ve failed. “You got 30 days of dieting practice built up in your brain,” says O’Connor. “That doesn’t go away just because you slipped up on day 31.” To prevent slip-ups from snowballing, Rubin suggests breaking the day into sections. That way, if you eat too many doughnuts at a morning meeting, you don’t give up and binge for the rest of the day. Rather, you start fresh at noon and try again.

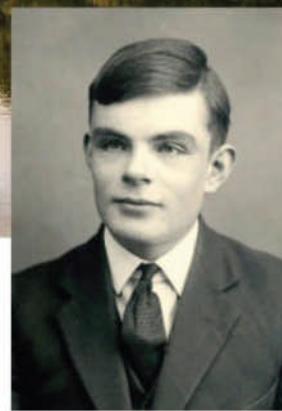
And it gets easier, O’Connor promises. “Whatever you do, you’re more likely to do it again because you’ve just done it.” Willpower is like a muscle; although it can get depleted, it also gets stronger with practice.

How long do you need to practise for? O’Connor says to give it at least three months, which is longer than the often-repeated mantra that it takes 21 days for habits to form. The University College London study found that there was huge variation in how long it took to cement a new habit. The average was 66 days, but it ranged between 18 and 254.

My experience backs this up. My journalling habit came easily; within a week or two, it was second nature. Stopping the nail biting, however, seems to be on the 254-day pace, if that. But knowing that it can take months means I’m persevering. Besides, I’ve realised it can be hard for everyone. Even de Wit admits being unable to stop popping her bubble gum, to the chagrin of her partner. “Unfortunately, when you study habits it doesn’t mean you don’t have any bad habits,” she says. Writing about them doesn’t guarantee it, either. ■

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CONTROL YOURSELF

Understand the language of emotions and we can manage them more skilfully, says Linda Geddes

RILEY is moodily picking at her dinner. Noticing that something is amiss, her dad asks how school was. Inside Riley's brain, a small green girl called Disgust flicks a switch, and Riley rolls her eyes: "School was great, all right?" she replies sarcastically. Sitting at the control panel in Dad's mind, a skinny man called Fear reports the eye-roll to a character named Anger, who seems to be in charge. "Make a show of force," he orders. "Riley, I do not like this new attitude," Dad responds. The situation escalates until Riley screams: "Just shut up!" A big red button inside Dad's head is pressed: "That's it. Go to your room!"

This brain's-eye view of emotions in Pixar's movie, *Inside Out*, is entertaining, but it reinforces the questionable idea that our emotions control us – that they are powerful, primal forces we struggle to understand both in ourselves and in others. Popular though this picture may be, it is one that psychologists would like to dispel. Other animals may be slaves to emotion, but human emotional life is more complex and cerebral, they argue. What's more, mastery of your emotions is important not just for psychological well-being, but also for success in many areas of life.

The concept of "emotional intelligence"

surfaced two decades ago and was an instant hit. It tantalised us with the idea that we each have an EQ to our IQ, and promised to let us measure how emotionally clued-up individuals are. But it has its problems, not least in suggesting that people with a low EQ are forever saddled with it. EQ tests also often fail to do what they say on the tin: allow employers to find the most emotionally savvy candidate for the job. As a result, psychologists are falling out of love with emotional intelligence. Instead, they have identified three skills that can help us all become more emotionally adept, and reap the benefits.

Trace emotions back to their origins, and the notion that we are in thrall to them doesn't seem so misplaced. Emotions evolved to help animals react quickly in life-or-death situations. The fight-or-flight response is a classic example. Before you are conscious of feeling fearful, your body and mind are already primed to act – your heart is racing, your vision focused, and you experience a hot rush of blood to the head and perhaps an urge to lash out. Emotions generate such physiological changes in all animals, but for us they are more than just subconscious calls to action. "Human emotions are enormously

tilted towards social situations," says Mark Pagel, an evolutionary biologist at the University of Reading, UK. "We have jealousy, sympathy, a sense of injustice, and guilt. It's these social emotions which really mark us out as a species." They are also what make our emotional lives so complicated.

Some people are clearly better at coping with this complexity than others. This might help explain why the idea of emotional intelligence was so eagerly received in 1995, following the publication of psychologist Daniel Goleman's book *Emotional Intelligence: Why it matters more than IQ*. An international bestseller, it launched an industry peddling tests to select emotionally intelligent candidates for management positions and careers such as medicine. But for all the hype and the money spent, there has been a sense of disappointment – not just among employers. "People ask, 'what the hell was it good for?'" says Klaus Scherer, director of the Swiss Center for Affective Sciences in Geneva.

One problem with the tests is that they often ask participants to rate their own abilities – for example, how good they are at keeping calm in difficult situations. Assuming respondents do not lie, they may still lack ➤



ONE LANGUAGE, MANY DIALECTS

Charles Darwin coined the term “the language of the emotions”. But do all people speak the same language? To get at an answer, David Matsumoto at San Francisco State University studied thousands of photos taken at the 2004 Olympic and Paralympic games in Athens, Greece, comparing the facial expressions of athletes who were born blind with those of their sighted counterparts. “You can rule out any possibility that they visually learned to put these expressions on their faces,” he says. “We found that there are seven categories of emotion that are universally produced on the face.” His list – anger, contempt, disgust, fear, happiness, sadness and surprise – closely matches the universal emotions identified by psychologist Paul Ekman, who pioneered the field in the 1960s.

But although we all express pure and unfettered emotion in the same way, everyday variations arise, Matsumoto suspects, because we regulate our emotions to conform to cultural norms, with knock-on effects on the way we interpret emotion in others. One study, for example, found that American and European students frequently reported feeling pride, anger or irritation, whereas Japanese students more often experience feelings of closeness, shame, guilt or debt to another. Another study found that white Europeans could easily distinguish between facial expressions of surprise, fear, disgust and anger, whereas east Asians often confused disgust and anger, and fear and surprise. Eye-tracking revealed that the white Europeans looked at all areas of the face equally, while east Asians focused on the eyes.

What do such studies tell us?

According to Batja Mesquita at the Catholic University of Leuven (KUL) in Belgium, if you live in a culture where an emotion like anger is viewed as disturbing and selfish, you will not be rewarded for expressing it, and over time you may even cease to feel it as frequently or intensely. She has found that immigrants gradually adapt their emotions to the norms of their new home. It's as if we all speak the same language but adopt the local dialect.

the self-awareness to give accurate answers. Another concern is that rather than measuring how well we use our emotions, the tests really measure personality and general intelligence. It has become clear that if you take these two factors into account, emotional intelligence scores say almost nothing about how competent someone is likely to be in the workplace.

Emotionally fluent

Scherer notes that the concept of emotional intelligence caught on before it had been properly researched. We now know far more about human emotions, in particular, that although some people are naturally more emotionally adept than others, all of us can learn to master our emotions more effectively. The notion of emotional intelligence is confused, in part because the very term EQ suggests an innate and unalterable measure – akin to IQ – even as its proponents promise that employees, students, indeed anyone, can learn to boost their score. Many psychologists prefer the term “emotional competence”, because it signifies an ability that can be honed. Many also think of this ability as a sort of language – one that all humans share (see “One language, many dialects”, left). This, in turn, suggests how we can become more emotionally fluent. Just as learning a language entails recognising words, understanding how to use them, and controlling a conversation, so mastering the language of emotions requires three key skills – perception, understanding and regulation of emotions.

Perception is the bedrock on which the two other skills rest. Perceiving emotions is not as straightforward as it might sound. Traditional tests of emotional intelligence probe this skill using pictures of faces. “The tests are too easy,” says Katja Schlegel at Northeastern University in Boston, Massachusetts. For a start, expressions of emotion extend beyond the face to gestures and movements, plus tone of voice and other sounds. Aural and visual cues can interact; for example, one study found that the way people interpret laughter and crying sounds is altered by the facial expressions accompanying them. “The same laugh is perceived as sounding significantly happier when paired with a smiling face than when paired with a sad face,” says César Lima at University College London.

A static picture isn't even a good representation of the way our faces express emotion. “The human face is equipped with a large number of independent muscles, each



of which can be combined and activated at different levels of intensity over time,” says Rachael Jack at the University of Glasgow, UK. Her studies using computer-generated faces that randomly combine facial expressions, such as lip curls and raised eyebrows, suggest that each emotion has an associated sequence

“Emotions are like a language - one that all humans share”

of facial movements, which she calls “action units”, unfolding a bit like the letters of a word. Action units strung together in specific patterns create “sentences” that communicate a more complex social message.

Schlegel is working with colleagues at the University of Geneva, Switzerland, to develop a better way of assessing how we judge emotional cues in everyday life. Named the Geneva Emotion Recognition Test (GERT), it involves a series of short videos of actors expressing an emotion by uttering meaningless syllables. People’s scores can range from 0 to 1, and preliminary research suggests that they are meaningful. When Schlegel invited pairs of strangers to negotiate a work contract, those with higher scores both negotiated more successfully and were perceived as being nicer and more cooperative



RITA SCAGLIA / PICTURETANK

Gestures and movement are essential to the language of emotional expression

than people with lower scores. "This is why I think emotion recognition is such an important skill," she says. "It is difficult to convince a person of your ideas if you're not paying attention to their needs and interests."

So, how can you improve your emotion recognition skills? Schlegel teaches people to look for the appropriate cues in the face, voice and body, then gives them video clips to practise on, and get feedback. In one study she found that undergraduates trained in this way achieved an average GERT score of 0.75, compared with 0.6 for controls.

Lima's group, meanwhile, has been looking at whether musical training can help. They found that adult musicians are better than non-musicians at judging the emotion in someone's tone of voice. Brain imaging studies suggest that this reflects more than simply a general sensitivity to basic aspects of sound, says Lima. "Music training can modulate brain responses known to be more specifically associated with emotions and with our ability to interpret others' minds."

Recognising emotions is not enough, though. You also have to understand how they are used – and that's the second skill. "Not everyone smiles when they're happy, or scowls when they're angry," says Lisa Feldman Barrett, also at Northeastern University. Indeed, she has found tremendous variability in brain activity, both between people and in the same individual, in response to different

types of threat. This suggests that there is no "essence" of fear or anger. "Somebody who is highly emotionally competent has a very broad vocabulary of emotion concepts that are highly flexible," she says. "They know how to impose meaning on smiles and scowls, frowns and vocal cues." They can take emotional signals – both from the outside world or their own bodies – and make sense of them.

The ability to understand emotions in this way is not innate. "None of us are born knowing the difference between feeling overwhelmed and worried, elated and ecstatic. It's a language that has to be taught," says Marc Brackett, director of the Yale Center for Emotional Intelligence. In an attempt to do that, a decade ago he helped create a programme called RULER, now used in some 10,000 US schools. It teaches children and young adults to interpret physiological changes in their bodies linked to emotions, label them, and learn strategies to regulate their emotions. "It's remarkable work that has a tremendous impact on kids' competence," says Barrett. "When you can take a physical change in your body and understand it as an emotion, you learn to make meaning out of that change." Evidence also suggests that it improves the relationship between teachers and students.

Other researchers are investigating whether having a broad and accurate vocabulary for your own emotions can make you more aware of other people's emotions. "It's still an open question," says Agneta Fischer at the University of Amsterdam in the Netherlands, who is leading one such study.

Once you can recognise and make sense of emotional signals, then you need the final

skill – the ability to regulate your feelings. "Emotion regulation is important, both to ensure that you properly analyse and appraise a situation, and also that you conform to social standards and don't allow yourself to show certain emotions at certain times," says Scherer. Again, this isn't something we are born with, and as we develop, some of us

"Mastering the language of emotions requires three key skills"

learn ineffective strategies for doing it, such as avoiding emotionally charged situations or trying to shut down our emotions completely. Research shows that people who address emotional situations directly rather than avoiding them have higher levels of well-being and are better able to cope with stress.

There are ways to improve your regulation skills. One approach psychologists favour is "reappraisal" – trying to put yourself in someone else's shoes so as to be more objective, and change your emotional response accordingly. When a team led by Ute Hüsleger at Maastricht University in the Netherlands taught this strategy to hairdressers, waiters and taxi drivers, they found that it resulted in more tips. "Reappraisal helps you to display authentic positive emotions, and that is rewarded by customers," she says.

But rethinking your emotions from scratch requires a lot of effort. Another promising approach is mindfulness – observing the coming and going of your emotions without action or judgement. In a separate study, Hüsleger randomly picked members of a group of 64 employees to receive mindfulness training, and monitored them all over 10 days. Those who got the training reported more job satisfaction and less emotional exhaustion. "The idea is that when you just see emotions as they are, as thoughts and sensations, you gain a sense of perspective and the 'hot' aspect of the emotion dissolves," she says.

Everyone knows that mastering a language takes time and practice. Some people are naturals. Others struggle to communicate effectively. But when it comes to the language of emotions, making the effort to improve is surely worth it, because the proponents of emotional intelligence were right about one thing – being emotionally fluent really does bring benefits. ■



RANDI SIDMAN-MOORE/MASTERFILE/CORBIS



Empathy is a healthy emotion – but could there be too much of a good thing, asks **Emma Young**

I feel your pain

TANIA SINGER wasn't the first person to put a Buddhist monk in an fMRI machine. But the neuroscientists who had scanned supposedly caring, sharing brains before did it to find out where empathy comes from. Singer was looking for ways to avoid it.

Few people would argue that the world is cursed with an excess of empathy. But we are starting to discover that our capacity to share other's emotions and take their perspective comes with a sting in its tail. Overdosing on the misfortunes of others is not just a problem for those in high-exposure professions such as nursing. All of us are vulnerable to catching the pain of others, making us angrier, unhappier, and possibly even sicker.

Fortunately, work on locating the root of empathy in the brain has also led to the discovery that with the right training, we might be able to tune how much we let others' emotions affect us. This could allow us the best of both worlds – to care, without letting it consume us.

Empathy is undeniably a good thing. Understanding how others are feeling is a bonding mechanism that we are finding in an increasing number of animals, including dolphins and rats. In humans, primatologist Frans de Waal of Emory University in Atlanta, Georgia, has suggested that being affected by another's emotional state was the earliest step in our evolution as a collaborative species.

But the pitfalls will be apparent to anyone who has been in a room full of babies. If one starts crying, pretty soon, they're all at it.

Babies don't understand the difference between their own emotions and those being felt by others, and so what one feels, they all feel. Negative and positive emotions alike spread like a virus. As our sense of self develops, we learn to distinguish other people's emotions from our own, although a variety of experiments, including some that have looked at our behaviour in online social networks, indicate we are not entirely free of

the risk of emotional contagion (see "Socially contagious", below).

That's because the distinction between what we and others feel isn't terribly clear to our brains. Singer, then at University College London (UCL), and her colleagues demonstrated this in 2004 when they put 16 romantic couples into an MRI scanner. When they gave the volunteers a painful electrical shock, this elicited activity in brain regions known to respond to physical pain and also in regions tuned to emotional pain. But when volunteers saw their loved one get a shock, no activity registered in their physical pain centres – while the emotion regions lit up like fireworks. Notable among these was the anterior insula, where a lot of the coordination between brain and body takes place.

