11 steps to a better brain

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It doesn't matter how brainy you are or how much education you've had - you can still improve and expand your mind. Boosting your mental faculties doesn't have to mean studying hard or becoming a reclusive book worm. There are lots of tricks, techniques and habits, as well as changes to your lifestyle, diet and behaviour that can help you flex your grey matter and get the best out of your brain cells. And here are 11 of them.

Enlarge image
Bionic Brains

Enlarge image
You must remember this

Smart drugs

Does getting old have to mean worsening memory, slower reactions and fuzzy thinking?

AROUND the age of 40, honest folks may already admit to noticing changes in their mental abilities. This is the beginning of a gradual decline that in all too many of us will culminate in full-blown dementia. If it were possible somehow to reverse it, slow it or mask it, wouldn't you?

A few drugs that might do the job, known as "cognitive enhancement", are already on the market, and a few dozen others are on the way. Perhaps the best-known is modafinil. Licensed to treat narcolepsy, the condition that causes people to suddenly fall asleep, it has notable effects in healthy people too. Modafinil can keep a person

awake and alert for 90 hours straight, with none of the jitteriness and bad concentration that amphetamines or even coffee seem to produce.

In fact, with the help of modafinil, sleep-deprived people can perform even better than their well-rested, unmedicated selves. The forfeited rest doesn't even need to be made good. Military research is finding that people can stay awake for 40 hours, sleep the normal 8 hours, and then pull a few more all-nighters with no ill effects. It's an open secret that many, perhaps most, prescriptions for modafinil are written not for people who suffer from narcolepsy, but for those who simply want to stay awake. Similarly, many people are using Ritalin not because they suffer from attention deficit or any other disorder, but because they want superior concentration during exams or heavy-duty negotiations.

The pharmaceutical pipeline is clogged with promising compounds - drugs that act on the nicotinic receptors that smokers have long exploited, drugs that work on the cannabinoid system to block pot-smoking-type effects. Some drugs have also been specially designed to augment memory. Many of these look genuinely plausible: they seem to work, and without any major side effects.

So why aren't we all on cognitive enhancers already? "We need to be careful what we wish for," says Daniele Piomelli at the University of California at Irvine. He is studying the body's cannabinoid system with a view to making memories less emotionally charged in people suffering from post-traumatic stress disorder. Tinkering with memory may have unwanted effects, he warns. "Ultimately we may end up remembering things we don't want to."

Gary Lynch, also at UC Irvine, voices a similar concern. He is the inventor of ampakines, a class of drugs that changes the rules about how a memory is encoded and how strong a memory trace is - the essence of learning (see *New Scientist*, 14 May, p 6). But maybe the rules have already been optimised by evolution, he suggests. What looks to be an improvement could have hidden downsides.

Still, the opportunity may be too tempting to pass up. The drug acts only in the brain, claims Lynch. It has a short half-life of hours. Ampakines have been shown to restore function to severely sleep-deprived monkeys that would otherwise perform poorly. Preliminary studies in humans are just as exciting. You could make an elderly person perform like a much younger person, he says. And who doesn't wish for that?

Food for thought

You are what you eat, and that includes your brain. So what is the ultimate mastermind diet?

YOUR brain is the greediest organ in your body, with some quite specific dietary requirements. So it is hardly surprising that what you eat can affect how you think. If you believe the dietary supplement industry, you could

become the next Einstein just by popping the right combination of pills. Look closer, however, and it isn't that simple. The savvy consumer should take talk of brain-boosting diets with a pinch of low-sodium salt. But if it is possible to eat your way to genius, it must surely be worth a try.

First, go to the top of the class by eating breakfast. The brain is best fuelled by a steady supply of glucose, and many studies have shown that skipping breakfast reduces people's performance at school and at work.

But it isn't simply a matter of getting some calories down. According to research published in 2003, kids breakfasting on fizzy drinks and sugary snacks performed at the level of an average 70-year-old in tests of memory and attention. Beans on toast is a far better combination, as Barbara Stewart from the University of Ulster, UK, discovered. Toast alone boosted children's scores on a variety of cognitive tests, but when the tests got tougher, the breakfast with the high-protein beans worked best. Beans are also a good source of fibre, and other research has shown a link between a high-fibre diet and improved cognition. If you can't stomach beans before midday, wholemeal toast with Marmite makes a great alternative. The yeast extract is packed with B vitamins, whose brain-boosting powers have been demonstrated in many studies.

