ALZHEIMER'S UPDATE: NEW INSIGHTS MAY SPEED THERAPIES *page 56*

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MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

November/December 2009
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Why High-IQ People Do Dumb Things

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PHOTOILLUSTRATION BY AARON GOODMAN; PASIEKA/SPL/PHOTO RESEARCHERS, INC. (*brain image*)

Smart Set

We've all seen the pretty pictures. Colored scans, produced by techniques that measure blood flow or the movement of a tracer chemical, reveal the activity of areas of the brain when we are thinking about something. The revolution in imaging in the past couple of decades has taught us a lot about what the brain is doing while we cogitate. One thing we've learned is that those more active areas aren't always the same from brain to brain when considering a certain problem. Not all brains are the same size or shape, as you might expect, but they also *think* differently.

So where does intelligence arise? Neuroscientist Richard J. Haier poses that question in our cover story, "What Does a Smart Brain Look Like?" Just as occurs with other types of processing, how we think when we are solving tasks differs among individuals. "Two people with the same IQ may solve a problem with equal speed and accuracy, each using a very different network of brain areas," Haier writes. It may be time for a new definition of intelligence, he proposes, based on the size of key brain areas and how efficiently they manage information flow. Could brain scans someday show our aptitude for a given subject, helping us figure out what topics to focus on for our best success? Turn to page 26 to learn more.

Intelligence not only exists in various places in the brain, it's variable as well. We all know people who seem perfectly smart and yet have made poor decisions at critical junctures. As it turns out, there's a reason for that: it is possible to test high in IQ yet to suffer from a logical-thought defect known as dysrationalia. In "Rational and Irrational Thought: The Thinking That IQ Tests Miss," beginning on page 34, neuroscientist Keith E. Stanovich provides two causes. One is that people are often cognitive misers—taking the easy way out when trying to solve problems, which leads them to make errors. Second, they may lack the specific knowledge, rules or strategies to handle a situation. Stanovich argues that tests that can measure dysrationalia should be conducted more often to identify the flaw, the better to manage it. Sounds smart to us.

Mariette DiChristina
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INTELLIGENCE—A SPECIAL SECTION

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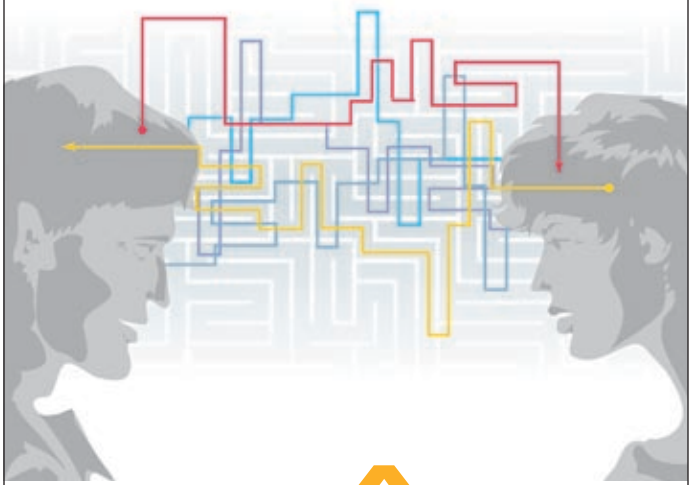

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PARENTS AND PEERS

As a psychologist very familiar with the research, I think in "Do Parents Matter?" Judith Harris is conflating personality and behavior, which are two different concepts. Personality has more to do with genetic traits related to mood and energy (which plenty of research indicates are strongly influenced by genetics). Behavior, on the other hand, depends on context and is guided by laws of behaviorism—that is, reinforcement principles. If parents do (or do not) provide reinforcement for specific types of behavior, you will either see or not see those behaviors. Likewise, certain behaviors will be reinforced in the classroom by teachers.

I teach these basic principles. When people apply them, they work "like magic." Simple but effective television shows, such as *Supernanny,* demonstrate their power. To suggest that parents "do not matter" or have little influence is beyond laughable. There is no doubt that peers matter, as Harris says—but the research shows they matter more when the parents ignore their impact, do not address their impact or do not take actions to ameliorate negative impact.

"Rhombs99"
adapted from a comment at
www.ScientificAmerican.com/Mind-and-Brain

BRAIN TRAINERS

We disagree with the conclusion Robert Goodier presents in "Brain Training's Unproven Hype" [Head Lines]. As professionals working in this area, we use personalized computer-based brain-training protocols to help children and adults improve targeted skills. The improvements transfer to other tasks and endure over time.

