

Adapted from the book *The Instant Egghead Guide to the Mind*, by Emily Anthes and *Scientific American*. © 2008 by *Scientific American*. Published by arrangement with St. Martin's Press.

Six Ways to Boost Brainpower

The adult human brain is surprisingly malleable: it can rewire itself and even grow new cells. Here are some habits that can fine-tune your mind

By Emily Anthes

Amputees sometimes experience phantom limb sensations, feeling pain, itching or other impulses coming from limbs that no longer exist. Neuroscientist Vilayanur S. Ramachandran worked with patients who had so-called phantom limbs, including Tom, a man who had lost one of his arms.

Ramachandran discovered that if he stroked Tom's face, Tom felt like his missing fingers were also being touched. Each part of the body is represented by a different region of the somatosensory cortex, and, as it happens, the region for the hand is adjacent to the region for the face. The neuroscientist deduced that a remarkable change had taken place in Tom's somatosensory cortex.

Ramachandran concluded that because Tom's cortex was no longer getting input from his missing hand, the region processing sensation from his face had slowly taken over the hand's territory. So touching Tom's face produced sensation in his nonexistent fingers.

This kind of rewiring is an example of neuroplasticity, the adult brain's ability to change and remold itself. Scientists are finding that the adult brain is far more malleable than they once thought. Our behavior and environment can cause substantial rewiring of the brain or a re-

organization of its functions and where they are located. Some believe that even our patterns of thinking alone are enough to reshape the brain.

Researchers now know that neurogenesis (the birth of new neurons) is a normal feature of the adult brain. Studies have shown that one of the most active regions for neurogenesis is the hippocampus, a structure that is vitally important for learning and long-term memory.

Neurogenesis also takes place in the olfactory bulb, which is involved in processing smells. But not all the neurons that are born survive; in fact, most of them die. To survive, the new cells need nutrients and connections with other neurons that are already thriving. Scientists are currently identifying the factors that affect the rate of neurogenesis and the survival of new cells. Mental and physical exercise, for instance, both boost neuron survival.

IMAGE COMPOSITION BY SCIENTIFIC AMERICAN MIND; JULIE FELTON
iStockphoto (brain on opposite and following pages); DEAN TURNER /iStockphoto
(background on opposite page and in brain icons on following pages)



Exercise can improve the brain's executive functions: planning, organizing, multitasking and more. Physical activity improves the delivery of oxygen and nutrients to brain cells.

METHOD 1: EXERCISE

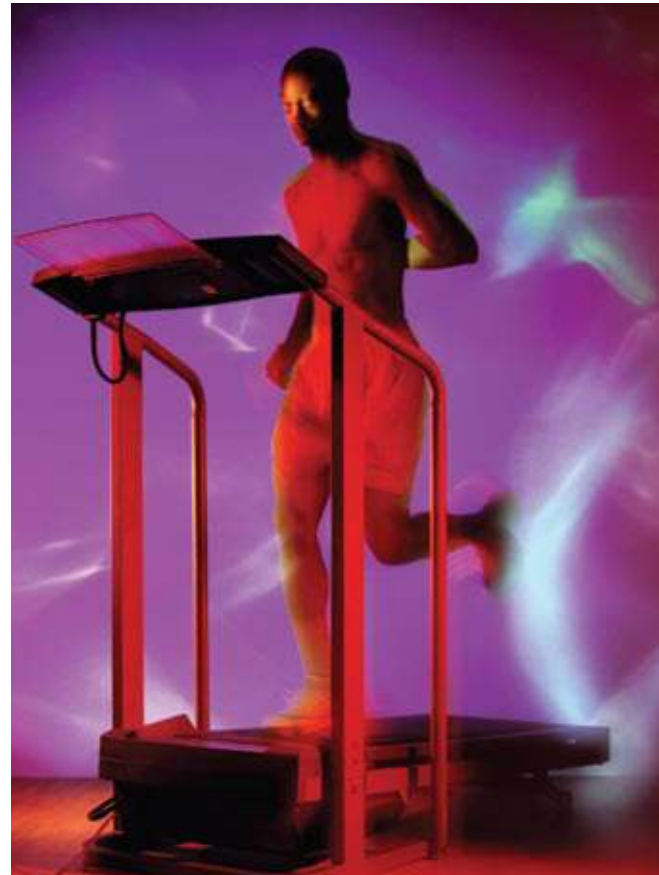


Mice that run on wheels increase the number of neurons in their hippocampus and perform better on tests of learning and memory. Studies of humans have revealed that exercise can improve the brain's executive functions (planning, organizing, multitasking, and more). Exercise is also well known for its mood-boosting effects, and people who exercise are less likely to get dementia as they age. Among those who are already

aged, athletic senior citizens have better executive function than do those who are sedentary; even seniors who have spent their entire lives on the couch can improve these abilities just by starting to move more in their golden years.