A smart choice for lunch is omelette and salad. Eggs are rich in choline, which your body uses to produce the neurotransmitter acetylcholine. Researchers at Boston University found that when healthy young adults were given the drug scopolamine, which blocks acetylcholine receptors in the brain, it significantly reduced their ability to remember word pairs. Low levels of acetylcholine are also associated with Alzheimer's disease, and some studies suggest that boosting dietary intake may slow age-related memory loss.

A salad packed full of antioxidants, including beta-carotene and vitamins C and E, should also help keep an ageing brain in tip-top condition by helping to mop up damaging free radicals. Dwight Tapp and colleagues from the University of California at Irvine found that a diet high in antioxidants improved the cognitive skills of 39 ageing beagles - proving that you can teach an old dog new tricks.

Round off lunch with a yogurt dessert, and you should be alert and ready to face the stresses of the afternoon. That's because yogurt contains the amino acid tyrosine, needed for the production of the neurotransmitters dopamine and noradrenalin, among others. Studies by the US military indicate that tyrosine becomes depleted when we are under stress and that supplementing your intake can improve alertness and memory.

Don't forget to snaffle a snack mid-afternoon, to maintain your glucose levels. Just make sure you avoid junk food, and especially highly processed goodies such as cakes, pastries and biscuits, which contain trans-fatty acids. These not only pile on the pounds, but are implicated in

a slew of serious mental disorders, from dyslexia and ADHD (attention deficit hyperactivity disorder) to autism. Hard evidence for this is still thin on the ground, but last year researchers at the annual Society for Neuroscience meeting in San Diego, California, reported that rats and mice raised on the rodent equivalent of junk food struggled to find their way around a maze, and took longer to remember solutions to problems they had already solved.

It seems that some of the damage may be mediated through triglyceride, a cholesterol-like substance found at high levels in rodents fed on trans-fats. When the researchers gave these rats a drug to bring triglyceride levels down again, the animals' performance on the memory tasks improved.

Brains are around 60 per cent fat, so if trans-fats clog up the system, what should you eat to keep it well oiled? Evidence is mounting in favour of omega-3 fatty acids, in particular docosahexaenoic acid or DHA. In other words, your granny was right: fish is the best brain food. Not only will it feed and lubricate a developing brain, DHA also seems to help stave off dementia. Studies published last year reveal that older mice from a strain genetically altered to develop Alzheimer's had 70 per cent less of the amyloid plaques associated with the disease when fed on a high-DHA diet.

Finally, you could do worse than finish off your evening meal with strawberries and blueberries. Rats fed on these fruits have shown improved coordination, concentration and short-term memory. And even if they don't work such wonders in people, they still taste fantastic. So what have you got to lose?

The Mozart effect

Music may tune up your thinking, but you can't just crank up the volume and expect to become a genius

A DECADE ago Frances Rauscher, a psychologist now at the University of Wisconsin at Oshkosh, and her colleagues made waves with the discovery that listening to Mozart improved people's mathematical and spatial reasoning. Even rats ran mazes faster and more accurately after hearing Mozart than after white noise or music by the minimalist composer Philip Glass. Last year, Rauscher reported that, for rats at least, a Mozart piano sonata seems to stimulate activity in three genes involved in nerve-cell signalling in the brain.

This sounds like the most harmonious way to tune up your mental faculties. But before you grab the CDs, hear this note of caution. Not everyone who has looked for the Mozart effect has found it. What's more, even its proponents tend to think that music boosts brain power simply because it makes listeners feel better - relaxed and stimulated at the same time - and that a comparable stimulus might do just as well. In fact,

one study found that listening to a story gave a similar performance boost.

There is, however, one way in which music really does make you smarter, though unfortunately it requires a bit more effort than just selecting something mellow on your iPod. Music lessons are the key. Six-year-old children who were given music lessons, as opposed to drama lessons or no extra instruction, got a 2 to 3-point boost in IQ scores compared with the others. Similarly, Rauscher found that after two years of music lessons, pre-school children scored better on spatial reasoning tests than those who took computer lessons.

Maybe music lessons exercise a range of mental skills, with their requirement for delicate and precise finger movements, and listening for pitch and rhythm, all combined with an emotional dimension. Nobody knows for sure. Neither do they know whether adults can get the same mental boost as young children. But, surely, it can't hurt to try.