The story concludes with the message that exercise, a good diet and an active social life have brain benefits, but it is doubtful that software can improve on these standbys: "the evidence isn't in." As for this article? Frankly, we have our doubts. The evidence presented here is incomplete and unconvincing.

Rohn Kessler and Amy Price
Boca Raton, Fla.

JULIE FELTON *iStockphoto*

IMPERFECTIONS?

Emily Laber-Warren's article, "Can You Be Too Perfect?" contains a clear description of the nature of perfectionism and the ways in which it can bedevil the lives of those who experience it. Yet as a psychologist who has studied the issue for more than 30 years, I suggest that "healthy perfectionism" is a contradiction in terms—what we really need is a distinction between perfectionism and striving for excellence.

Perfectionism is about being perfect—not simply outstanding. The emotional problem for perfectionists is not

failure per se but rather the perceived meaning of failure: it implies a personal flaw. Perfectionism is a self-esteem issue; a common conviction for perfectionists is that "unless I am perfect, I am worthless." Perfection is imagined to be the road to personal acceptability. In contrast, many conscientious, positive, striving people have excellence and success as their goals, but they do not worry that imperfect performance is a sign of personal failing.

Perfectionists can have many positive qualities, none of which would disappear if we could magically eliminate their perfectionism. In counseling for this problem, a specific recovery process is launched with the aim of helping perfectionists feel more acceptable for who they are, not for what they do.

Thomas S. Greenspon
Minneapolis

I read with interest your article on perfectionism. I am an educated, degreed woman of 50 years, and I consider myself to be of above-average intelligence. I took the quiz knowing that I am a nonperfectionist. I have always been very content with that.

I was completely fine with the article until the author compared nonperfectionists to Homer Simpson. How insulting. I guess I should compare perfectionists to Frazier, or Sheldon in *The Big Bang Theory,* or Monk to be equally as insulting to the author, who must consider herself a "healthy perfectionist."

I believe everyone has some things that they "obsess" over. I like my gardens to be weed-free, but if they are not it is usually because I lack time to maintain them—and I can still sleep at night. I will try to make my drawings and paintings perfect. I love to sew and want my embroidery to look beautiful. My husband will spend hours on a presentation but not on a home maintenance project. My children both have things that they are "picky" about. I think "healthy" is being picky about the important things and letting the rest go.

Kathleen Stauffer
via e-mail

A MATTER OF WIRING

It is my view that the theory presented by Christof Koch in "A Theory of Consciousness" [Consciousness Redux] is incomplete science at best and philosophy at worst. Any study deserving to be considered science must be at least testable. My view is that the definition of integration as meaningful connections between pieces of data is arbitrary and requires more specifics to be scientific. The transistors inside a microprocessor may have a limited number of connections between the registers (memory locations), but software provides nearly unlimited possibilities for sorting the data. The same could also be said for the performance of the human mind, using the reasonable assumption that our brains are more or less constant between individuals and that it is our innovation and experience that count.

Dave Rauschenfels
Minneapolis

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EVOLVING TREATMENT

"Do ADHD Drugs Take a Toll on the Brain?" by Edmund S. Higgins, raises a question about the root causes of secondary symptoms or conditions in patients with ADHD.