A variety of mechanisms might be responsible for this brain boost. Exercise increases blood flow to the brain, which also increases the delivery of oxygen, fuel and nutrients to those hard-working neurons. Research has shown that exercise can increase levels of a substance called brain-derived neurotrophic factor (BDNF), which encourages growth, communication and survival of neurons.

Of course, all this research does nothing to help explain dumb jocks.



ON THE FRONTIER

New research suggests a little music can make your workout better yet. Volunteers completed two workout sessions. In one, they sweated to the sweet sound of silence; in the other, they listened to Vivaldi's *Four Seasons*. After each workout, participants completed assessments of their mood and verbal skills.

Exercise alone was enough to boost both, but verbal scores improved twice as much when the exercisers had tunes to listen to. Maybe you can get your insurance company to pay for a new iPod.

COCKTAIL PARTY TIDBITS

>> Exercise also improves sleep quality, a pile of studies suggests. And immune function. Is there anything it can't do?

>> You don't need to be Chuck Norris (thankfully) to get the brain benefits of exercise. Studies of senior citizens have shown that as little as 20 minutes of walking a day can do the trick.

ISTOCKPHOTO (legs in icon); PETER BEAVIS/Getty Images (man on treadmill); HENNING DALHOFF/Bonnier Publications/SPL/Photo Researchers, Inc. (neurogenesis on opposite page, top left)

FAST FACTS

Changing Your Mind

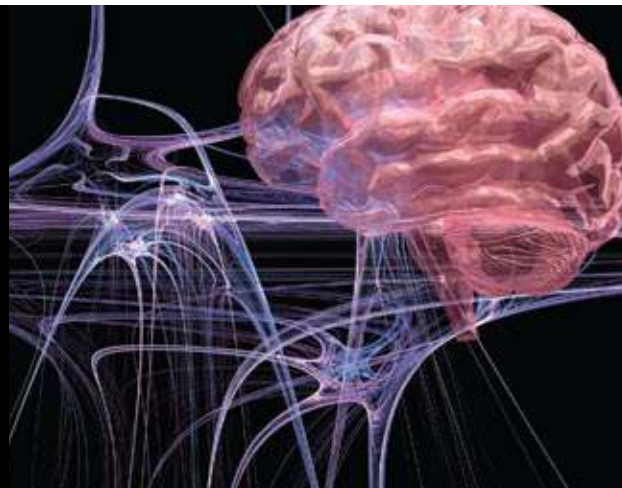
1 >> Scientists are finding that the adult human brain is far more malleable than they once thought. Your behavior and environment can cause substantial rewiring of your brain or a reorganization of its functions.

2 >> Studies have shown that exercise can improve the brain's executive skills, which include planning, organizing and multitasking. What you eat can also influence how effectively your brain operates.

3 >> Activities such as listening to music, playing video games and meditating may boost cognitive performance as well.



Neurogenesis, or the birth of new neurons (left) is a normal feature of the adult brain. To survive, a new neuron needs nutrients and connections with other neurons (right). Mental and physical exercise both boost neuron survival.



METHOD 2: DIET



The brain needs fuel just as the body does. So what will really boost your brainpower, and what will make you lose your mind? Saturated fat, that familiar culprit, is no better for the brain than it is for the body. Rats fed diets high in saturated fat underperformed on tests of learning and memory, and humans who live on such diets seem to be at increased risk for dementia.

Not all fat is bad news, however. The brain is mostly fat—all those cell membranes and myelin coverings require fatty acids—so it is important to eat certain fats, particularly omega-3 fats, which are found in fish, nuts and seeds. Alzheimer's disease, depression, schizophrenia and other disorders may be associated with low levels of omega-3 fatty acids.