Since then, many other studies have confirmed that this "empathy for pain" network exists, and that it doesn't distinguish whether the pain you're observing is physical or psychological. "The basic principle is the same," says Singer, who is now at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany.

What's more, it has become apparent that we don't just catch pain from those we are intimate with. The first hints came from people in care-giving professions who often see the stress and pain of others, such as hospice staff, nurses, psychotherapists and paediatricians. Since the early 1990s, a kind of empathy burnout has increasingly been documented – given names including ➤

SOCIALLY CONTAGIOUS

Social networks such as Facebook and Twitter provide for many of us a very public window on our emotions – and seem to indicate just how sensitive those emotions are to outside influence.

In 2014 Facebook caused a furore when the company revealed it had secretly been experimenting with the feelings of half a million users. By tweaking the algorithms that determine whether the stories people see are more positive or negative in tenor, the researchers claimed they had shown that emotional states could be transferred via social network.

In September 2015, researchers at the University of Southern California followed up with their own study on Twitter, demonstrating increases in negative posts after people saw a Twitter timeline that had been tweaked to be more negative than usual.

STRANGER DANGER

How much do you have to care about someone to be infected by their stress? For some of us, not very much.

That at least is the conclusion of Tania Singer at the Max Planck Institute for Human Cognitive and Brain Studies in Leipzig, Germany. She paired volunteers either with a loved one or a stranger and subjected one member of each pair to the Trier social stress test, a standard protocol to induce stress. In front of a panel of judges, you get 3 minutes to prepare a 5-minute speech, and once that's done, you are quizzed for 5 minutes on increasingly difficult arithmetic. All the while, the judges watch impassively. For most people, the test results in a flood of the stress hormone cortisol, clammy hands and a rapid heartbeat.

In Singer's experiment as one member of each pair was tested, their partner merely watched, either through a one-way mirror, or via a television. To remove any fear that the observer would be tested next, they had written guarantees that they wouldn't go through it themselves.

Even so, some 10 per cent of volunteers experienced cortisol flooding simply from watching the stranger's stress – even when that stress was merely on a screen. "To find such a significant hormonal response in someone who is merely passively observing another person getting stressed on TV, even when it was a stranger, was quite a surprise," says Singer.

"secondary traumatic stress" and "vicarious traumatisation". Symptoms include lowered ability to feel empathy and sympathy, increased anger and anxiety, and more absenteeism (see "The hurt locker", page 96). Various studies link these symptoms with an indifferent attitude to patients, depersonalisation and poorer care.

It's perhaps unsurprising that empathy burnout can affect people frequently surrounded by other people's pain. But a number of experiments suggest that the dark side of empathy spells trouble for everyone. You can "catch" stress any time you understand someone else's pain and share in it, activating your empathy for pain network.

Empathy overload

One location this is likely to happen is the workplace: we spend 8 or 9 hours a day with our colleagues, creating relationships that help us empathise with and catch their distress. Some companies, such as Ochsner Health System, which owns and operates hospitals and clinics in Louisiana, have begun to institute stress-free zones to limit contagion. "Venting is not productive," says Missy Hopson Sparks, a vice-president at Ochsner. So the company designated zones, including hospital floors, where sharp conversations, even whispered, were off limits. Morale in clinics rose. The policy was so successful it was rolled out across the company.

Singer's research indicates that for some people the physical effects of emotional contagion apply even when they observe a person they don't know suffering distress (see "Stranger danger", left). That is backed up by experiments in which, for example, people who watched a 15-minute TV newscast reported increased anxiety afterwards, with their anxiety only decreasing after an extended relaxation exercise.

For those less prone to experiencing "empathic distress", it might be tempting to dismiss it as someone else's problem. That's shortsighted, says Olga Klimecki at the University of Geneva in Switzerland. People who experience more empathic distress in their daily lives are more likely to become aggressive when provoked, "even towards an innocent person", she says.

That's backed up by work published in 2015 by Michael Poulin at the State University of New York at Buffalo, indicating that empathy can lead us to act aggressively, specifically when we see someone we value being

mistreated. "Experiencing a suffering person's distress as if it were your own is highly aversive and unpleasant," he says.

The irony is that the effects of empathy overload might undercut the very things for which empathy evolved in us – mutually beneficial cooperation and collaboration.

"Even in the short-term distress transmitted via empathy leads just as much to a desire to escape a helping situation as it does to a desire to help," says Poulin. Empathy, so beneficial when we lived as hunter-gatherers, can be a liability in a modern world characterised by anonymous, crowded cities and emotion-laden media content.

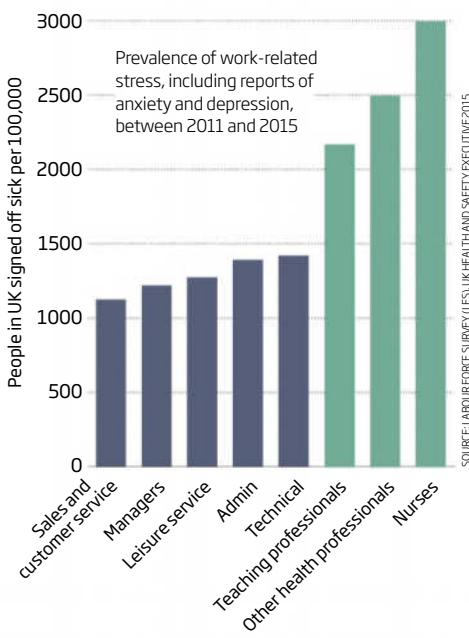
If that's true, can we do anything about it?

Perhaps, says Christian Keysers of the Netherlands Institute for Neuroscience in Amsterdam. "Just like some people are better at regulating their own emotions, some are better at regulating empathy," he says. His work suggests we're not stuck with the amount of empathy we are born with, but can adopt the strategies of others.

In 2014, Keysers and his colleagues looked at how people diagnosed with psychopathy, who are commonly thought to lack all capacity for empathy, react when they see images of

The hurt locker

Some jobs give you a much higher chance of getting ill because of work-related stress, anxiety and depression than others, in part because of how frequently you witness the pain of others



"Empathy, once a benefit, may become a liability in an anonymous, crowded modern world"



ASHLEY GILBERTSON / VIVA

people in pain. At first, the team presented images without any instructions as to what to feel. The volunteers' brains showed, predictably, less activity in areas associated with empathy for sensations, and in the insula, than the brains of healthy people.

But then Keysers asked his psychopathic volunteers to consciously empathise, and something very different happened: their brain responses were identical to the control group's. In other words, even if your default empathy state is "off", you can turn it on when desired. That was an eye-opener, says Keysers: it seemed clear that a spectrum of empathy could exist in all individuals.

Hence why Tania Singer found herself putting Matthieu Ricard, a molecular biologist turned Buddhist monk, into an fMRI machine. Experiments have shown that the training Buddhists undergo give them a heightened ability to manipulate their neural circuitry of empathy. One of the first such studies was done by Richard Davidson at the University of Wisconsin, Madison. Monk volunteers were asked to lie in fMRI machines as they heard sounds such as women screaming in pain. As they listened, Davidson asked them to engage in a form of compassion

meditation known as loving kindness meditation, in which you are encouraged to gradually extend warmth and care out from yourself to others. Davidson found that this process changed the firing of the monks' neural circuitry. It suppressed activity in the anterior insula, the brain region implicated in Singer's earlier experiments on empathy, and also in the amygdala, a region involved in threat detection but recruited during empathic responses.

In her latest experiments with Ricard, Singer asked him to empathise with suffering instead of engaging in compassion as he had been trained to do. When she did so, his empathy for pain network lit up, and almost immediately, he begged her to stop the experiment, calling the feeling "unbearable".

Your inner psycho

This hints that looking on other people with compassion rather than empathy might be a way to sharpen the distinction between you and someone else and avoid empathy burnout. "Compassion is feeling for and not with the other," says Ricard. With Klimecki and others, Singer has started to test the idea

Stress can be contagious even if we feel it remotely

on regular people. After putting subjects through compassion training, their brains responded to negative videos much like the monks' brains. This was reflected in increased well-being.

Singer's work in this area is fascinating, says Antonia Hamilton at the Institute of Cognitive Neuroscience at UCL, "especially the distinction between compassion and empathy". Singer and her team completed the first major project that turned this research into practice. Her group recruited 300 people, some whose jobs put them at higher risk of empathy burnout, and trained them in alternatives to empathy, including compassion.

One participant was Irina Schroen, a nurse in the neonatal unit at the Charité University Clinic in Berlin, Germany, whose experiences had come to affect her so severely that she was ready to give up her career. Singer's training, she says, saved her professional life. "My colleagues are once again happy to work with me," she says. "They say, 'It's incredible how relaxed you are now'."

Singer hopes it will pull more people like Schroen back from the brink of burnout, and more broadly help people and communities deal with social conflict – including problems resulting from war and the arrival of refugees.

Others in high-stress, high-performance professions might benefit from sliding more towards the "psychopath" end of the scale, says Del Paulhus, who studies personality traits at the University of British Columbia in Canada. "Too much empathy would undermine success as a surgeon, an athlete in violent sports, a lawyer, soldier," he says.

During his time in office, US president Barack Obama identified an "empathy deficit" as a pressing problem. How to increase became a hot topic; a study by Stanford University researchers appeared to link empathy training for teachers with fewer disciplinary problems in students. Education researchers and business leaders in the US and the UK have called for empathy to be taught in schools.

Appropriately dosed, empathy is undoubtedly a good thing, but we need to consider the side effects before we start prescribing it wholesale. "It's not at all clear the world needs more empathy if that means experiencing another person's suffering as your own," says Poulin. "Doing that may simply double the world's suffering". ■

A GOOD CRY

Turning on the waterworks could work to our advantage, if only we knew when, how and why, says Sonia van Gilder Cooke

BRITISH tennis player Andy Murray knows what it's like to be unpopular. Early in his career, his aloofness and volatility on the court left many with the impression that he was petulant, spoiled, even unpatriotic. Then came Wimbledon 2012, and a gruelling final against six-time champion Roger Federer. After Murray lost, he took the microphone to thank his fans. He quavered, tried to speak and stopped to wipe away tears. In that moment, Murray won over the British public. "It took me crying at Wimbledon," he later acknowledged.

But tears can have the opposite effect. In 1972, they were the undoing of US Democratic presidential hopeful Edmund Muskie. He was his party's front runner at first, but his campaign fell apart after he was accused of crying while addressing the press to defend his wife's reputation. He claimed the moisture on his face was melting snowflakes – the event took place outdoors in a blizzard – but to no avail. His image as the candidate of calm and reason was shattered.

That crying can change people's fates is beyond doubt; history is full of examples. But why tears can have such a far-reaching effect is not obvious. "If you compare tearful crying with other emotional expressions, very little is known," says psychologist Asmir Gracanin at the University of Rijeka, Croatia. What we do know is that emotional crying is downright weird. Many animals produce tears to protect their eyes, but humans alone cry out of feeling. And we cry not only when we're sad, but also when we're happy, overwhelmed, enraptured and in pain. Why do we do it? What are the benefits of blubbing? More pointedly, when should you keep a stiff upper lip, and when might it help to turn on the waterworks?

People have long puzzled over crying.

Aristotle purportedly viewed tears as an excretion like urine. "That they are of one nature is plain to the taste," he is reported to have said. Reflecting this idea, in the 1940s, American psychoanalyst Phyllis Greenacre suggested that female weeping was a symptom of penis envy – a way for a woman to imitate a man urinating. Less provocatively, Darwin concluded that, in addition to lubricating the eye, tears "serve as a relief to suffering", although he didn't explain exactly how.

The idea that crying is cathartic remains popular. But what does that even mean? For Freudians it suggests the release of pent-up emotions – the principle behind folk wisdom encouraging people to "let it out". Another interpretation is that crying rids the body of harmful chemicals, such as stress hormones, produced by emotional distress. This theory dates from the 1980s, when biochemist William Frey found that tears of emotion were richer in protein than non-emotional tears. But Ad Vingerhoets at Tilburg University in the Netherlands is dubious, having twice tried and failed to replicate this finding.

The myth of catharsis

Like other bodily fluids, tears tend to reflect the composition of the blood, he notes, but that doesn't mean their function is to purge the blood of certain substances. "We would never say that after having drooled, we feel better," he says. Besides, the average cry only produces around a millilitre of tears.

So why do many people say that crying makes them feel better? One possibility, says Gracanin, is that it's just that misery doesn't last for ever. Our mood improves by the ➤



BRAND NEW IMAGES/GETTY



time we've finished crying, even if it's just returning to normal from rock bottom. There is also some evidence that crying relaxes the body by activating the parasympathetic nervous system, or by pumping up levels of oxytocin, the "cuddle hormone". Gracanin is investigating these possibilities, but says that even if the effects are genuine, the reason we feel better may be something other than tears. "We still don't know," he says.

Could crying have another purpose? These days, most researchers believe its function is not physiological, but social. "If you cry, you send a signal that you need help," says Gracanin.

At first glance, liquid dripping from the eyes is a strange signal of helplessness, but neuroscientist Robert Provine at the University of Maryland, Baltimore County, thinks he knows how it evolved. Many animals clean their eyes and reduce irritation by secreting tears from the lacrimal glands, above the outer corner of each eye. Provine believes that as humans evolved, tears acquired a second role. "If someone has injured their eye or is suffering from disease, others might comfort or assist them," he says. "And after that, the presence of tears emerged as a cue for caregiving." In other words, once crying started to elicit help from others, it became worth our while to shed tears over any hurt, physical or mental.

Still, why did the eyes become the channel for signalling distress, and not sweaty palms or pale lips? The eyes are perhaps the best clue we have to what others are thinking, Gracanin points out, so we are predisposed

to look at them. You can also generally count on eyes to be visible. "They are a quite nice place to put a signal, as opposed to some other body part," he says.

And what a signal: Martijn Balsters at Tilburg University has found that the presence of tears on sad faces that volunteers saw for just 50 milliseconds boosted feelings of sympathy, supportiveness and friendship towards the individual pictured. Tears also help us overcome feelings of revulsion. Dennis Kuester at Jacobs University in Bremen, Germany, showed people pictures of injured faces, with and without tears, and measured the action of the levator labii, a facial muscle closely associated with expressions of disgust. Faces with tears provoked less revulsion than ones without them. "Tears really show that someone is in need of support, of empathy, of help, and

We view tears more sympathetically in powerful people and those seen as having earned the right to cry (below)



JIM WATSON/AFP/Getty Images

"One reason crying affects us so strongly is that, as many actors know, it's hard to fake"

that you should approach that person, even if there are some signs of injury," says Kuester.

One reason crying affects us so strongly is that, as many actors know, it's hard to fake. "It is considered an 'honest' signal, which makes it really powerful," says Vingerhoets. Provine agrees. "The ability to shed and respond to tears of emotion is important in the evolution of empathy," he says. Tears, it could be argued, bring out the best in us.