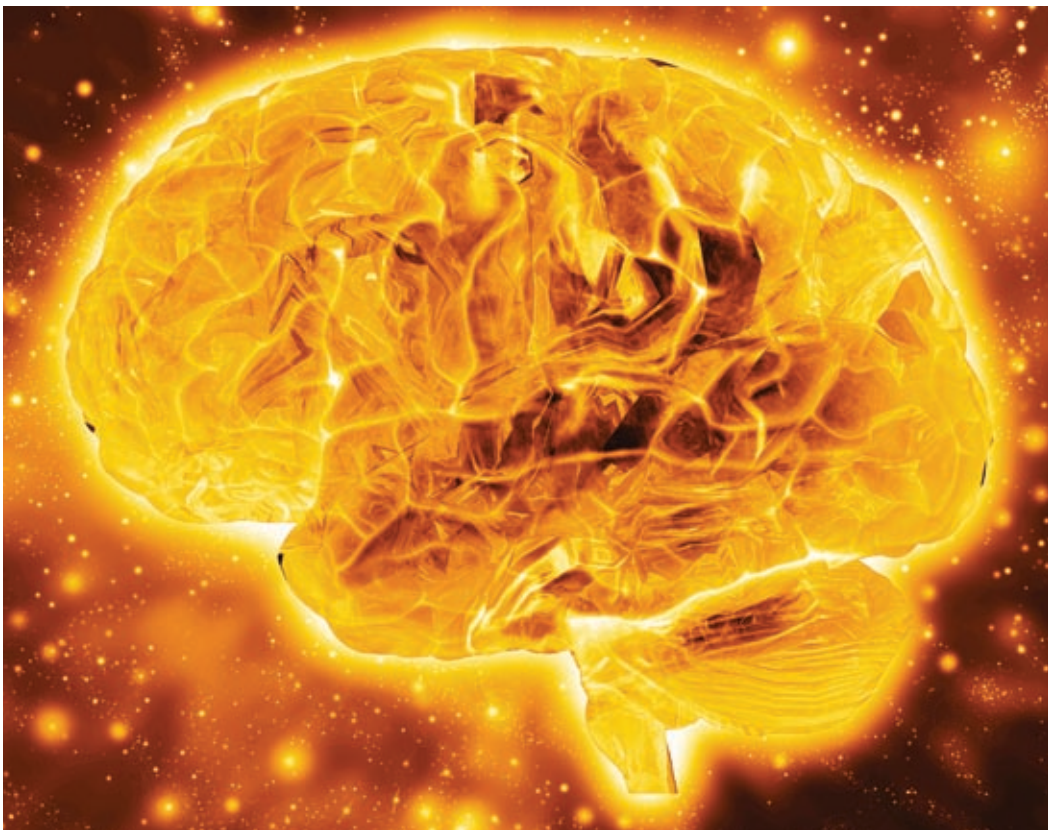
In my experience of more than 45 years as a psychologist, often working with ADHD individuals from preschoolers to senior citizens, I have observed cases in which patients develop anxieties and depressions as a result of a mismatch between their medical treatment and their developing brain. As they accumulate life experience or deal with short-term stressors, their medication regimen may need adjustment. Unfortunately, practitioners may see the anxiety or depression and treat it as a new problem, without exploring the underlying developmental causes that may be related to the primary ADHD.

Treatment of ADHD entails understanding its impact at all life stages. A child may fail a class, not do homework or drive unsafely, and exploration could reveal medications falling below therapeutically effective levels at such times. Once their treatment is "fine-tuned" to reflect these changes, the difficulties may resolve without adding another diagnosis or class of medications.

Teaching individuals self-monitoring and medication scheduling is imperative. We should be cautious about adding a second diagnosis to anyone with ADHD before current treatment has been evaluated from a developmental perspective.

Gust Jenson
Menomonie, Wis.

Head Lines



GETTY IMAGES

>> NEUROSCIENCE

Wide-Reaching Effects

The brain's plasticity is even greater than suspected

The idea that the adult brain changes with experience was once a radical idea, but it is now well accepted that certain areas—say, the motor cortex, when learning a new physical skill—can grow new neurons or create stronger connections.

Now scientists report that the brain is even more mutable than suspected. Thanks to an unconventional research technique, neuroscientists have found the first physical proof that new experiences and information have wide-ranging effects throughout both hemispheres of the brain, rather than just creating connections in one discrete area.

The story begins in the hippocampus, the area of the brain associated with short-term memory. In the past, researchers have electrically stimulated slices of disembodied hippocampus and seen how stimulation changes the structure of nearby neurons. But the new study took a different tack. Led by Santiago Canals, a biological cyberneticist currently at the Institute of Neurosciences in Alicante, Spain, the team set aside the dissected hippocampi in favor of a more true-to-life approach. After implanting electrodes in live rats, the group used a combination of functional MRI, electroencephalography (EEG) and micro-stimulation—triggering nerve cells with small doses of electric current—to trace in real time what happened to neuronal structures in the rats' brains when neurons in the hippocampus were stimulated. In contrast to studying the slices, this method allowed the scientists to see what happened in the hippocampus in context with what was going on all over the brain—like comparing a 2-D drawing of a bedroom with a 3-D rendering of the whole house.

"We have learned that what we call neuronal plasticity isn't exclusive to individual synapses or even the neurons where they contact but rather occurs throughout the functional network in which synapses and neurons are embedded," Canals says. "Those networks are absent in brain slices, so they couldn't be studied before."

By showing how activity in the hippocampus causes widespread changes in brain structure, Canals says the findings could explain why new memories are at first dependent on the hippocampus but can eventually be recalled without triggering that part of the brain at all.