Bionic brains

If training and tricks seem too much like hard work, some technological short cuts can boost brain function

(See graphic, above)

Gainful employment

Put your mind to work in the right way and it could repay you with an impressive bonus

UNTIL recently, a person's IQ - a measure of all kinds of mental problem-solving abilities, including spatial skills, memory and verbal reasoning - was thought to be a fixed commodity largely determined by genetics. But recent hints suggest that a very basic brain function called working memory might underlie our general intelligence, opening up the intriguing possibility that if you improve your working memory, you could boost your IQ too.

Working memory is the brain's short-term information storage system. It's a workbench for solving mental problems. For example if you calculate 73 - 6 + 7, your working memory will store the intermediate steps necessary to work out the answer. And the amount of information that the working memory can hold is strongly related to general intelligence.

A team led by Torkel Klingberg at the Karolinska Institute in Stockholm, Sweden, has found signs that the neural systems that underlie working memory may grow in response to training. Using functional magnetic resonance imaging (fMRI) brain scans, they measured the brain activity of adults before and after a working-memory training programme, which involved tasks such as memorising the positions of a series of dots on a grid. After five weeks of training, their brain activity had increased in the regions associated with this type of memory (*Nature Neuroscience*, vol 7, p 75).

Perhaps more significantly, when the group studied children who had completed these types of mental workouts, they saw improvement in a range of cognitive abilities not related to the training, and a leap in IQ test scores of 8 per cent (*Journal of the American Academy of Child and Adolescent Psychiatry*, vol 44, p 177). It's early days yet, but Klingberg thinks working-memory training could be a key to unlocking brain power. "Genetics determines a lot and so does the early gestation period," he says. "On top of that, there is a few per cent - we don't know how much - that can be improved by training."

Memory marvels

Mind like a sieve? Don't worry. The difference between mere mortals and memory champs is more method than mental capacity

AN AUDITORIUM is filled with 600 people. As they file out, they each tell you their name. An hour later, you are asked to recall them all. Can you do it? Most of us would balk at the idea. But in truth we're probably all up to the task. It just needs a little technique and dedication.

First, learn a trick from the "mnemonists" who routinely memorise strings of thousands of digits, entire epic poems, or hundreds of unrelated words. When Eleanor Maguire from University College London and her colleagues studied eight front runners in the annual World Memory Championships they did not find any evidence that these people have particularly high IQs or differently configured brains. But, while memorising, these people did show activity in three brain regions that become active during movements and navigation tasks but are not normally active during simple memory tests.

This may be connected to the fact that seven of them used a strategy in which they place items to be remembered along a visualised route (*Nature Neuroscience*, vol 6, p 90). To remember the sequence of an entire pack of playing cards for example, the champions assign each card an identity, perhaps an object or person, and as they flick through the cards they can make up a story based on a sequence of interactions between these characters and objects at sites along a well-trodden route.

Actors use a related technique: they attach emotional meaning to what they say. We always remember highly emotional moments better than less emotionally loaded ones. Professional actors also seem to link words with movement, remembering action-accompanied lines significantly better than those delivered while static, even months after a show has closed.

Helga Noice, a psychologist from Elmhurst College in Illinois, and Tony Noice, an actor, who together discovered this effect, found that non-thesps can benefit by adopting a similar technique. Students who paired their words with previously learned actions could reproduce 38 per cent of them after just 5 minutes, whereas rote learners only managed 14

per cent. The Noices believe that having two mental representations gives you a better shot at remembering what you are supposed to say.

Strategy is important in everyday life too, says Barry Gordon from Johns Hopkins University in Baltimore, Maryland. Simple things like always putting your car keys in the same place, writing things down to get them off your mind, or just deciding to pay attention, can make a big difference to how much information you retain. And if names are your downfall, try making some mental associations. Just remember to keep the derogatory ones to yourself.

Sleep on it

Never underestimate the power of a good night's rest

SKIMPING on sleep does awful things to your brain. Planning, problem-solving, learning, concentration,working memory and alertness all take a hit. IQ scores tumble. "If you have been awake for 21 hours straight, your abilities are equivalent to someone who is legally drunk," says Sean Drummond from the University of California, San Diego. And you don't need to pull an all-nighter to suffer the effects: two or three late nights and early mornings on the trot have the same effect.

Luckily, it's reversible - and more. If you let someone who isn't sleep-deprived have an extra hour or two of shut-eye, they perform much better than normal on tasks requiring sustained attention, such taking an exam. And being able to concentrate harder has knock-on benefits for overall mental performance. "Attention is the base of a mental pyramid," says Drummond. "If you boost that, you can't help boosting everything above it."