But it's also clear that our reactions to crying depend on a lot of factors, not least the sex of the person crying – although not necessarily in the way stereotypes might dictate. For example, psychologists Heather MacArthur and Stephanie Shields of Pennsylvania State University presented subjects with scenarios in which both men and women in the roles of nurse and firefighter broke down in tears while trying to help an injured person. The

A VERY PECULIAR PRACTICE

Look closely at crying, and you will see just how strange it is. For one thing, it encompasses two very different processes: vocal wailing and tearing.

Human babies excel at the former, and for good reason – bawling is a very effective way of getting attention from caregivers. For their first few weeks, babies don't even shed tears, because their tear glands are still developing. But as they grow, crying becomes less vocal and more tearful.

This could be an evolutionary adaptation, suggests Ad Vingerhoets at Tilburg University in the Netherlands. Wailing advertises vulnerability to everyone around,

including predators, so once a child can move around, it is wiser to use the more covert signal of tears.

Another puzzle is that we cry throughout our lives. Intriguing changes in crying behaviour seem to reflect its changing functions as we age. Around adolescence, we begin to cry less over physical pain and more over emotional pain. Many people also start to exhibit "moral crying", in reaction to acts of bravery, self-sacrifice and altruism. Why we do this is still a mystery.

Also mysterious is why, as we age, we increasingly shed tears over things that are positive. Robert Provine at the University of Maryland, Baltimore

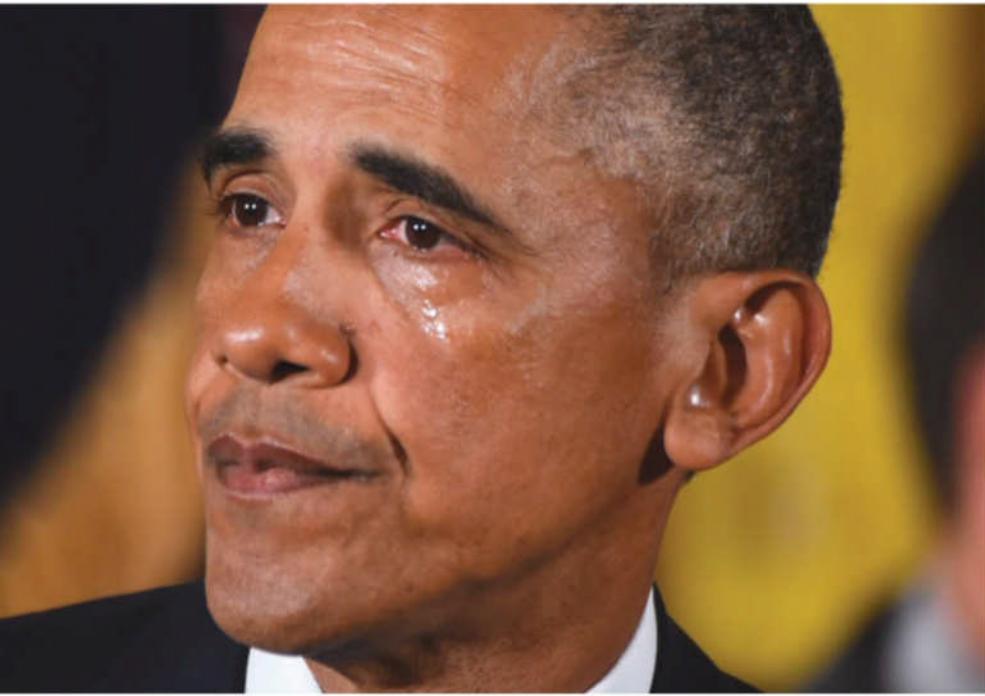
County, has a suggestion. "Given that emotional tearing is recently evolved, it's a very crude estimate of emotional expression," he says. "We also produce tears when we yawn, when we sneeze, when we laugh, when we cough."

Another theory is that so-called tears of joy do not actually reflect happiness at all; events such as weddings and holidays are often bittersweet because they remind us of the passage of time and mortality. This may be why children usually do not cry out of happiness: they don't yet make the associations with sacrifice, loss and impermanence.

Then there's the question of why

some people cry more than others. In a recent review of research, Vingerhoets reported that neurotics and people who are highly empathic cry the most. The former use tears manipulatively – as do narcissists, psychopaths and tantrum-throwing toddlers. Sociopaths are thought most likely to cry fake or "crocodile" tears.

And, although boys and girls cry frequently until puberty, in Western cultures women cry at least twice as often as men. Men are culturally conditioned to restrain their tears, but there may be more to it than that. Studies in animals suggest the hormone testosterone might have a tear-suppressing effect.



participants were then asked to rate the masculinity of the person who cried and the acceptability of crying. The firefighters were generally considered more masculine, whatever their sex.

Given the popular association between femininity and emotional display, you might think that crying by those in the more stereotypically feminine role of nurse would be more acceptable. In fact, the researchers found the opposite. "The more masculine people perceived the crier to be, the more they thought their tears were appropriate to the situation," says MacArthur. "It didn't matter whether that firefighter was female or male."

Doing a stereotypically masculine job may give you more of a licence to cry, whatever your sex, but being female means you are more likely to be comforted when you cry. This may have an unexpected explanation rooted in how tears alter our looks. Kuester showed a series of computer-generated neutral faces of ambiguous gender to volunteers, asking them to rate how masculine or feminine these looked with and without tears. His hypothesis was that adding tears to faces would make them look more feminine, given that stereotypes link tears and femaleness.

To his surprise, male respondents thought that tears made faces look more masculine. In another experiment, using faces with a range

of ages, Kuester found that men perceived tears as making faces look younger. In light of these findings, he speculates that tears may help protect women from inappropriate male advances and aggression. "When a woman is crying, it suggests to the male that, OK, now this is not a sexual object, but someone who needs help," says Kuester.

Men may not be sending out the same signals when they cry and, in many cultures,



BACK PAGE IMAGES/REX SHUTTERSTOCK

they are under pressure to suppress their emotions. But these may not be as strong or pervasive as we tend to think. MacArthur and Shields looked at crying in the domain of men's competitive sport and found that far from being a place of "manly" restraint, sport provides a safe arena for displays of feeling, including cheering, crying and hugging, among fans and players. In the sporting context, "emotion widely believed to be 'unmanly' is allowed", they write.

"Crying in men isn't just acceptable, sometimes it can be downright desirable"

What's more, crying in a man isn't just acceptable, sometimes it can be downright desirable. In another study, Shields and colleagues found that participants rated men who showed intense yet controlled emotion in a sad situation as more competent than those who showed no emotion at all. "Such displays convey that men are human, feeling beings," the researchers conclude. The finding doesn't surprise Thomas Dixon, director of the Centre for the History of the Emotions at Queen Mary University of London, and author of *Weeping Britannia*. This take on manliness has appeared time and again throughout history, he says. "People have argued that crying shows that you are not only strong and rational, but also feeling, and that that's the ultimate kind of masculinity."

Although crying is still full of mysteries (see "A very peculiar practice", far left), its benefits are becoming clearer. "Showing your vulnerability is sometimes very positive," says Vingerhoets. But tears must be used wisely. "How positively tears are viewed depends on what you're crying about – it has to be perceived as something important, and not your fault," says Shields.

How you cry is also crucial: welling up usually makes a better impression than open weeping. Ironically, the powerful are more often admired for their tears than the weak. "The individual who would be most sympathetically seen would be somebody who has earned the right to cry via status," says Shields. That might help explain why Murray has gone from being considered spoilt and petulant to a two-time winner of the BBC Sports Personality of the Year award. "Crying changes everything," says Provine. ■



BORED? WELL, DON'T BE

The true nature of boredom turns out to be far more stimulating than you might think, finds Caroline Williams

ASI sit, trying to concentrate, my toes are being very gently nibbled. It's my dog, Jango, an intelligent working breed, and he's telling me that he is bored. I know from experience that if I don't take him out right now, or at least find him a toy, he will either pull my socks off and run away with them, or start barking like a beast possessed.

His cousins in the wild don't seem to suffer the same problem. Coyotes spend 90 per cent of their time apparently doing nothing, but never seem to get fed up, according to Marc Bekoff at the University of Colorado in Boulder, who has studied them for years. "They might be lying down but their eyes are moving and their heads are moving and they are constantly vigilant," he says. Trapped indoors, Jango has little to be vigilant about, and a lot of spare mental capacity. Bored office workers everywhere will know the feeling.

We tend to think of boredom as a price we pay for being intelligent and self-aware. Clearly we aren't the only species to suffer. Yet, given how common this emotion is in daily life, it's surprising how little attention it has received. That is changing and, as interest increases, researchers are addressing some fascinating questions. What exactly is boredom? Why are some people more prone to it than others? What is it for? Is it a good or bad thing? And what can we do to resist it when it strikes? Some of the answers are hotly contested – boredom, it

turns out, is really rather stimulating.

Like other emotions, boredom didn't just arise spontaneously when humans came on the scene. Many creatures, including mammals, birds and even some reptiles, seem to have a version of it, suggesting that there is some kind of survival advantage to feeling bored. The most plausible explanation is that it serves as a motivator. Boredom could have evolved as a kind of kick up the backside, suggests animal psychologist Francoise Wemelsfelder at Scotland's Rural College in Edinburgh, UK. "If a wild animal has done nothing for a while there is a lot of evidence that it will go out to look for things to do, and there is definitely survival value in that," she says. It will know, for example, that an escape route is blocked, because it has explored its territory.

Where boredom stops being useful and starts becoming a problem is when the desire to explore is thwarted. "All animals want and need to engage with the environment," says Wemelsfelder. That's why they get bored if you put them in a plain wire cage and, if left there, may end up exhibiting strange behaviours such as pacing in a figure of eight or pulling out their own feathers. "Even if they don't sit there thinking, 'damn I'm bored', I still think they suffer," she says.

Human boredom may be more complex, but there are parallels. In his book, *Boredom: A lively history*, Peter Toohey at the University

continued on page 106 ➤

**Boredom is the dream
bird that hatches the
egg of experience**

WALTER BENJAMIN

CYRUS CORNU/DOLCE VITA/PICTURETANK

FASCINATING BOREDOM

Do boring people get bored?

It is sometimes said that only boring people get bored. That is almost certainly unfair, but some people clearly suffer more than others. The standard way to measure a person's propensity to boredom is the boredom proneness scale (BPS), first published in 1986 by Richard Farmer and Norman Sundberg of the University of Oregon (to take the test, see right).

So who is easily bored? Studies using the BPS indicate that men get bored more than women, that extroverts are prone, as are people with narcissistic personality traits, anxious types and those who lack self-awareness. Highly

competitive sorts who are also sensation-seekers are particularly prone, which has led some to suggest a link between boredom and a heightened desire for stimulation caused by low levels of the "pleasure" neurotransmitter dopamine. On the other hand, creative people and those with a higher need for mental stimulation seem to be protected from boredom to some extent, perhaps because they do better at finding some interest or meaning in whatever they have to do.

But it's not just about your boredom threshold; how intensely you experience boredom also matters. "You might not

score high on boredom proneness but in the moment, you might still be really bored," says John Eastwood at York University in Toronto, Canada. He prefers to see boredom as a state, rather than a trait, and has developed his own test – the multidimensional state boredom scale – to measure how it feels in the here and now.

Nothing evokes this state quite as well as feeling trapped in a situation where you have no control over your choices. So it's not about being boring. "Only captive people get bored" might be a more accurate statement.

BRAND NEW IMAGES/GETTY

You might be interested to know...

6 hours

An average Briton is bored each week
online survey www.triviala.com

73 %

People who believe boredom can be positive

Journal of Applied Social Psychology, vol 30, p 576

1 in 10

People who claim to never be bored

Journal of Applied Social Psychology, vol 30, p 576

What's your boredom style?

Boredom takes five distinct forms depending on how negative and how energetic you feel. You may experience them all, but one kind will be your specialty. Which is it?

Do you tend to experience boredom as a benign or even positive state?

IF YES

**YOU SPECIALISE IN
INDIFFERENT BOREDOM**

When bored you most often feel relaxed and calm, not particularly fed up, but not engaged with the world. This is the most positive type of boredom. It may even lead to creativity.

When bored, are you typically very fidgety and tense?

IF YES

**YOU SPECIALISE IN
REACTANT BOREDOM**

The explosive combination of high arousal and negative emotion leaves you restless, angry and in need of an outlet. This is the most damaging form of boredom.

Do you experience boredom as an extremely negative feeling?

IF YES

**YOU SPECIALISE IN
APATHETIC BOREDOM**

When bored you tend to feel disengaged and unable to do anything about it. This especially unpleasant type of boredom is most similar to depression and learned helplessness.



Keeping you awake?

The boredom proneness scale was devised in 1986 by Richard Farmer and Norman Sundberg of the University of Oregon. It is now accepted as a standard way to measure your propensity for boredom, although we have reworded several items to simplify scoring. By the way, if manually calculating a score sounds boring, our online quiz can do it for you at bit.ly/NSboredom.

Answer the questions using a scale from 1 to 7, where 1=highly disagree, 4=neutral, 7=highly agree

1 It is not easy for me to concentrate on my activities.

2 Frequently when I'm working I find myself worrying about other things.

3 Time always seems to be passing slowly.

4 I often find myself at "loose ends", not knowing what to do.

5 I am often trapped in situations where I have to do meaningless things.

6 Having to look at someone's home movies or travel slides bores me tremendously.

7 I do not have projects in mind all the time, things to do.

8 I find it hard to entertain myself.

9 Many things I have to do are repetitive and monotonous.

10 It takes more stimulation to get me going than most people.

11 I get a kick out of few things I do.

12 I am seldom excited about my work.

13 In many situations I can find nothing to do or see to keep me interested.

14 Much of the time I just sit around doing nothing.

15 I am not good at waiting patiently.

16 I often find myself with nothing to do – time on my hands.

17 In situations where I have to wait, such as a line or a queue, I get very restless.

18 I rarely wake up with a new idea.

19 It would be very hard for me to find a job that is exciting enough.

20 I would like more challenging things to do in my life.

21 I feel that I am working below my abilities most of the time.

22 Few people would say that I am a creative or imaginative person.

23 I have few interests and lots of spare time.

24 Among my friends, I am the one who gives up on things first.

25 Unless I am doing something exciting, even dangerous, I feel half-dead and dull.

26 It takes a lot of change and variety to keep me really happy.

27 It seems that the same things are on television or the movies all the time; it's getting old.

28 When I was young, I was often in monotonous and tiresome situations.

HOW YOU SCORED
Below 81 You don't bore easily at all. You find amusement in the slightest thing and life is continually interesting. Lucky you!

81 to 117 You get bored sometimes, but these scores reflect average levels. Try to put those down times to good use!

Above 117 You get bored so easily you probably dropped off while reading this. On the bright side, provided you have the right kind of boredom (see below) creativity might come more easily to you, helping you avoid the intolerable dull life.