—Maggie Koerth-Baker

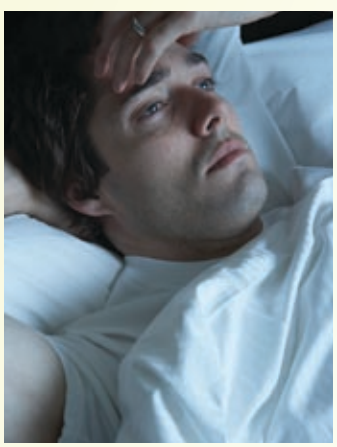
For Best Results, **Mix It Up**

Next time you want your group to really shine, try bringing in an outsider, says a study in the journal *Personality and Social Psychology Bulletin*. Researchers at Northwestern University found that having a newcomer does more than introduce fresh ideas; it actually fosters more thinking and better results, especially when the newcomer agrees with some—but not all—existing group members. "Having people who don't think the same way is good," says Northwestern psychologist Katherine W. Phillips, the study's lead author. "It is an uncomfortable situation, so you'll do a lot of hard work to understand the different perspectives." The findings reflect our natural tendency to try to maintain harmony within groups, Phillips says. *—Winnie Yu*

>> GENETICS

Related Disorders

Insomnia and depression may arise from common genes



Sleepless nights may be genetically linked to depression, according to new research from the University of Pennsylvania and Virginia Commonwealth University. In a study of twins, researchers found that genetically identical twins who suffered from insomnia were significantly more likely than nonidentical twins to also suffer from depression. The two disorders have been linked before, but the role of genetics has not been clear. The new study indicates that insomnia and depression have overlapping genes, and the next step is to pinpoint those genes through DNA analysis. Possible contenders are the genes related to the neurotransmitters serotonin and norepinephrine, which are involved in both the sleep-wake cycle and mood regulation. *—Monica Heger*

>> COGNITION

Mental Bottleneck

Our ability to multitask is limited by the prefrontal cortex

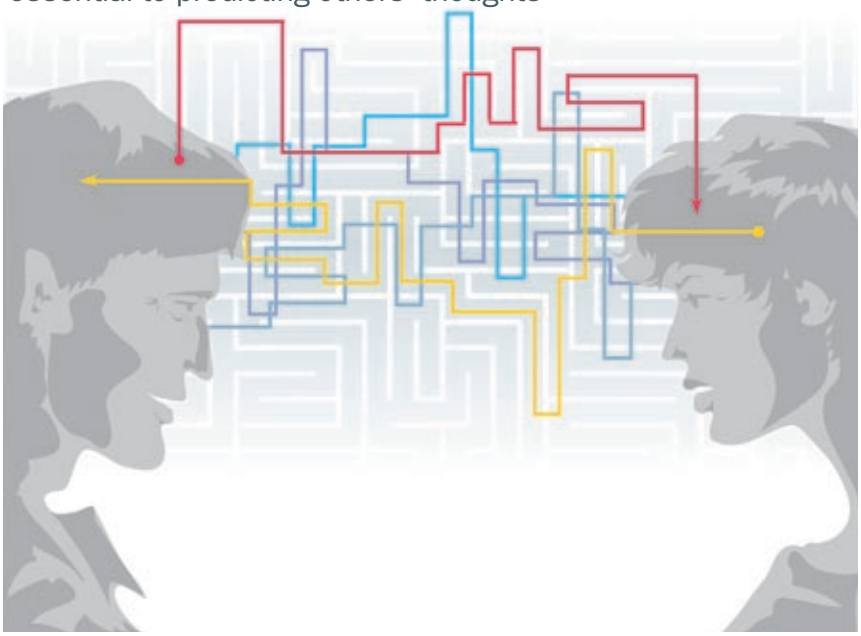
Next to the many amazing feats our brain pulls off daily, its inferior ability to juggle a few simple tasks sticks out like a sore thumb. Now research from Vanderbilt University suggests that these limits on multitasking arise from slow processing in the prefrontal cortex, the brain's central executive. Although the area has been known to be involved in multitasking, its exact role is a matter of debate.

Using functional MRI, the researchers found that when people were juggling two assignments, their prefrontal cortex appeared to deal with the tasks one by one—creating that familiar mental bottleneck—instead of processing them in parallel as do sensory and motor parts of the brain. With training the prefrontal activation time became shorter, cranking up the speed of the mental conveyor belt by about 10 times. Unfortunately, the researchers note, the benefits of training might not apply to tasks other than those specifically practiced. "It's not like you become able to multitask [with drills]; it's just that you become able to do each task very quickly," says cognitive neuroscientist Paul Dux, now at the University of Queensland in Australia, who conducted the experiment. *—Frederik Joelving*

>> COMMUNICATION

Reading Minds

Advanced language skills may be essential to predicting others' thoughts



What's this guy thinking? Does he know what I know? Most of us develop the ability to make inferences about what other people might be thinking, the hallmark of "theory of mind," at age four. Scientists have long known that the acquisition of language plays a role in this process, but so far it had been unclear whether social experience could substitute for it. A new study suggests it cannot.