Fruits and vegetables also appear to be brain superfoods. Produce is high in substances called antioxidants, which counteract atoms that can damage brain cells. Researchers have found that high-antioxidant diets keep learning and memory sharp in aging rats and even reduce the brain damage caused by strokes. That's food for thought.

ON THE FRONTIER

It's not just what you eat that affects the brain. It's also how much. Research has shown that laboratory animals fed calorie-restricted diets—anywhere from 25 to 50 percent less than normal—live longer than other animals do. And it turns out they also have improved brain function, performing better on tests of memory and coordination. Rodents on calorie-restricted diets are also better able to resist the damage that accompanies Alzheimer's, Parkinson's and Huntington's disease.

COCKTAIL PARTY TIDBITS

- >> Some of the best brain foods: walnuts, blueberries and spinach.
- >> It is especially important that babies get enough fat. Babies who don't get enough of the stuff have trouble creating the fatty myelin insulation that helps neurons transmit signals. Luckily for babies, breast milk is 50 percent fat.
- >> Populations that traditionally eat diets high in omega-3 fatty acids tend to have lower rates of disorders of the central nervous system.



Video games can improve mental dexterity, while boosting

METHOD 3: STIMULANTS



Stimulants are substances that rev up the nervous system, increasing heart rate, blood pressure, energy, breathing and more. Caffeine is probably the most famous of the group. (It is actually the most widely used “drug” in the world.) By activating the central nervous system, caffeine boosts arousal and alertness. In high doses, though, this stimulation can go too far, causing jitters, anxiety and insomnia.

Cocaine and amphetamines are less benign. Although they work on the brain through different mechanisms, they have similar effects. Taking them increases the release of some of the brain’s feel-good neurotransmitters—including dopamine and serotonin—and produces a rush of euphoria. They also increase alertness and energy.

That all sounds pretty good, but cocaine and amphetamines are extremely addictive drugs and in high doses they can cause psychosis and withdrawal. The withdrawal symptoms are nasty and can lead to depression, the opposite of that euphoric feeling. And of course, an overdose can kill you.

ON THE FRONTIER

Although high doses of caffeine can undoubtedly have unpleasant effects (ranging from irritability to the most unpleasant of all: death in rare cases), small to moderate amounts can boost our mental

functioning in ways researchers are now measuring.

One study showed that the equivalent of two cups of coffee can boost short-term memory and reaction time. Functional MRI scans taken during the study also revealed that volunteers who had been given caffeine had increased activity in the brain regions involving attention. In addition, research suggests caffeine can protect against age-related memory decline in older women.

COCKTAIL PARTY TIDBITS

>> Three quarters of the caffeine we ingest comes from coffee. Try to limit yourself to fewer than 100 cups a day. That much coffee contains about 10 grams of caffeine, enough to cause fatal complications.

>> One of fiction’s most famous stimulant users is the great caper cracker Sherlock Holmes. Many of the detective’s capers include descriptions of the relief he found from injecting cocaine. It must be tough to make sure justice is done.



ISTOCKPHOTO (coffee cup in icon); RYOICHI UTSUMI/Getty Images (coffee on table)

hand-eye coordination, depth perception and pattern recognition.

METHOD 4: VIDEO GAMES



Video games could save your life. Surgeons who spend at least a few hours a week playing video games make one-third fewer errors in the operating room than nongaming doctors do. Indeed, research has shown that video games can improve mental dexterity, while boosting hand-eye coordination, depth perception and pattern recognition. Gamers also have better attention spans and information-

processing skills than the average Joe has. When nongamers agree to spend a week playing video games (in the name of science, of course), their visual-perception skills improve. And strike your notions of gamers as outcasts: one researcher found that white-collar professionals who play video games are more confident and social.

Of course, we cannot talk about the effects of video games without mentioning the popular theory that they are responsible for increasing real-world violence. A number of studies have reinforced this link. Young men who play a lot of violent video games have brains that are less responsive to graphic images, suggesting that these gamers have become desensitized to such depictions. Another study revealed that gamers had patterns of brain activity consistent with aggression while playing first-person shooter games.

This does not necessarily mean these players will actually be violent in real life. The connections are worth exploring, but so far the data do not support the idea that the rise of video games is responsible for increased youth violence.