SOURCE FOR KEEPING YOU AWAKE?: BOREDOM PRONENESS – THE DEVELOPMENT AND CORRELATES OF A NEW SCALE BY RICHARD FARMER & NORMAN D. SUNDBERG, MARCH 1986, TAYLOR & FRANCIS
SOURCE FOR WHAT'S YOUR BOREDOM STYLE? DIAGRAM: MOTIVATION AND EMOTION, VOL 38, P401

When bored, do you tend to look for ways to alleviate the feeling?

IF YES

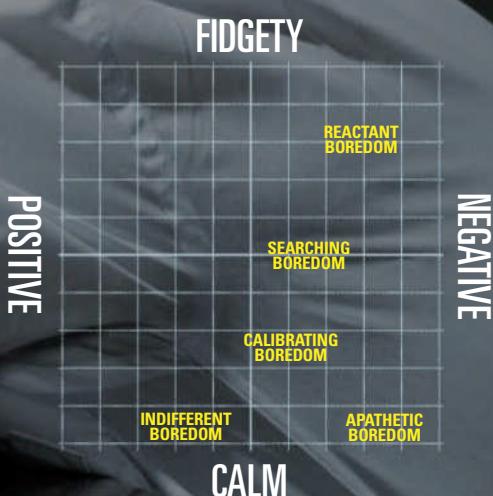
YOU SPECIALISE IN SEARCHING BOREDOM

Being bored makes you feel negative and restless. You actively seek ways to alleviate your boredom and if you fail to find diversions it may become reactant.

YOU SPECIALISE IN CALIBRATING BOREDOM

IF NO

For you, boredom feels unpleasant but you tend not to look for ways out of it, although you are open to boredom-reducing options if they should arise.



The cure for boredom is curiosity. There is no cure for curiosity

DOROTHY PARKER

◀ of Calgary, Canada, compares it to disgust – an emotion that motivates us to avoid certain situations. “If disgust protects humans from infection, boredom may protect them from ‘infectious’ social situations,” he suggests. And, as with other animals, boredom seems to occur when we feel physically or mentally trapped. One study, for example, found that people given no choice but to participate in a dull activity in the lab reported that time dragged, and rated the task as more boring than those who had chosen to participate.

We all know how it feels – it’s impossible to concentrate, time stretches out, a fog descends and all the things you could do seem equally unlikely to make you feel better. But defining boredom so that it can be studied in the lab has proved difficult. For a start, it isn’t simply about aversion or feeling trapped, but can include a lot of other mental states, such as frustration, apathy, depression, indifference and surfeit. There isn’t even agreement over whether boredom is always a low-energy, flat kind of emotion or whether feeling agitated and restless counts as boredom, too.

Thomas Goetz at the University of Konstanz in Germany suspects it can be all of these

Doing a repetitious, monotonous task may bore you, but it could also make you more creative

things. By asking people about their experiences of boredom, he and his team identified five different types: indifferent, calibrating, searching, reactant and apathetic (see “What’s your boredom style?” page 104). These can be plotted on two axes – one running left to right, which measures low to high arousal, and the other from top to bottom, which measures how positive or negative the feeling is. Intriguingly, Goetz has found that while people experience all kinds of boredom, and might flit from one to another in a given situation, they tend to specialise in one. However, it remains to be seen whether there are any character traits that predict the kind of boredom each of us might be prone to.

Of the five types, the most damaging is “reactant” boredom with its explosive combination of high arousal and negative emotion, which adds up to a restless, angry person in need of an outlet. The most useful is what Goetz calls indifferent boredom: someone isn’t engaged in anything satisfying but neither are they particularly fed up, and actually feel relaxed and calm. He believes that in the right circumstance this type of boredom can be a positive experience. “If you have a hard day and in the evening you go to a class, it might be boring but it’s OK to be bored because you had a stressful day. Time feels like it’s standing still, but it’s not too bad,” he says.

Psychologist Sandi Mann at the University of Central Lancashire, UK, goes further. She believes this positive kind of boredom and, to some extent all kinds, can be good for us. “All emotions are there for a reason, including boredom,” she says. As well as motivating us to do something more interesting, Mann has



MARY EVANS/CLASSIC STOCK/H. ARMSTRONG ROBERTS

found that being bored makes us more creative. “We’re all afraid of being bored but in actual fact it can open our minds, it can lead to all kinds of amazing things,” she says.

In experiments published in 2014 Mann found that people who had been made to feel bored by copying numbers out of the phone book for 15 minutes came up with more creative ideas about how to use a polystyrene cup than a control group who had gone straight to the cup problem. People who just read the phone book for 15 minutes were more creative still. Mann concluded that a passive, boring activity is best for creativity because it allows the mind to wander. In fact, she goes so far as to suggest that we should seek out more boredom in our lives.

Psychologist John Eastwood at York University in Toronto, Canada, isn’t convinced. “If you are in a state of mind-wandering you are not bored,” he says. “In my view, by definition boredom is aversive, it’s an undesirable state.” That doesn’t necessarily mean that it isn’t adaptive, he adds. “Pain is adaptive – if we didn’t have physical pain, bad things would happen to us. Does that mean that we should actively cause pain? No.” In other words, even if boredom has evolved to help us survive, it can still be toxic if allowed to fester. “All emotions tell us how we are in

The two enemies of human happiness are pain and boredom

ARTHUR SCHOPENHAUER



ANDREW TESTA/PANOS



Ennui or not ennui? Boredom isn't caused by a lack of stimulation but by a failure to focus

the world. Boredom tells us we have pent-up, unused potential and desire to connect to the world. Then the question is what do I do to cope with that situation?" Eastwood says.

Eastwood is interested in what boredom actually is – and his model highlights why it can be so difficult to cope with. For him, the central feature is a failure to switch our attention system into gear. The problem isn't so much a lack of stimulating things to do, but trouble focusing on anything. With nothing to focus your attention away from the passage of time, it seems to go painfully slowly. What's more, your efforts to rectify the situation can end up making you feel worse. "People try to connect with the world and if they are not successful there's that frustration and irritability," he says. "Then they fall back into lethargy and if that doesn't work they get aroused again, so there's an oscillation between the under and over-arousal states in an attempt to resolve the problem." Perhaps most worryingly, says Eastwood, repeatedly failing to engage attention can lead to a state where we don't know what to do any more, and no longer care.

Eastwood's group is exploring why the

attention system fails. It's early days but they think that at least some of it comes down to personality. Boredom proneness has been linked with a variety of traits (see "Do boring people get bored?" page 104). People who are motivated by pleasure – the sensation-seeking stimulation junkies – seem to suffer particularly badly, as do anxious types. Other personality traits, such as curiosity and self-control, are associated with a high boredom threshold. What Eastwood's team would like to know is why the attention system is prone to fail in some types of people more than others, what this suggests about the neuroscience of attention failure, and whether this can tell us anything about why some people experience boredom more than others.

Bored to death?

Whatever its cause, a failure to focus might help explain why boredom feels bad. Psychologists Matthew Killingsworth at the Robert Wood Johnson Foundation in California and Daniel Gilbert at Harvard University used a smartphone app to interrupt people at random intervals to ask them if they were on-task and how happy they felt. It turned out that the unhappiest people were those who were least focused on what they were supposed to be doing.

More evidence that boredom has detrimental effects comes from studies of people who are more or less prone to boredom. It seems those who bore easily face poorer prospects in education, their career and even life in general. They are also more likely to have problems with anger and aggression, and to partake in risky behaviours such as alcohol and drug abuse and gambling.

Boredom is the root of all evil – the despairing refusal to be oneself

SØREN KIERKEGAARD

Boredom: the desire for desires

LEO TOLSTOY

One study even seemed to suggest that it's possible to be bored to death. Researchers from University College London looked at self-rated boredom levels in civil servants in 1985. When they followed them up in 2009, they found those who had been consistently bored were significantly more likely to die early.

Of course, boredom itself cannot kill, it's the things we do to deal with it that may put us in danger. What can we do to alleviate it before it comes to that? Goetz's group has one suggestion. Working with teenagers, they found that those who "approach" a boring situation – in other words, see that it's boring and get stuck in anyway – report less boredom than those who try to cope by avoiding it and mucking around. So when boredom strikes, distracting yourself from the feeling with snacks, TV or social media probably isn't the best strategy.

In fact our techno-loaded, overstimulated lives might be part of the problem. Mann believes that with so many distractions we are neglecting our ability to daydream. "We have this inbuilt mechanism to cope with boredom, but we're not using it," she says. Wermelsfelder speculates that our overconnected lifestyles might even be a new source of boredom. "In modern human society there is a lot of overstimulation but still a lot of problems finding meaning," she says. So instead of seeking yet more mental stimulation, perhaps we should leave our phones alone, listen to the boredom and use it to motivate us to engage with the world in a more meaningful way.

If that sounds too hard, technology itself might provide an answer in the future. Sidney D'Mello at Notre Dame University in Indiana is working on a computer-based tutor for use in schools. By tracking eye position and body posture, it can tell when a person is getting bored, and will adjust its instructions accordingly. It's not difficult to imagine a similar program sitting on every office desktop, waiting to cajole you back into action. Ironically, it might turn out to be one kind of techno-distraction that we find incredibly easy to turn off. ■

CHAPTER SEVEN

REST BEST

A user's guide to sleep

Getting enough zeds is being touted as an elixir of good health, but how can you maximise its potential? *New Scientist* answers the questions keeping you up at night

AGROWING obsession with sleep is consuming our waking hours. Sleep is as vital for life as food or water. Lab rats deprived of sleep die within a month, and people who inherit the rare disease fatal familial insomnia meet the same fate, but on a longer timescale. We still don't know why. But while the fundamental reasons for sleep remain a mystery, the many ways it affects our well-being are frequently in the news.

In recent years, sleep has been labelled the third pillar of good health, along with diet and exercise, says Matt Walker at the University of California, Berkeley. But that's underselling it: sleep is the foundation on which these two other pillars rest. "There is no tissue within the body and no process within the brain that is not enhanced by sleep, or demonstrably impaired when you don't get enough," says Walker.

In addition to its well-recognised benefits for memory consolidation, repair and growth, sleep – or the lack of it – is now thought to have a host of other effects. Too little time in the land of nod messes with your emotions and your ability to make sound decisions. It affects your immune system and appetite, and has been linked to metabolic diseases such as obesity and type 2 diabetes. Increasingly,

a lack of sleep is implicated in mental health problems including depression, bipolar disorder and schizophrenia, and neurological conditions like Alzheimer's disease. What's more, sleeping at the wrong time plays havoc with your body clocks, adding to the negative effects.

But just as we are learning that sleep is vital for so many facets of good health, it seems we are also failing to get enough of it. A report by the UK's Royal Society for Public Health says Britons get an hour less than they need each night. A poll found that 17 per cent of people in the US have been diagnosed with a sleep disorder and a third of adults experience symptoms of insomnia.

If all this is enough to keep you awake at night, don't worry. On the following pages, we tackle the questions that may haunt you in the wee small hours. For a start, how much sleep do you really need (page 109)? If you're short on shut-eye, does a lie-in or nap redress the balance (page 110)? What can you do if you want more sleep (page 114), or want to cheat the system and get by on less (page 111)? And how do you best nod off and make sure you wake up feeling rested (page 112)? We sort fact from fiction to find out what's normal and reveal what you can do to become master of your unconscious hours.



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39

per cent

of people in the US take their cellphone into the bedroom and use it when trying to get to sleep

34

minutes

is the average extra sleep people get per night after drinking sour cherry juice before bed for seven days



67

per cent
of the time that men
dream about people it's
about another man.
Women dream equally
about men and women

1.2

minutes
is the sleep lost per
night for each cigarette
you smoke during
the day

How much shut-eye do I need?

WE ALL know 8 hours is the magic number for a decent night's sleep. Or is it? Nobody seems to know where this number came from. In questionnaires, people tend to say they sleep for between 7 and 9 hours a night, which might explain why 8 hours has become a rule of thumb. But people also tend to overestimate how long they have been out for the count.

According to Jerome Siegel, who studies sleep at the University of California, Los Angeles, the 8 hour rule has no basis in our evolutionary past – his study of tribal cultures with no access to electricity found that they get just 6 or 7 hours. “And those people are pretty healthy,” adds Derk-Jan Dijk at the University of Surrey, UK.

So perhaps 8 hours is the wrong target and we can get by just fine with 7. This seems to be a minimum requirement. A recent analysis in the US concluded that regularly getting less sleep than that increases the risk of obesity, heart disease, depression, and early death, and recommended that all adults aim for at least 7 hours.

By this benchmark, reports seem to suggest we are walking around in a state of sleep deprivation. The US Centers for Disease Control and Prevention estimates that 35 per cent of US adults are getting less than 7 hours a night, and a survey in the UK found

that the average was 6.8 hours. The media widely states that we are getting less sleep than we used to. The implication is that it's taking a severe toll on our health.

Not everyone is convinced. “Sleep has not changed in the past 100 or so years,” says sleep scientist Jim Horne, who takes the idea to task in his book *Sleeplessness – Assessing sleep need in society today*. That's a notion backed up by a recent review of scientific literature on sleep between 1960 and 2013, which found no significant link between sleep duration and the year a study was conducted.

What studies have shown is that the amount of sleep we need is influenced by our genes and varies among individuals. Exactly which genes are involved is not well understood, but a recent study of over 50,000 people found one gene variant that added 3.1 minutes of sleep for every copy you have. The amount of sleep you need also changes as you age. Taking this into account, the US National Sleep Foundation updated their guidelines last year, and came up with a recommended range of 7 to 9 hours for adults, but with added leeway of an hour either side to account for natural variation (see chart, below).

So how much is enough for you? A general rule of thumb is that you shouldn't need an alarm clock to ➤

Sleep: the magic numbers

There are no magic numbers. Sleep need varies as we age, and for each individual



SOURCE: NATIONAL SLEEP FOUNDATION

wake you up in the morning. Dijk also recommends jotting down what time you switch off to keep an accurate record of how much sleep you get.

While giving yourself more time under the covers can be good for your health, says Shawn Youngstedt of Arizona State University in Tempe, take care – you can have too much of a good thing. “There seems to be a sweet spot for all health-related behaviours. For sleep that seems to be about 7 hours.” Regularly getting 8 hours or more could send you to an early grave, he says. “Typically, the association is at least as strong, often stronger, than the association of short sleep with mortality.”

Just why this is remains a mystery. It could come down to the simple fact that when we are asleep we are moving very little, and there’s plenty of evidence to show that inactivity is bad for you.

And although this might not matter if you are active during the day, it could be that people who spend more time asleep do less exercise, possibly because they simply have less time, Youngstedt suggests. Long sleep is also associated with inflammation, an immune response linked to everything from depression to heart disease. And you might not need as much sleep as you think, says Youngstedt. “Many sleep for a long time out of habit or boredom, and we have found that they can tolerate mild sleep restriction,” he says. So try cutting down and see how you feel.