These are not the only benefits of a decent night's sleep. Sleep is when your brain processes new memories, practises and hones new skills - and even solves problems. Say you're trying to master a new video game. Instead of grinding away into the small hours, you would be better off playing for a couple of hours, then going to bed. While you are asleep your brain will reactivate the circuits it was using as you learned the game, rehearse them, and then shunt the new memories into long-term storage. When you wake up, hey presto! You will be a better player. The same applies to other skills such as playing the piano, driving a car and, some researchers claim, memorising facts and figures. Even taking a nap after training can help, says Carlyle Smith of Trent University in Peterborough, Ontario.

There is also some evidence that sleep can help produce moments of problem-solving insight. The famous story about the Russian chemist Dmitri Mendeleev suddenly "getting" the periodic table in a dream after a day spent struggling with the problem is probably true. It seems that sleep somehow allows the brain to juggle new memories to produce flashes of creative insight. So if you want to have a eureka moment, stop racking

your brains and get your head down.

Body and mind

Physical exercise can boost brain as well as brawn

IT'S a dream come true for those who hate studying. Simply walking sedately for half an hour three times a week can improve abilities such as learning, concentration and abstract reasoning by 15 per cent. The effects are particularly noticeable in older people. Senior citizens who walk regularly perform better on memory tests than their sedentary peers. What's more, over several years their scores on a variety of cognitive tests show far less decline than those of non-walkers. Every extra mile a week has measurable benefits.

It's not only oldies who benefit, however. Angela Balding from the University of Exeter, UK, has found that schoolchildren who exercise three or four times a week get higher than average exam grades at age 10 or 11. The effect is strongest in boys, and while Balding admits that the link may not be causal, she suggests that aerobic exercise may boost mental powers by getting extra oxygen to your energy-guzzling brain.

There's another reason why your brain loves physical exercise: it promotes the growth of new brain cells. Until recently, received wisdom had it that we are born with a full complement of neurons and produce no new ones during our lifetime. Fred Gage from the Salk Institute in La Jolla, California, busted that myth in 2000 when he showed that even adults can grow new brain cells. He also found that exercise is one of the best ways to achieve this.

In mice, at least, the brain-building effects of exercise are strongest in the hippocampus, which is involved with learning and memory. This also happens to be the brain region that is damaged by elevated levels of the stress hormone cortisol. So if you are feeling frazzled, do your brain a favour and go for a run.

Even more gentle exercise, such as yoga, can do wonders for your brain. Last year, researchers at the University of California, Los Angeles, reported results from a pilot study in which they considered the mood-altering ability of different yoga poses. Comparing back bends, forward bends and standing poses, they concluded that the best way to get a mental lift is to bend over backwards.

And the effect works both ways. Just as physical exercise can boost the brain, mental exercise can boost the body. In 2001, researchers at the Cleveland Clinic Foundation in Ohio asked volunteers to spend just 15 minutes a day thinking about exercising their biceps. After 12 weeks, their arms were 13 per cent stronger.

Nuns on a run

If you don't want senility to interfere with your old age, perhaps you

should seek some sisterly guidance

THE convent of the School Sisters of Notre Dame on Good Counsel Hill in Mankato, Minnesota, might seem an unusual place for a pioneering brain-science experiment. But a study of its 75 to 107-year-old inhabitants is revealing more about keeping the brain alive and healthy than perhaps any other to date. The "Nun study" is a unique collaboration between 678 Catholic sisters recruited in 1991 and Alzheimer's expert David Snowdon of the Sanders-Brown Center on Aging and the University of Kentucky in Lexington.

The sisters' miraculous longevity - the group boasts seven centenarians and many others well on their way - is surely in no small part attributable to their impeccable lifestyle. They do not drink or smoke, they live quietly and communally, they are spiritual and calm and they eat healthily and in moderation. Nevertheless, small differences between individual nuns could reveal the key to a healthy mind in later life.

Some of the nuns have suffered from Alzheimer's disease, but many have avoided any kind of dementia or senility. They include Sister Matthia, who was mentally fit and active from her birth in 1894 to the day she died peacefully in her sleep, aged 104. She was happy and productive, knitting mittens for the poor every day until the end of her life. A post-mortem of Sister Matthia's brain revealed no signs of excessive ageing. But in some other, remarkable cases, Snowdon has found sisters who showed no outwards signs of senility in life, yet had brains that looked as if they were ravaged by dementia.