ON THE FRONTIER

Video games activate the brain's reward circuits but do so much more in men than in women, according to a new study. Researchers hooked men and women up to functional MRI machines while the participants played a video game designed for the study. Both groups performed well, but the men showed more activity in the limbic system, which is associated with reward processing. What is more, the men showed greater connectivity between the structures that make up the reward circuit, and the better this connection was in a particular player, the better he performed. There was no such correlation in women. Men are more than twice as likely as women are to say they feel addicted to video games.

COCKTAIL PARTY TIDBITS

- >> Video games are a \$10-billion industry in the U.S.
- >> In 2003 a 16-year-old boy shot and killed two police



officers and a police dispatcher. Two years later the families of the victims filed suit against the company that made the massively popular video game *Grand Theft Auto*. The lawsuit alleges that the perpetrator was inspired by his obsession with the controversial video game.

(The Author)

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METHOD 5: MUSIC



When you turn on Queen's *Greatest Hits*, the auditory cortex analyzes the many components of the music: volume, pitch, timbre, melody and rhythm. But there's more to music's interaction with the brain than just the raw sound. Music can also activate your brain's reward centers and depress activity in the amygdala, reducing fear and other negative emotions.

A highly publicized study suggested that listening to Mozart could boost cognitive performance, inspiring parents everywhere to go out and buy classical CDs for their children. The idea of a "Mozart effect" remains popular, but the original study has been somewhat discredited, and any intellectual boost that comes from listening to music seems to be tiny and temporary. Nevertheless, music does seem to possess some good vibrations. It can treat anxiety and insomnia, lower blood pressure, soothe

patients with dementia, and help premature babies to gain weight and leave the hospital sooner.

Music training can bolster the brain. The motor cortex, cerebellum and corpus callosum (which connects the brain's two sides) are all bigger in musicians than in nonmusicians. And string players have more of their sensory cortices devoted to their fingers than do those who don't play the instruments. There is no agreement yet on whether musical training makes you smarter, but some studies

have indeed shown that music lessons can improve the spatial abilities of young kids.

ON THE FRONTIER

Music lessons and practice during childhood increase the sensitivity of the brain stem to the sounds of human speech. According to a recent study, the brain stem is involved in very basic encoding of sound, and lots of exposure to music can help fine-tune this system, even in kids without particular musical gifts.

So buck up, tone-deaf children of the world! Think of it like eating vegetables: chewing on that clarinet is good for you.

COCKTAIL PARTY TIDBITS

>> The auditory cortex is activated by singing a song in your head. The visual cortex is activated by merely imagining a musical score.

>> Playing classical and soothing music can increase the milk yield of dairy cows.



Music can activate your brain's reward centers and depress activity in the amygdala, the hub of emotional memory, reducing fear and other negative feelings.



METHOD 6: MEDITATION



Forget apples. If reams of scientific studies are to be believed (and such studies usually are), an om a day can keep the doctor away. Meditation, or the turning of the mind inward for contemplation and relaxation, seems to help all types of conditions—*anxiety disorders, sure, but it can also reduce pain and treat high blood pressure, asthma, insomnia, diabetes, depression and even skin conditions.*

And regular meditators say they feel more at ease and more creative than nonmeditators do.

Researchers are now illuminating the actual brain changes caused by meditation by sticking meditators into brain-imaging machines. For one, although the brain's cells typically fire at all different times, during meditation they fire in synchrony. Expert meditators also show spikes of brain activity in the left prefrontal cortex, an area of the brain that has generally been associated with positive emotions. And those who had the most activity in this area during meditation also had big boosts in immune system functioning.

Meditation can increase the thickness of the cerebral cortex, particularly in regions associated with attention and sensation. (The growth does not seem to result from the cortex growing new neurons, though—it appears that the neurons already there make more connections, the number of support cells increases, and blood vessels in that area get bigger.)

ON THE FRONTIER

Meditation can increase focus and attention, improving performance on cognitive tasks. Researchers spent three months training volunteers in the practice of Vipassana meditation, which centers on minimizing distractions.

Then the volunteers were asked to perform a task in which they had to pick a few numbers out of a stream of letters. People who had undergone meditation training were much better at identifying numbers that briefly flashed onto a computer screen. They also seemed to be able to do this without exerting as much mental energy.

COCKTAIL PARTY TIDBITS

» Monks who take part in these scientific studies have typically spent more than 10,000 hours in meditation. That's more than a year.

» In 2005 the Dalai Lama was a distinguished speaker at the Society for Neuroscience's annual conference, the world's largest gathering of brain researchers. **M**