What of those grating individuals who claim to get by just fine on a few hours each night? They probably are sleep-deprived, but have got used to the effects and now fail to notice them as strongly. Or else they may simply be napping later on in the day. Only a tiny minority of us, probably less than 3 per cent, can get by on 4 to 6 hours of sleep with no problems at all. Ying-Hui Fu at the University of California, San Francisco, and her colleagues found a particular gene in a family of these natural short-sleepers. When the team engineered mice to express this short sleep gene, they recovered from sleep deprivation quicker and seemed to whizz through the non-REM stages of sleep faster than non-engineered mice.

The team thinks this gene variant interacts with proteins that are at the core of the circadian clock, opening up the tantalising possibility that we could one day genetically engineer our way to a shorter night’s sleep, without the downsides. In the meantime it is comforting to know that, for most of us, getting stuff done on very little sleep is, so far, physically impossible. **Caroline Williams**

Fig.1



Can I catch up on what I miss?

DESPITE our best intentions, we don’t always get enough sleep. So what happens when we party until dawn or shave off a couple of hours each night?

The need to sleep is controlled by a two-tier system. The circadian clock relies on light to keep your sleep/wake pattern within around 24 hours. Then there’s sleep drive or sleep pressure. The longer you are awake, the more a chemical called adenosine builds up in your brain, sending signals that increase your desire for sleep (see diagram, right). “After 16 hours it should be at a screaming level that means you have to fall asleep,”

says Matthew Walker, who researches sleep at the University of California, Berkeley. “When you do, the pressure valve is released.”

Caffeine keeps you perky by blocking adenosine receptors in the brain, but the effects of overriding the sleep drive quickly show themselves. Being awake for 24 hours will leave you with the same level of cognitive impairment as having a blood alcohol content of 0.1 per cent – more than the drink-drive limit in several countries. Chronic lack of sleep takes a toll, too. In one study, researchers followed students who slept just 4 hours a night for six nights in a row. They developed higher blood pressure, increased levels of the stress hormone cortisol and insulin resistance, a precursor to type 2 diabetes. They also produced half the normal number of antibodies

Can I cheat by sleeping in bits?

THINK snoozers are losers? Then why not join the world of the sleep hackers, people who have ditched full nights of shut-eye in favour of microsleeps.

Marie Staver is one. She was 19 and worried about fitting in all her college work when she attempted the Uberman sleep schedule (see graphic, right). For the next 6 months, Staver never slept for more than 20 minutes at a time, napping every 4 hours, totalling just 2 hours sleep a day. It's one of a number of sleep schedules that promise to maximise our waking hours. But can messing with sleep to such an extreme be a good idea?

According to historian Roger Ekirch of Virginia Tech in Blacksburg, breaking sleep into more than one bout is entirely natural. Pre-industrial civilisations around the world are known to have naturally segmented their sleep into two distinct phases, with an hour or two of "quiet wakefulness" in the middle of the night, he says. We've done away with this practice, but by this logic, people who experience middle-of-the-night insomnia simply have the natural urge to wake.

That idea was challenged in 2015 when Jerome Siegel at the University of California, Los Angeles, investigated how humans might have slept in the pre-industrial era. His team visited three tribes of hunter-gatherers in the African and South American tropics.



a number of phases, each with their own restorative properties. We might be able to cheat time, but what about these health benefits?

"Fragmenting sleep across the night has been demonstrated to be as deleterious as total sleep deprivation for some health outcomes, such as metabolism as well as emotions and moods," says Matthew Walker at the University of California, Berkeley. We know, for instance, that shift workers and others who sleep outside of their normal light-dark circadian rhythms are at a high risk of numerous diseases.

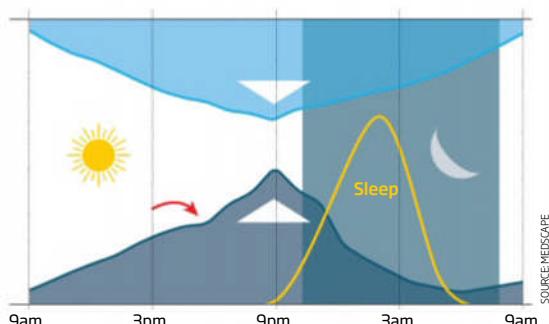
"This body clock does not offer a lifestyle choice; it is a biological reality, and departing from it can and does have very serious health consequences," says Colin Espie at the University of Oxford. And people who regularly don't get enough sleep die younger. So for the extra hours you save, you might end up losing years from the end of your life.

Besides, if Staver's Uberman experience was anything to go by, those extra hours might not be all they're cracked up to be. "I started off with a huge to-do list, but it went away in days. So I scrubbed my baseboards with a toothbrush, reorganised and darned all my socks." With that in mind, you might be better off asleep after all. **Sean O'Neill**

The drive to sleep

Two forces control whether we should be awake or asleep

Sleep pressure builds up the longer you are awake. It is balanced by the force of **circadian alertness** (although a **plateau in the afternoon** can make you feel sleepy). As night falls, however, circadian alertness drops off more quickly – and you enter the land of nod



in response to a flu vaccination.

Fortunately, these immediate effects were reversed when the students caught up on the hours of sleep they had lost. So if your sleep pressure is high, the simple solution is to repay the debt as soon as you can with a lie-in or a nap (see "How can I nap like a pro", page 114). "You certainly can recover from the immediate effects of insufficient sleep by then sleeping longer," says Derk-Jan Dijk of the University of Surrey, UK. "Many of us do it every weekend."

However, this requires you to recognise you need more sleep, and the more sleep deprived you become, the more you underestimate how tired you actually are. If you are suffering from chronic sleep loss – after a hectic period of work, for example – take a proper holiday to break the cycle,

says Dijk. "That's one way to recalibrate your assessment of what is optimal."

But there's a more serious concern. The jury is still out on whether naps and lie-ins can mitigate the long-term health effects of too little sleep. We know that shift work and jet lag, which mess with our body clock, also cause havoc with our health. Regularly sleeping at the wrong time can lead to diabetes, obesity and cancer, among other problems. Now, it seems, catching up on sleep at the weekend, a phenomenon known as social jet lag, might cause the same kinds of health problems as shift work.

So, although anyone can recover from the short-term effects of the odd white night, a long-term habit of catching up on sleep at the weekends may well catch up with you in the end. Catherine de Lange

What's the best way to get to sleep?

SWITCH OFF

Tablets, phones and laptops generate lots of short wavelength blue light, which interferes with production of our sleep hormone, melatonin. This is normally produced in the mid to late evening, but using screens for 2 hours before bed reduces melatonin concentrations by 22 per cent. Screen time before bed can also mean it takes longer to fall asleep and seems to cut down REM sleep. That could be because messing with melatonin delays the whole sleep cycle, leaving less time to get through all the stages before morning. But if your big vice is bedtime TV, relax. While the light from the box is bright, we normally watch from far enough away to mitigate much of the problem. Dim, red light before bed is best. So chuck screens out of the bedroom, or just limit usage to less than 2 hours – any less doesn't seem to significantly reduce melatonin production. Or try using an app that strips out the sleep-robbing light. Screen time first thing in the morning, however, might help shake off grogginess by stimulating cortisol, which peaks 20 to 30 minutes after waking.

DRINK UP

Struggling to sleep through the night? Melatonin pills probably aren't the answer. Their half-life in the body is just 30 minutes to 2 hours, which might explain why studies into whether melatonin supplements can improve sleep in general produced mixed results.



JOEL ADDAMS/AURORA

Instead, for more time in the land of nod, make yours a sour cherry juice. It's rich in melatonin, and a recent study found that after seven days, healthy adults who drank it twice a day got on average 34 minutes more shut eye, and napped less during the day. It could be that melatonin in cherries is more bioavailable than that in supplement tablets.

TEMPERATURE CONTROL

For a good night's sleep, watch the temperature. Melatonin cools the body by a couple of degrees while we sleep, and an overheated bedroom can interfere with this process. Too cold, though, and you may struggle to drop off. One recent study found that air conditioning set too low made it harder to get to sleep because the body was pulling out all the stops to keep warm. The best pattern for a night's rest is to start warm, cool off a little then warm up in the early morning, mimicking the body's natural temperature changes. A general rule is to keep the bedroom between 18 and 21 °C, with a window open if it's not too noisy.

CUT DOWN

Need a nightcap to get to sleep? Unwise. Having a few drinks before bed disrupts slow-wave sleep, adding a boost of alpha brainwaves that are usually only present in the daytime. Even an early evening tipple can be bad. "We showed that a couple of drinks around happy hour – 5 or 6 pm – led to breath alcohol concentrations of zero by the time people went to sleep, but still caused a lot of extra wakefulness in the second part of the night," says Derk-Jan Dijk at the University of Surrey, UK. He thinks it might be a side effect of the way alcohol is metabolised. Older people are more sensitive to the effects.

STUB IT OUT

Smoking affects sleep no matter what time you light up. Research shows that each cigarette smoked during the day reduces total sleep time by 1.2 minutes. Animal studies suggest that nicotine disrupts a circadian clock protein in the lungs and brain. Caroline Williams

5

is the number of minutes it takes you to fall asleep if you're sleep deprived. The ideal is 10 to 15 minutes

Fig.2



What makes for a good night's rest?

TO REAP the benefits of a good night's rest, there are three things you need to consider, says Charles Czeisler at Brigham and Women's Hospital and Harvard Medical School in Boston: how much you sleep, how well, and when.

Carving out the time to visit the land of nod is one thing, but guaranteeing good quality rest can be beyond our control. For instance, people often sleep poorly their first night in a new place. To find out why, Masako Tamaki and colleagues at Brown University in Rhode Island scanned people's brains as they slept in unfamiliar places, then again when those spots had become familiar. In the first scenario, the team found that parts of one hemisphere of the brain remained active while the participants were asleep. This "first-night effect" may be an evolutionary adaptation, keeping part of your brain alert to make sure the new environment is safe. "We call this system the night watch," Tamaki says.

Even in a familiar environment, sounds like a snuffling dog or planes overhead can interfere with sleep, whether you're aware of

Fig.3



them or not. "They may force us to transition out of a deeper stage of sleep," says Czeisler. If they wake you up, you may not realise it was a noise that roused you.

Temperature is another neglected factor. Studies show that people with sleep disorders who wake up a lot during the night can benefit from wearing a suit that slightly warms the skin. Counter-intuitively, this helps the body to release more heat. The cooling effect reduces the number of awakenings and also leads to more restorative slow-wave sleep. Taking a hot bath before bed can help achieve the same thing.

Perhaps the most surprising factor affecting sleep quality is the time we hit the hay. The more sleep cycles we go through (see diagram, page 114), the longer the duration of REM sleep in each cycle.

REM sleep is crucial for incorporating things we've learned into our existing knowledge, for regulating our emotions, and might also play a critical role in brain development. The bulk of REM sleep tends to happen in the hours just before we get up. That's because more builds up in the second half of the night. But it's not just to do with how long you've been snoozing. It's also related to what time of day it is, says Czeisler, and whether those hours of shut-eye line up with your circadian clock.

That makes the effects of blue light on our body clocks particularly insidious – it affects sleep quality as well as quantity. Czeisler and his colleagues compared the sleep patterns of those who read a book on an iPad before bed with those who read print. After a few days, those using the electronic devices were getting less REM sleep, not only because it took them longer to nod off, but because their circadian rhythms also shifted about an hour and a half later. "It sort of pushed the REM sleep later and later – and off the cliff," says Czeisler.

Something similar happens when you have to get up unusually early. "You are most likely robbing yourself of the last two hours of sleep, so you're going to have selectively deprived yourself of REM sleep," says Czeisler. Setting the alarm and repeatedly hitting the snooze button can add to the problem: "You're destroying the architecture of your sleep."

Perhaps our wake-up routine is an opportunity to reclaim artificial light for the better. Czeisler advocates the use of light-based alarm clocks, which mimic the break of day and can help sync our circadian rhythms to our daily schedules. Light eases us out of deep sleep, leaving us less groggy – even when modern life demands that we rise before dawn.

Tiffany O'Callaghan

Things that go bump in the night

Sleep apnoea

A surprisingly common condition in which you stop breathing for 10 seconds or more as you sleep. The lack of oxygen causes your brain to wake you up, or pull you into much lighter sleep. Either way, it can have a profound effect on the quality of your sleep – and that of any bedfellow, as it's often accompanied by loud snoring.

Sleep paralysis

A terrifying experience, where the body, which naturally becomes paralysed during REM sleep, is still paralysed when you wake. You are fully conscious but cannot move or speak, sometimes for several minutes. Some people also feel as if they are choking or their chest is being crushed and they may have visual hallucinations. The condition can be exacerbated by sleep deprivation, some drugs, and disorders such as sleep apnoea.

Hypnagogic jerks

Those jumps or twitches you experience as you nod off, often accompanied by the sensation of falling. The cause remains a mystery. One idea is that you start dreaming before your body becomes paralysed. Another is that the twitches are a by-product of your nervous system relaxing as you drift off.

REM sleep disorder

If you've ever punched or shouted at your partner in the night, only to remember nothing next morning, you may have been in the grip of this condition. Here, the body isn't fully paralysed during REM sleep, so people act out their dreams. This tends to happen only with bad dreams.

Exploding head syndrome

This entails the sensation of a loud noise, like an exploding bomb or a gunshot, as you drift off or wake up. It affects about 1 in 10 of us and it tends to start around age 50. Nobody knows what causes it – perhaps physical changes in the middle ear, or a minor seizure in the brain's temporal lobe. Despite its name, the condition is harmless.

Catherine de Lange

How can I nap like a pro?

CAUGHT napping? Clever you! Once a sign of laziness, it's now clear that taking 40 winks is a great way to improve your performance.

A "nano-nap", lasting just 10 minutes, can boost alertness, concentration and attention for as much as 4 hours. Take 20 minutes and you increase your powers of memory and recall, too. Either way, you are unlikely to enter the deeper stages of sleep, so will avoid the phenomenon known as sleep inertia, the groggy feeling that can occur when waking from deep sleep. On the flip side, you won't get the benefits of deep sleep. However, light sleep turns out to be more important than we thought.

"There are wonderful little champagne cork bursts of electrical activity that happen during light sleep, called sleep spindles, and the field of sleep research is rapidly seeing that they have learning

100

times an hour:
how often someone
with sleep apnoea
might stop breathing
in the night

and memory benefits," says Matthew Walker of the University of California, Berkeley.

Still, deep sleep provides the biggest boost to learning. If that's your aim, opt for a nap of between 60 and 90 minutes, says Walker. His research shows this aids learning by shifting memories from short-term storage in the brain's hippocampi to lockdown in the prefrontal cortex – a bit like clearing space on a USB memory stick, Walker says. As well as helping you to retain factual information, longer naps can increase motor memory, which is useful for training skills such as sport or playing a musical instrument.