How did Sister Matthia and the others cheat time? Snowdon's study, which includes an annual barrage of mental agility tests and detailed medical exams, has found several common denominators. The right amount of vitamin folate is one. Verbal ability early in life is another, as are positive emotions early in life, which were revealed by Snowdon's analysis of the personal autobiographical essays each woman wrote in her 20s as she took her vows. Activities, crosswords, knitting and exercising also helped to prevent senility, showing that the old adage "use it or lose it" is pertinent. And spirituality, or the positive attitude that comes from it, can't be overlooked. But individual differences also matter. To avoid dementia, your general health may be vital: metabolic problems, small strokes and head injuries seem to be common triggers of Alzheimer's dementia.

Obviously, you don't have to become a nun to stay mentally agile. We can all aspire to these kinds of improvements. As one of the sisters put it, "Think no evil, do no evil, hear no evil, and you will never write a best-selling novel."

Attention seeking

You can be smart, well-read, creative and knowledgeable, but none of

it is any use if your mind isn't on the job

PAYING attention is a complex mental process, an interplay of zooming in on detail and stepping back to survey the big picture. So unfortunately there is no single remedy to enhance your concentration. But there are a few ways to improve it.

The first is to raise your arousal levels. The brain's attentional state is controlled by the neurotransmitters dopamine and noradrenalin. Dopamine encourages a persistent, goal-centred state of mind whereas noradrenalin produces an outward-looking, vigilant state. So not surprisingly, anything that raises dopamine levels can boost your powers of concentration.

One way to do this is with drugs such as amphetamines and the ADHD drug methylphenidate, better known as Ritalin. Caffeine also works. But if you prefer the drug-free approach, the best strategy is to sleep well, eat foods packed with slow-release sugars, and take lots of exercise. It also helps if you are trying to focus on something that you find interesting.

The second step is to cut down on distractions. Workplace studies have found that it takes up to 15 minutes to regain a deep state of concentration after a distraction such as a phone call. Just a few such interruptions and half the day is wasted.

Music can help as long as you listen to something familiar and soothing that serves primarily to drown out background noise. Psychologists also recommend that you avoid working near potential diversions, such as the fridge.

There are mental drills to deal with distractions. College counsellors routinely teach students to recognise when their thoughts are wandering, and catch themselves by saying "Stop! Be here now!" It sounds corny but can develop into a valuable habit. As any Zen meditator will tell you, concentration is as much a skill to be lovingly cultivated as it is a physiochemical state of the brain.

Positive feedback

Thought control is easier than you might imagine

IT SOUNDS a bit New Age, but there is a mysterious method of thought control you can learn that seems to boost brain power. No one quite knows how it works, and it is hard to describe exactly how to do it: it's not relaxation or concentration as such, more a state of mind. It's called neurofeedback. And it is slowly gaining scientific credibility.

Neurofeedback grew out of biofeedback therapy, popular in the 1960s. It works by showing people a real-time measure of some seemingly uncontrollable aspect of their physiology - heart rate, say - and encouraging them to try and change it. Astonishingly, many patients found that they could, though only rarely could they describe how they did

it.

More recently, this technique has been applied to the brain - specifically to brain wave activity measured by an electroencephalogram, or EEG. The first attempts were aimed at boosting the size of the alpha wave, which crescendos when we are calm and focused. In one experiment, researchers linked the speed of a car in a computer game to the size of the alpha wave. They then asked subjects to make the car go faster using only their minds. Many managed to do so, and seemed to become more alert and focused as a result.

This early success encouraged others, and neurofeedback soon became a popular alternative therapy for ADHD. There is now good scientific evidence that it works, as well as some success in treating epilepsy, depression, tinnitus, anxiety, stroke and brain injuries.

And to keep up with the times, some experimenters have used brain scanners in place of EEGs. Scanners can allow people to see and control activity of specific parts of the brain. A team at Stanford University in California showed that people could learn to control pain by watching the activity of their pain centres (*New Scientist*, 1 May 2004, p 9).

But what about outside the clinic? Will neuro feedback ever allow ordinary people to boost their brain function? Possibly. John Gruzelier of Imperial College London has shown that it can improve medical students' memory and make them feel calmer before exams. He has also shown that it can improve musicians' and dancers' technique, and is testing it out on opera singers and surgeons.

Neils Birbaumer from the University of Tübingen in Germany wants to see whether neurofeedback can help psychopathic criminals control their impulsiveness. And there are hints that the method could boost creativity, enhance our orgasms, give shy people more confidence, lift low moods, alter the balance between left and right brain activity, and alter personality traits. All this by the power of thought.