A longer nap could also improve your equanimity. If you are feeling emotional, try snoozing for 45 minutes or more. This should take you through a stage of REM sleep, and brain scans of people following a REM sleep nap showed more positive responses to images and to

pleasant experiences.

Bear in mind, though, the time of day you nap may affect the type of sleep you get. During the night, each 90-minute sleep cycle includes a bout of non-REM sleep followed by REM sleep (see diagram, below). However, deep non-REM sleep tends to dominate in the first half of the night, with the balance then shifting to REM sleep. A morning nap is much more likely to contain REM sleep, says Walker, "because your brain still has a preferential hunger for it". In the afternoon and evening that changes.

As a result, morning naps are likely to contain more emotionally calming dream sleep and afternoon naps more restorative and memory-boosting deep sleep. Still, Walker warns against trying to hack your sleep to pick the benefits, because your brain may just take the kind of sleep it needs.

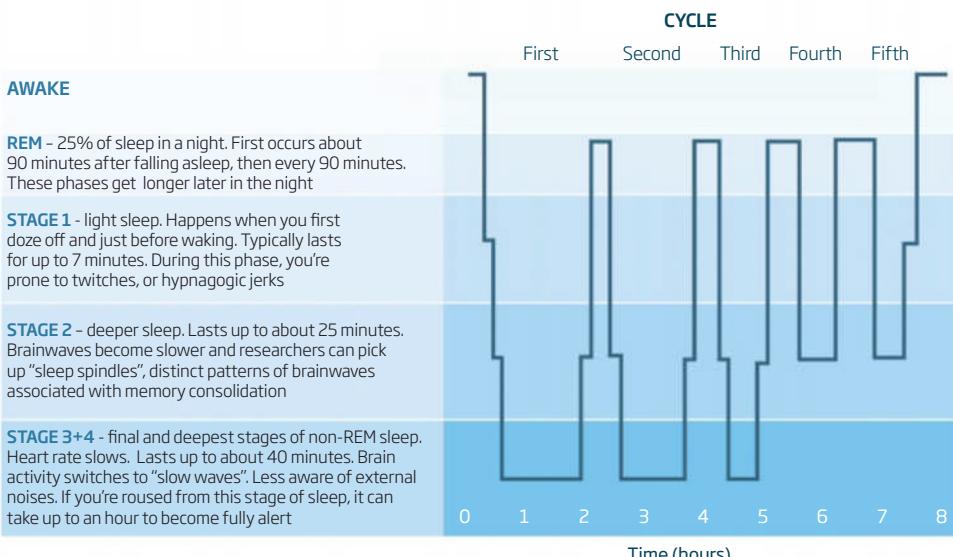
Besides, for all of us, the urge to nap is strongest at one particular time of day: after lunch. Don't blame what you've eaten but your circadian rhythms (see "The drive to sleep", page 111). "Everyone has this little pre-programmed drop in our alertness, as if we want to go to sleep," Walker says. Succumb, and it could benefit your body as well as your mind. Greek men who did away with a siesta, for example, had worse cardiovascular health and increased rates of cancer. Walker puts this down to a loss of deep sleep. "Deep sleep lowers your blood pressure and lowers the contracting speed of the heart, so that you wake up with a better managed cardiovascular system," he says.

If you're tempted to nap, it's easy. Find a warm, dim and quiet place to lie down (getting to sleep when you're sitting takes 50 per cent longer). And if you want to keep it short, simply drink a cup of coffee immediately beforehand – the caffeine kicks in after about 20 minutes, wiping away the sleep inertia and leaving you raring to go.

Catherine de Lange

Going through phases

A typical night's sleep involves several cycles. How much time you spend in each phase affects sleep quality

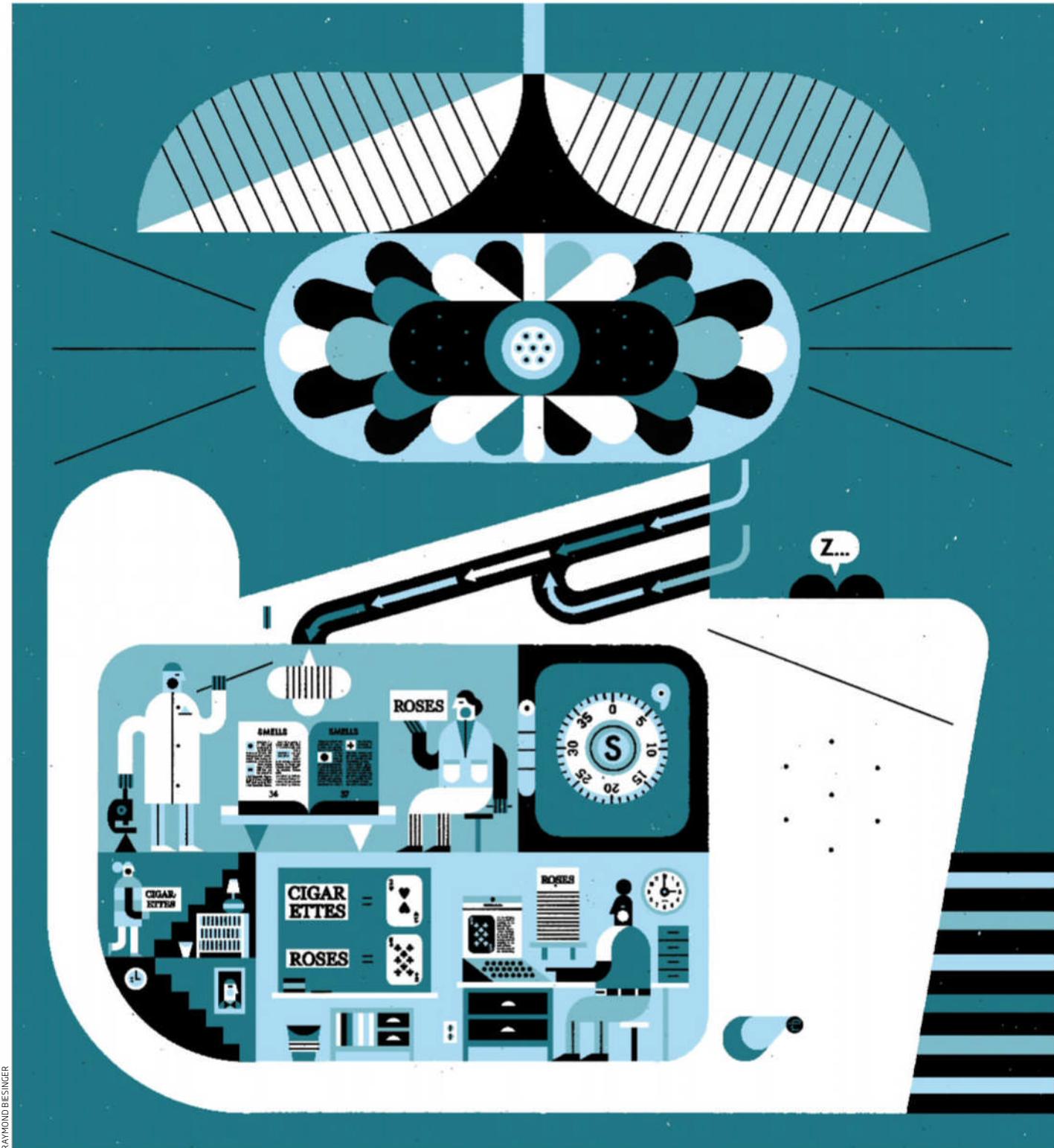




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EVEN as science fiction, the idea that we can learn as we sleep has a controversial history. In Aldous Huxley's dystopian novel *Brave New World*, recorded voices whisper class prejudices into the ears of sleeping children, conditioning them for their future roles in society. Despite the evil ends that Huxley imagined, the appeal of getting something for nothing was irresistible to readers and, following the book's publication in 1932, there was a surge in interest in sleep learning. But was there any fact in the fiction?

In 1951, two researchers at George Washington University in Washington DC decided to find out. They recruited 30 volunteers and set up tape recorders and speakers in their bedrooms. For half an hour one night, as the volunteers slept, the recorders played either music or Chinese words and their English equivalents. Next morning, those who had heard the vocabulary performed better on a Chinese language test. "Learning can occur during sleep," the scientists concluded, grandly. Others soon agreed. A second team claimed to have taught Morse code to a group of sleeping naval students. A third found that children stopped biting their nails simply by listening to the sentence, "My fingernails taste terribly bitter", six times a night for 54 nights.

But it wasn't long before these findings were challenged. The volunteers hadn't been monitored, so there was no evidence they were truly asleep as the audio played. So in 1955, researchers did several more studies, this time measuring brain activity using electroencephalography (EEG) to make sure the recordings were played only during sleep. No learning was detected. The original claims were discarded, and sleep learning was once again relegated to the realm of science fiction.

Yet after half a century in disrepute, sleep learning is experiencing a revival, with ingenious experiments revealing that our sleeping brains can absorb new information – under the right circumstances.

Unconscious activity

These days, we know far more about what goes on in our brains during sleep. "Up until a decade ago, most people thought not much was happening," says Sid Kouider, a cognitive neuroscientist at the École Normale Supérieure in Paris, France. Then, using EEG, researchers discovered that the brain doesn't shut off. Parts of it are surprisingly active even when we are unconscious. The sleeping brain appears to review and store memories, replaying

moments in the day to preserve important information.

The discovery that memory consolidation happens during sleep set some people wondering whether they could exert control over the process. In 2007, neuroscientist Jan Born and colleagues at the University of Lübeck in Germany tested the idea. They invited 18 volunteers to play a memory game shortly before going to bed. Each person learned the locations of 15 pairs of cards on a computer screen while smelling the scent of roses. Then, while sleeping, they were re-exposed to the scent, which Born predicted would cue memories of what they had learned.

The researchers chose smell as a cue because odours don't arouse us from sleep, and are closely associated with memories. In fact, the brain regions that process odours are directly connected to the hippocampus, a part of the brain with a crucial role in the creation of memories. Sure enough, participants recalled more card pairs after being exposed to the odour than after sleeping without the smell.

Reading these findings, Ken Paller, director of the cognitive neuroscience programme at Northwestern University in Illinois, was intrigued. He wanted to find out whether the same results could be achieved using sounds instead of smells. His volunteers learned the locations on a screen of 50 images, each paired with a specific sound, such as a meow for a cat and a whistle for a kettle. Then the participants took a nap, during which Paller's team quietly played half of the sounds to them. Upon waking, they better recalled the locations of objects whose sounds had been played while ➤

Learning while you snooze sounds too good to be true, but there might be a way, finds **Megan Scudellari**

SMART SLUMBER

they slept, than those for which the associated sounds hadn't been played.

Paller went on to show that people who learned to play a simple song on a video game similar to *Guitar Hero* were better able to play that melody upon waking if it had been played quietly as they slept.

It was becoming clear that memories can be influenced during sleep by external cues. In 2011, researchers in Born's lab made another discovery. Volunteers who learned a set of word pairs believing they would be tested the next morning performed better than those who weren't informed of the test or who were informed but didn't sleep. This suggested that the mere expectation that a memory will be important in future is enough to incite the sleeping brain to replay and strengthen it.

Unlearning and forgetting

But it's not just learning that occurs during sleep. Turning the idea upside-down, sound associations can also help people unlearn ingrained prejudices – such as the idea that women are bad at science – while they sleep, found Paller, who was working alongside Xiaoqing Hu at the University of Texas at Austin and colleagues.

Meanwhile, Katherina Hauner, also at Northwestern University, has been able to erase bad memories during sleep. She showed volunteers images of faces while giving them a mild electric shock and an odour: mint, lemon or pine. Once they had learned to associate some of the faces with pain, the participants slept, while Hauner exposed them to just the smells – no shock this time. At first these triggered anxiety, as measured by microscopic sweat on their skin, but gradually the fear

**It's possible to
unlearn a phobia
while you sleep**



MAYA FLORE / AGENCIA VUI / CAMERA PRESS

diminished. When they awoke, they were less anxious in response to the images. Volunteers who underwent the same procedure but without sleeping didn't lose their fear.

With the realisation that it is possible to enhance or reduce retention of specific memories during sleep, people began questioning the dogma that the brain

can't learn new information as we slumber. Perhaps the scientists in the 1950s were actually on to something.

Two experiments indicate they were. In the first, Anat Arzi and her colleagues at the Weizmann Institute of Science in Israel attempted to teach a simple association during sleep – linking a sound with an odour. Humans unconsciously inhale deeply for a pleasant odour and sniff weakly for an unpleasant one. So Arzi and her team exposed sleeping volunteers to an audio tone paired with a pleasant odour (deodorant or shampoo) and a second tone paired with an unpleasant odour (rotten fish or meat). Although they had no conscious awareness of either the tones or smells, upon waking the volunteers sniffed deeply when they heard the tone linked with the nice smell and shallowly on hearing the other – without any odours being present. "We realised that we can learn an association during sleep and can retrieve this association upon waking," says Arzi. "This study opened the door to so many questions."

Her most immediate question was whether an association learned during sleep could influence behaviour when awake. In a second

IN YOUR DREAMS

External cues such as smells and sounds can influence your mind during sleep (see main story) – but only during slow wave sleep. So what happens if we experience an outside stimulus during rapid eye movement (REM) sleep, the period in which we dream?

In 1958, scientists sprayed sleepers with water and flashed lights at them to find out. Upon waking, 42 per cent reported that their dreams incorporated instances of water and 23 per cent said they included flashing lights. In other experiments – which might not get ethical approval today – researchers found they could influence the content of dreams with electric shocks, bed rocking and mild pain.

Stimuli we experience while awake can also affect our dreams. A week of wearing goggles that filter out all colours but red resulted in red-tinged dreams. And attempting to suppress thoughts about a person during wakefulness prompted an increase in dreaming about that person.

But the most powerful way to manipulate your dreams is to take control of them yourself during lucid dreaming (see page 124). Memories are consolidated during slow wave sleep, but lucid dreaming also seems to have waking benefits. It has been linked with improvements in motor skills, for example, and better mental health.

"We might someday use sleep to unlearn prejudices and alter bad habits"

experiment, Arzi invited 66 smokers to spend a night in a sleep lab, during which she exposed them to the smell of cigarettes paired with the smell of either rotten fish or rotten eggs. Lo and behold, they smoked 30 per cent less the week after the experiment than the week before. As in Hauner's fear study, the same procedure conducted while participants were awake didn't result in altered behaviour. This suggests that there is something special about how our brains process memories during sleep that enhances learned associations.

Importantly, Arzi, Hauner and others have found that learning rarely occurs during rapid eye movement, or REM, sleep. It primarily occurs during slow wave sleep, a form of deep sleep in which brain cells slowly cycle from being active to inactive and back again. The same is true for odour-induced memory reactivation, as in Born's original rose-scented experiment. One possible explanation is that the slow oscillations of brain cells cement memories, says Arzi. Alternatively, it could be a protective mechanism so that memories are not formed during REM sleep, which is prime time for dreaming. "We don't want to remember our dreams as if they were real," she says. "That could be dangerous."

With the discovery that our sleeping brains can learn simple associations, scientists are now reaching for the next level of complexity – to find out whether they can learn verbal information. We know that the part of the brain that processes auditory information is active during sleep and preferentially responds to meaningful information. You are more likely to wake up when someone calls your name or cries "Fire!", for example, than to the sound of someone else's name or a nonsensical shout. With this in mind, Kouider sought to discover whether the brain can process meaningful verbal information during sleep.

He instructed awake volunteers, hooked up to EEG machines, to classify spoken words as either animals or objects by pressing a button with their right hand for "animal" and with their left for "object". Pushing a button with the right hand results in the left side of the brain lighting up with activity, and vice versa. Next, Kouider let the participants recline in a darkened room and drift off to sleep as they continued to classify words. At some point, they stopped pressing the buttons, but their brains didn't stop categorising. The hemispheres associated with a button press continued to light up correctly. Their unconscious brains were still absorbing and processing meaningful

Sleeping with the smell of rotten fish could help you quit smoking



SCOTT MACBRIDE/GETTY

information, though much more slowly than when awake.

"This is definitely demonstrating that during sleep, not only can you extract the meaning of acoustic information in your environment, but you can also prepare a response, make a decision," says Kouider. The key finding, he says, is that the brain continued to work on a task that it had begun before sleep. This suggests that any task that can be automated, such as classifying words, could be continued during sleep if begun beforehand. And it implies that our brains process new information even during sleep, so if we can just figure out the right ways to deliver that information – whether using

PUTTING SLEEP TO WORK

Though it's unlikely you will ever master a new language in your sleep, there are ways sleep can be used in everyday life, says Susanne Diekelmann at the University of Tübingen in Germany. Here are three to try:

Take naps: Sleep is most effective for memorisation if you sleep shortly after learning something new, so napping during the day may help cement newly formed memories.

Use odours: You may be able to enhance the memory reactivation process by studying with a specific odour nearby, such as mint, then keeping the odour by your bedside at night.

Make up a test: The mere expectation that something is important appears to strengthen memories of it during sleep, so after learning something new, have a quiz ready to test yourself the next morning.

sound, smell or automation – our sleeping, active brains are ready and able to learn.

It's early days for this field of research and even enthusiasts acknowledge that we should proceed with caution. "You always need to be careful not to disturb sleep itself," says Susanne Diekelmann, formerly in Born's lab and now at the University of Tübingen in Germany. That's because sleep is a requirement, not an option. Without it we become depressed and forgetful, and our risk of stroke, heart disease and premature death rise dramatically.

Some researchers believe there will always be a trade-off, no matter what tricks or techniques we might uncover to induce learning during sleep. "Everything has a cost," says Simon Ruch, who studies sleep and memory at the University of Bern in Switzerland. "If you really have to learn something, it's better that you stay up a little bit longer and learn it, then go to sleep."

Diekelmann is more upbeat. She believes that, in the future, sleep learning might help with the improvement of a musical, linguistic or athletic skill. Other possibilities are even more alluring. We might someday use sleep to unlearn deep-rooted prejudices, to alter bad habits, such as smoking, or to learn new associations, such as positive feelings about certain foods or experiences.

Paller and his team have already begun attempting to selectively strengthen memories of vocabulary words during sleep using auditory cues. Presumably, there is no shortage of high-school students prepping for examinations who would like to take part in that study. "We still have more experiments to do to say exactly how much you can change during sleep," says Paller. "But the door is open. It's possible." ■

The upside of nightmares

Bad dreams have some surprising benefits, discovers sleep scientist **Michelle Carr**

THE earliest dream Chris could remember was one that haunted his mind for months during preschool. In it, he watched family members and pets melting during a house fire. They turned into “several humongous blobs that resembled bubbling pizza topping”, each containing fragments of their body parts. More than 25 years later, the images still haunt him.

For Jess, nightmares marked a difficult time in her late teens when she was struggling with anxiety. “I would sometimes miss weeks of school because of my nightmares,” she recalls, several years later. “I couldn’t sleep, I couldn’t function.” Jess remembers nights spent half awake, falling in and out of a recurring nightmare where she was unable to scream or move, engulfed by paralysing fear. Even after waking, she couldn’t escape the feeling of helplessness.

Chris and Jess both responded to a “Get Paid to Nap!” advert inviting people who had at least two nightmares a week to take part in a research study. Early one morning in late 2014, they arrived at the Dream and Nightmare Laboratory in the Center for Advanced Research in Sleep Medicine in Montreal, Canada, where I was working at the time. They and other volunteers ran through questionnaires, tests of creativity and reported their waking daydreams before we pasted electrodes to their scalps and bodies and finally asked them to take a nap.

What we and other labs have found is casting nightmares in a new light. Horrific as having them frequently can be, it also seems

to endow more regular positive dreams, and heighten empathy and creativity. These discoveries are challenging not only our understanding of what causes nightmares, but also how we should treat them.

Research into nightmares has mainly focused on the negatives and the distress they cause. Over the years, they became classified as a mental disorder called “dream anxiety attack” in 1980. In the past few decades, the definition of nightmares has evolved to refer more generally to any intense negative dream that awakens the dreamer and is vividly

the normal functions of dreaming: to help people to deal with emotional experiences. The excessive fear and emotion in a nightmare wakes you before the dream can do its job. This is similar to the view of nightmares in post-traumatic stress disorder – when a traumatic memory is too strongly emotional, it repeatedly replays in dreams and cannot be overcome.

The other suggestion is that nightmares serve an evolutionary function by forcing the brain to re-enact adverse events during sleep so as to better prepare people to deal with them next time; an idea known as threat simulation theory. Katja Valli, who researches dreaming at the University of Turku in Finland, says nightmares are the “ultimate expression” of threat simulation, forcing us to attempt to escape or defend ourselves.

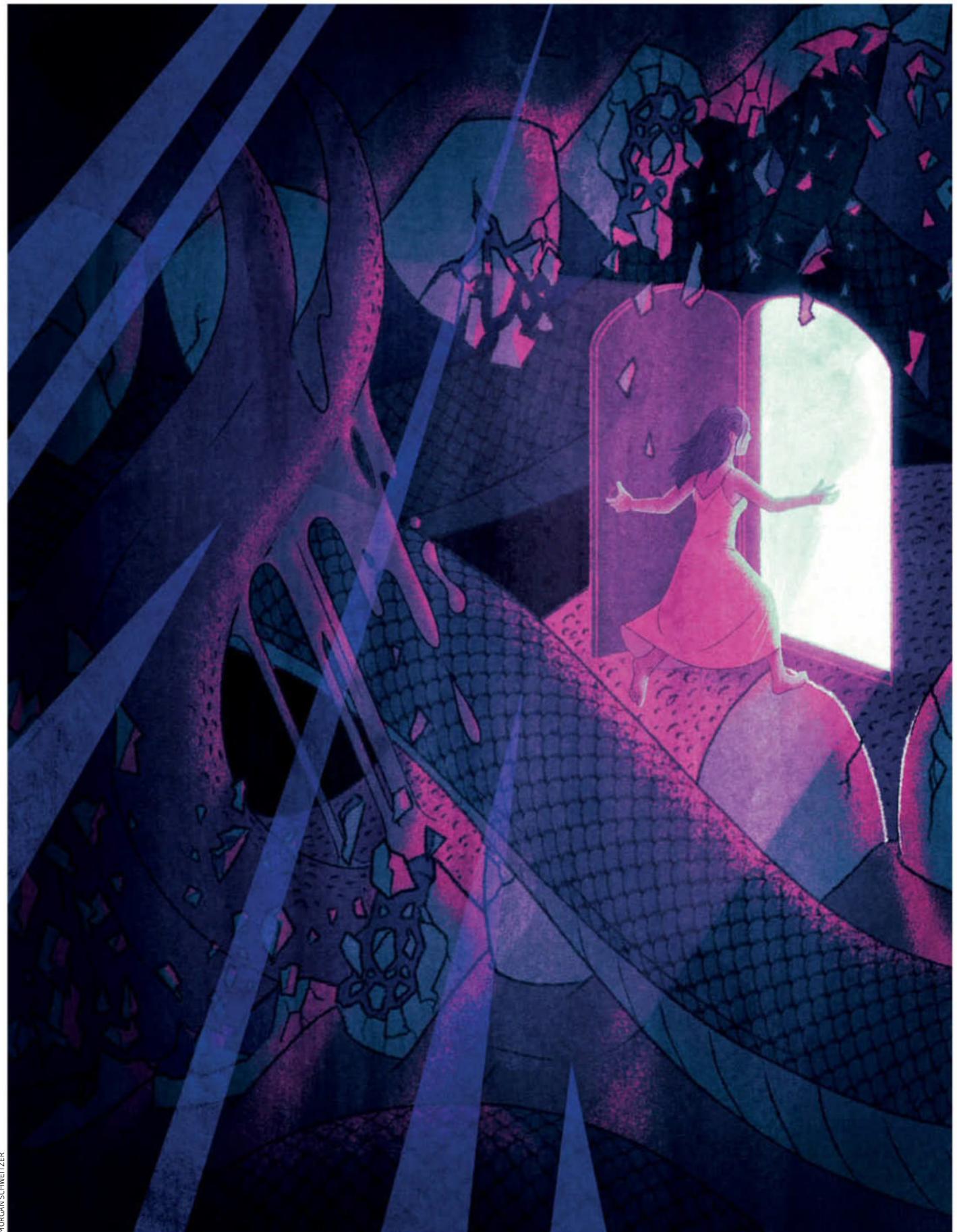
Although these nightmares usually happen late at night, our team was interested to find out whether people who have frequent nightmares have intensely negative dreams and thoughts during the day as well. And if so, whether this persistent negativity interferes with other waking functions. Understanding this could help us work out which theory about the cause of nightmares makes more sense – do they interfere with normal activity or serve a functional purpose?

In the hope of capturing some daymares in the lab, we hooked up Chris, Jess and 12 other volunteers to a montage of electrodes before they took a nap. Electrodes on the scalp measured brain activity, allowing us to determine sleep stages, particularly rapid

“People who have frequent nightmares may be more empathetic when awake”

recalled on awakening. Most are characterised by fear, but they can feature sadness, anger or any other negative emotion.

There are two main theories about what causes recurring nightmares. Clinical research shows that nightmares are often related to a history of abuse or neglect, leading to the idea that nightmares develop in response to an “accumulation of adverse events throughout life”, says Tore Nielsen, director of the Dream and Nightmare Laboratory and co-author of the most recent diagnostic criteria for nightmare disorder (see “When nightmares get serious”, page 122). Nielsen considers nightmares to be a disturbance in one of



eye movement (REM) sleep – the state when dreaming is most vivid. Other electrodes measured heart rate and muscle tension, including two above the right eyebrow – if you notice someone frowning or scrunching their face as they sleep, they are likely in the throes of a nightmare.

Once the electrodes were set, the volunteers were ready to star in their very own film noir, a 90-minute biography of their sleeping selves, filmed through an infrared camera and projected onto a TV in the control room. The sleep technicians watched as the subjects slipped into sleep, waiting for the distinct flitting eye movements that mark the onset of REM sleep, as the eyes scan the dream world. After 10 minutes of REM, a “beep” roused the dreamers and they groggily propped themselves up to recount their adventures.

Neither Chris nor Jess had a nightmare. In fact, no one in their group did. This was initially disappointing, but not unexpected; nightmares are notoriously difficult to catch in the lab. Even so, all 14 did recall a dream.

It turns out that people who have a lot of nightmares also have an unusually high number of good dreams. Our volunteers averaged about two nightmares per week, but they also recalled an average of 6.75 other dreams. At the time of the study, Chris was recalling eight dreams a week; of these, only two were nightmares. In comparison, the average dream recall frequency for someone of his age – 32 – is two or three dreams per week, with less than one per month being a nightmare.

The impact of good dreams is more than a fuzzy feeling on waking. In one of his positive dreams, Chris remembers taking part in a protest and protecting fellow activists from the police. Even though he had never been part of this kind of group in real life, he said the dream left him feeling “refreshed and optimistic”. My colleagues and I think it is possible that positive dreams spill over and enhance waking life in a manner analogous to how nightmares cause distress on waking.

For instance, some research suggests that social dreams enhance feelings of closeness in the real world. In fact, this has recently been proposed as an evolutionary function of positive dreams, parallel to the evolutionary function of threat simulation in bad dreams. The new social simulation theory of dreaming suggests that positive interactions in dreams encourage social behaviours and strengthen personal relationships. “We only get better at things we practise for,” says Valli, “so if the

WHEN NIGHTMARES GET SERIOUS

We all experience the odd bad dream, but when do nightmares become a serious problem? The diagnostic criteria for nightmare disorder looks at several elements.

THE NIGHTMARE

Repeated incidence of intensely negative, well-remembered dreams, usually in the last third of the night

THE AWAKENING

Becoming alert and aware on waking

DISTRESS

The nightmare causes clinically significant distress that interferes with quality of life or work

TIME PERIOD

Acute: Experienced over one month or less

Subacute: Less than six months

Persistent: More than six months

SEVERITY

Mild: Fewer than one per week

Moderate: One to six a week

Severe: Seven or more per week

function of dreaming is to facilitate social skills, dream simulations should focus on the positive aspects of social life: social bonding, bond strengthening, prosociality, and so on.”

We were expecting the waking hours of people who have a lot of nightmares to be dominated by the negativity of their visions, but in fact their many pleasant dreams may make them feel even more connected with others.

There are hints that those who have frequent nightmares may be more empathetic too. At least one recent study has found that those prone to nightmares are more likely to subconsciously mirror the actions or emotional expressions of others. Such mirroring enables us to understand another person’s perspective and feel what they feel, and is essential to developing relationships.

It is not clear whether this kind of emotional fine-tuning is a cause or consequence of frequent nightmares. It could be both. Sleep researcher Ernest Hartmann, while a psychiatrist at Tufts University School of Medicine in Boston in the 1980s, found that people seeking therapy for nightmares were not necessarily more fearful or anxious, but rather had a general sensitivity to all emotional experience. He concluded that sensitivity is the driving force behind intense dreams. Heightened sensitivity to threats or fear during the day results in bad dreams and nightmares, whereas heightened passion or excitement may result in more intense positive dreams. And both these forms of dreams may feed back into waking life, perhaps increasing distress after nightmares, or promoting social bonds and empathy after positive dreams.

The effects go further still. Hartmann realised that this sensitivity spills over into perceptions and thoughts: people who have a lot of nightmares experience a dreamlike quality to their waking thoughts. And this kind of thinking seems to give them a creative edge. For instance, studies show that such people tend to have greater creative aptitude and artistic expression. Jess and Chris scored highly on a test to measure this, called the boundary thickness scale, and both are artists: Jess is a painter and photographer, Chris a musician.

To further explore this creativity, we asked our volunteers to do a word-association task. We presented them with one word at a time and asked them to come up with three meaningfully associated words. Responses were scored by how common they were. For example, the three most common responses to the word “panic” are “attack”, “scared” and “fear”. However, people with frequent nightmares consistently responded with more unusual word associations than a control group, suggesting that they think outside the box and make broader associations between concepts, which are thought to be essential to creative thought.

So the evidence points towards the idea that, rather than interfering with normal





activity, people who are unfortunate in having a lot of nightmares also have a dreaming life that is at least as creative, positive and vivid as it can be distressing and terrifying. What's more, this imaginative richness is unlikely to be confined to sleep, but also permeates waking thought and daydreams.

That's not to say we should all be wishing for more nightmares. They can be overwhelming, especially when they become more frequent and out-of-control during periods of stress. They may also dredge up remnants of past trauma or abuse, and in these cases, the distress may vastly outweigh any advantages. Jess is clear on this point. "If I could take a medication that got rid of my nightmares, I would," she says.

A drug might not be necessary, though. Perhaps most importantly, these new findings challenge how we go about treating nightmares. Instead of focusing on abolishing negative dreams, or the memories of the trauma that caused them, there might be ways to help people control their dreams

and nightmares, without losing the benefits.

One problem is that nightmares awaken the dreamer before the brain's simulation scenario is complete. "So, in nightmares, it is not always possible to rehearse happy endings, or even to successfully respond to the threat," says Valli. Imagery rehearsal therapy is a waking visualisation technique designed to help people modify their nightmares and direct them towards a more

"Even video games can protect dreamers from distress during nightmares"

positive outcome. The person writes down their nightmare and decides on a more desirable ending. They then visualise and mentally play out this finale several times before they sleep. Perhaps capitalising on the vivid imagination of nightmare sufferers,

They seemed so friendly with the lights on

the therapy has been found to reduce nightmares and associated distress.

Another idea is that people could take control while they sleep. Although lucid dreams, where people consciously control what's going on in the dream world, are rare in the general population, they can be an upside of frequent nightmares. Jess has lucid dreams almost every day. She uses this dream space to work on art projects, especially if she is struggling to finish something in her waking hours. "I'll try to move things around in the dream to play with ideas for a painting or compose a photograph," she says, and often on awakening the process proves successful.

Dream come true

While lucid dream induction is difficult, it is a learnable skill (see page 124), and one that nightmare sufferers may be naturally adept at. Training is similar to imagery rehearsal therapy, but practising alternative endings should continue within the lucid dream state. One recent study found that such training reduces nightmare frequency. It also increases recall of more positive dreams and leaves dreamers with a generally more positive attitude and a decreased fear of dreaming.

Even video games can work as a waking threat simulation to protect dreamers from distress. For instance, research shows that soldiers who regularly play video games involving war and combat say they have less violent dreams and less of a sense of helplessness than soldiers who don't play the games. "Gamers report more dream control than any other groups," says Jayne Gackenbach, who is spearheading the work at MacEwan University in Edmonton, Canada. "If you're having fun in the tension around playing a combat-centric game, it makes sense that threat and thus fighting back or combat in dreams would also be fun."

These approaches might not work for everyone, because there are differences between the nightmares focusing on specific events had by people with post-traumatic stress disorder and the theme-based imagery common to most people who experience nightmares. But even understanding that these kinds of nightmares are different could help those who want to hang on to the creative and social benefits of nightmares while freeing themselves from the distress – something Chris is trying to teach himself to do. "I've grown to have a happy indifference towards my nightmares," he says. "They're just something to laugh at." ■

It was just a dream...

Exploiting our ability to lucid dream could help erase real-life traumas, finds sleep researcher Michelle Carr

I WAS scrambling away from a monstrous dark figure when I started to have the sneaking feeling that I had been here before, running from this man. I realised that I was in a bad dream, one I'd had several times recently. Only this time, I stopped mid-stride and turned around to face my attacker. "Who are you?" I screamed. "What do you want?"

I was in a lucid dream, a state of consciousness in between waking and sleeping, in which people are in a dream world but remain aware and able to control their actions. I normally use the dreams for fun – flying, say, or exploring – but sometimes I become lucid within bad dreams or nightmares. At first, I would simply wake myself up whenever this happened, but over time I realised I could change the dreams from within.

Psychologists have long been interested in using dreams to rewrite nightmares or help people overcome persistent fears. But the ability to use lucid dreams has been limited because they are difficult to trigger, and, as with all dreams, memories of them evaporate so quickly upon waking.

That could change, however, as more consistent ways to induce these dreams are uncovered. It is even becoming possible to communicate with the dreamer and record what's happening within dreams. These advances raise the tantalising prospect of unlocking this unique state

of mind to create therapies for people with nightmares (see page 120), anxiety and other conditions. We may soon be able to treat people within their dreams.

I learned to lucid dream several years ago, initially by accident. When I went to bed or as I woke up, I would often get caught in a scary half-awake state where I was alert but unable to move or speak – something called sleep paralysis. To get out of this, I found it easier to fall back asleep than force myself awake. Since I maintained some awareness while drifting off, this often resulted in a lucid dream.

"It's a step toward conveying the content of dreams to the outside world - in real time"

It turns out that what I was doing isn't so different from techniques used to induce lucid dreams deliberately (see "Lucid dreaming for beginners", page 126).

People have been experiencing and writing about lucid dreams for thousands of years. Now with the advent of brain imaging, we have been able to learn much more about what goes on during them. Comparing the brain scans of people who were awake, asleep or in lucid dreams revealed what many had long suspected: lucid dreaming is a state in between REM sleep – the phase in which most

of our dreams occur (see page 114) – and waking. Unlike regular dreams, lucid dreams involve brain activity in areas associated with working memory and regions thought to play a role in higher cognitive functions, such as planning and behavioural control.

Dreams have long been a focus of psychological therapy, for many reasons. Recurring nightmares can be symptomatic of anxiety, post-traumatic stress disorder and other conditions. Discussing dreams during therapy can provide an insulated way for people to explore traumatic subjects, and attempting to rewrite them can help overcome phobias or grief. For this, patients are encouraged to use a strategy known as imagery rehearsal therapy, in which they rehearse and then try to play out challenging scenarios within their dreams, or change the course of nightmares.

The first hints that lucid dreaming could enhance or even expand on the therapeutic use of dreams came when psychologists found that people who are capable of lucid dreaming may be more resilient to trauma and better able to avoid nightmares. Then, in 2015, Brigitte Holzinger and colleagues at the Institute for Consciousness and Dream Research in Vienna, Austria, showed that lucid dreaming makes therapy for nightmares more effective.

When Holzinger asked people undergoing a variation of imagery rehearsal therapy to try lucid dreaming, those who were successful stopped fearing sleep and began to enjoy their dreaming lives. One person even figured out how, within a nightmare, to go back to a point before a threat had started and continue the dream in another direction. People also found that lucid dreams brought a sense of power and control that translated into waking life, a welcome change from the helplessness often experienced in nightmares.



This outcome is the ideal for this kind of therapy: to enable people to confront the source of their trauma or anxiety by directing or changing the course of their dreams.

But the utility of strategies like these is limited by how well people can learn to lucid dream. Even with the best existing methods, results are spotty. Recently, though, researchers have found a way to induce such dreams.

In 2014, Ursula Voss and her colleagues at Goethe University Frankfurt in Germany discovered that a technique known as transcranial alternating current stimulation could spur lucidity in dreams. It involves applying a low electrical current to the brain's frontal cortex during REM sleep, and it works about two-thirds of the time. "Stimulating the frontal area is like putting 'wake' activity into sleep," says Cloé Blanchette-Carrière at the Dream and Nightmare Laboratory in Montreal, Canada.

Blanchette-Carrière is interested in therapies that would trigger lucid dreams instead of relying on people teaching themselves to induce them. "We want to apply this to nightmare sufferers or PTSD patients, to make them able to modify or control their dreams," she says.

The next hurdle in using lucid dreams as a treatment is to communicate with someone once they are asleep, to provide external support as they face a source of trauma, for instance. Many of us have experienced incorporating a noise from the waking world into a dream – a horn honking outside, or music playing on a nearby radio, for instance.

But can we deliberately send messages into people's dreams?

To find out, Kristoffer Appel, a sleep and dream researcher at Osnabrück University in Germany, recruited experienced lucid dreamers and monitored their brain waves and eye movements as they slept. When in lucid dreams people are capable of moving their eyes deliberately, so Appel instructed his volunteers to let him know when they were lucid by looking left-right, left-right. Once he got the cue, he tried to send signals into their dreams using audio tones and flashing lights.

Hello in there

Of 10 volunteers, seven reported incorporating the sounds or lights into their dreams. The tone might become a noise from a ship, car or cellphone. Some people registered the flashing lights as the whole dream turning bright and dark; for others, it was the lightning in a thunderstorm, or a lamp that switched on and off. Those who noticed the noises or lights realised that they were messages from the waking world.

But Appel wanted to go further: he wanted to send more complex messages, and he wanted the dreamers to respond. So he asked these same volunteers to learn basic Morse code for numbers. The idea was to use a series of audio tones to send the dreamers simple arithmetic problems, like $3+5$ or $7-2$. The dreamers didn't know the numbers in advance, and were told to answer using Morse code eye signals. For instance, a "3" in Morse code is three short and two long dashes, so



the subject would look three times to the left and two times to the right.

For Appel and the volunteers, it felt like there was a lot at stake. Many people who can lucid dream have spent months, if not years, teaching themselves how. Although confident it would be possible to communicate from within their dreams, the volunteers feared they might let the side down by waking too soon or failing to find the signals. But it worked, at least for three of them: they not only got the signals, but gave the correct answers. One participant described how he looked around his dream for something that might convey signals from outside. He was in a bus terminal, and spotted a ticket machine. Soon, it began to beep. "I was thrilled to bits... I decoded the first message, confirmed the numbers, solved the math problem, and answered it back to the wak[ing] world: $4+4=8$. I next walked along the street further, telling other pedestrians that I was solving tasks within a lucid dream."

Relying on eye movements limits how much information can be conveyed, however. So Remington Mallett, a researcher then at the University of Missouri–St Louis, decided to try using a brain-computer interface, a device

LUCID DREAMING FOR BEGINNERS

The simplest method to boost your chance of lucid dreaming is to perform "reality checks" during the day. As often as possible, stop to observe your environment and body, and ask yourself: "Is this a dream?" As this becomes a habit, it will be incorporated into your dreams. One night you will find yourself asking, "Is this a dream?" and realise, in fact, it is.

A more direct way is through the "Wake-Back-To-Bed" technique, which is exactly what it sounds like. Ideally, you should set an alarm about 2 hours before you normally wake up, which will put you at a phase in the sleep

cycle when REM sleep is longer and more intense. When the alarm goes off, sit up and stay awake for about 20 minutes. During this time it can help to think or write about the most recent dream you remember, noting anything that could have clued you in to the fact you were dreaming. When you go back to sleep, you should soon enter a dream, and your recently awake and intent mind is likely to follow.

Finally, you can complement these effortful techniques with technology. While there are many apps and sleep masks that are supposed to induce lucid dreams

via audio and visual signals, most of them simply run on a timer and send signals randomly while you sleep, so aren't that effective.

Perhaps the most promising devices are the Aurora Dreamband and the iBand+. Both are small headbands that use actual EEG, among other biosensors, to detect when you are in REM sleep and to trigger LED signals at this time to "wake" you up within your dream. What's more, both are paired with an app that tracks your sleep patterns and an alarm designed to wake you at the best point in the sleep cycle.



that – as the name suggests – enables the brain to talk directly to an external device such as a computer. Mallett believed lucid dreamers should be able to use it, since there is an overlap in the way the brain treats activities during lucid dreams and waking. When lucid dreamers imagine clenching a fist, for example, activity in the brain's motor cortex and even muscle twitches in the wrist of that hand can be detected.

To see whether controlling a brain-computer interface from inside a dream was possible, Mallett recruited two self-taught lucid dreamers to try a simple headset, the Emotiv EPOC. It maps the activity of the brain, and then uses these signals to direct different desired outcomes on the computer. So if you imagine moving the cursor on a screen, it moves. "You basically move virtual objects with your mind," says Mallett, like a "Jedi mind trick".

First, Mallett trained the volunteers – awake and lying down with their eyes closed – to move a block on a computer screen using only their minds. Once they reached 75 per cent accuracy, they were ready to try the task during sleep. When they became lucid, they let Mallett know with quick left-right eye movements, and then began the task.

Mallett saw the signal from both volunteers, and then the block steadily moved forward on the screen.

One volunteer said that during the waking task, he was imagining a street fighter character moving the block forward. During the dream he did the same thing. So in his sleeping mind was him as the dreamer, and in the dreamer's mind was the mental image of a little ninja moving the block. "It's fairly

"Imagine halting a recurring nightmare by choosing a different ending"

meta," says Mallett. "You're imagining about imagining something. We're taking this mental cognitive task and observing it objectively." It's a first step toward being able to convey the content of dreams to the outside world, in real time.

This approach could also help people learn how to control prosthetic limbs. Like moving blocks on the screen, a brain-computer interface can pick up activity in the motor cortex when you imagine moving your arm, sending the signals to the prosthesis. These

devices have even been used to restore brain-controlled walking in people who have had a spinal cord injury.

People with lower limb paralysis who must learn to control an exoskeleton face an added barrier, in that the brain may forget how to send motor signals to their legs. In August 2016, the Walk Again Project – an international collaboration led by Miguel Nicolelis at Duke University in Durham, North Carolina – helped people with partial paralysis regain some muscle control in their lower limbs. To do so, they first learned to use brain activity to control an avatar in virtual reality, getting it to walk around a field. This helped the brain relearn how to send motor signals, which meant that when people moved on to using a real exoskeleton they got the hang of controlling it more quickly. With lucid dreaming, people could exercise their mental muscles in their dream world every night, helping them eventually transition to controlling a real exoskeleton.

As well as the many therapeutic applications, looking into our lucid dreams could also enable us to harness our creativity. Many people find inspiration in their sleep. The melody for *Yesterday* came to Paul McCartney while he was dreaming, and Dmitri Mendeleev famously dreamed up the structure of the periodic table of elements. But as we know, when inspiration strikes in this way it is a race to jot it down once you wake up.

Gadgets like the headset in Mallett's study could eventually be used to help us record ideas from within lucid dreams. And Appel is developing a sleep mask that could record eye-movement Morse code for people to transfer messages. He is also experimenting with something more of us are familiar with: texting. "We are trying for dreamers to just follow the keys with their eyes and track the movements."

As techniques for inducing and communicating from within lucid dreams improve, the possibilities will only grow. For mental health professionals and those who study sleep disorders, the potential for psychological therapies is most inspiring. Imagine, after prolonged grief, getting to say the final goodbye you hadn't been able to. Imagine overcoming a persistent fear while receiving messages of support from the waking world, or halting a recurring nightmare by choosing a different ending. As Blanchette-Carrière says, "If people are able to control the dream, they will be empowered to modify their behaviour in real life." ■

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