Jennie Pyers of Wellesley College and her colleagues studied deaf adults in Nicaragua. Some of the participants had learned an early, rudimentary form of Nicaraguan sign language (NSL), whereas others were fluent in a more sophisticated form of NSL that included mental state terms, such as "know" and "think." Pyers and her team had all signers undergo a so-called false-belief test in which signers looked at a sequence of pictures showing two boys playing in a room and storing a toy underneath a bed. After one of the boys leaves the room, the other moves the toy to a different location. Study participants then had to choose between two pictures to complete the series: the first showed the returning boy looking for the toy in its original location on reentering the room, and the second showed him looking in its new location.

Those Nicaraguans with complex sign language skills were more likely to choose the first picture—indicating an understanding of false belief—than were those with less developed language skills. Moreover, after a two-year period during which early signers improved their NSL knowledge, they performed better at the false-belief task.

The findings support the hypothesis that although an implicit understanding of other people's knowledge and belief states develops early in life, advanced language is needed "to unlock the ability to productively use it," Pyers says. —*Nicole Branan*

VANDA GRIGOROVIC *iStockphoto*

>> LEARNING

Why Success Breeds Success

The brain may not learn from its mistakes after all

Have you ever bowled a string of strikes that seems like it came out of nowhere? There might be more to such streaks than pure luck, according to a study that offers new clues as to how the brain learns from positive and negative experiences.

Training monkeys on a two-choice visual task, researchers found that the animals' brains kept track of recent successes and failures. A correct answer had impressive effects: it improved neural processing and sent the monkeys' performance soaring in the next trial. But if a monkey made a mistake in one trial, even after mastering the task, it performed around chance level in the next trial—in other words, it was thrown off by mistakes instead of learning from them.

"Success has a much greater influence on the brain than failure," says Massachusetts Institute of Technology neuroscientist Earl Miller, who led the research. He believes the findings apply to many aspects of daily life in which failures are left unpunished but achievements are rewarded in one way or another—such as when your teammates cheer your strikes at the bowling lane. The pleasurable feeling that comes with the successes is brought about by a surge in the neurotransmitter dopamine. By telling brain cells when they have struck gold, the chemical apparently signals them to keep doing whatever they did that led to success. As for failures, Miller says, we might do well to pay more attention to them, consciously encouraging our brain to learn a little more from failure than it would by default.

—*Frederik Joelving*

GABE PALMER *Corbis*

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>> ENVIRONMENT

Pollution's Toll on the Brain

Breathing dirty air may have serious effects on cognition, in children and adults

Exercising on roads with heavy traffic may expose the brain to harmful levels of pollution.

JACK GESCHEIDT *Monsoon/Photolibrary/Corbis (jogger on city street);* AGE FOTOSTOCK *(doctor and patient)*

In these days of hybrid cars and carbon credits, it is common knowledge that substances exhaled by autos and coal plants are harmful to our respiratory system. What may be surprising is the degree to which they may harm the brain—in some instances, as much as exposure to lead. A recent string of studies from all over the world suggests that common air pollutants such as black carbon, particulate matter and ozone can negatively affect vocabulary, reaction times and even overall intelligence.

The most recent of these studies found that New York City five-year-olds who were exposed to higher levels of urban air pollutants known as polycyclic aromatic hydrocarbons (PAH) while in the womb exhibited an IQ four points lower than those subjected to less PAH. Alarmingly, "the drop was similar to that seen in exposure to low levels of lead," says epidemiologist Frederica Perera, director of the Columbia Center for Children's Environmental Health and head author of the study, in which mothers wore personal air monitors during their pregnancy. The IQ change was enough of a dip to affect school performance and scores on standardized tests.

"These weren't even superimpressively high levels of pollution," Perera says. "The levels we measured in our study are comparable to those in other urban areas." Most PAH pollutants come from motor vehicle emissions, especially diesel- and gas-powered cars and trucks, and from the burning of coal. (Tobacco smoke is another source, so the researchers did not enroll smokers in the study and corrected for secondhand smoke exposure.)

But children's growing brains are not the only ones affected by this dirty air. A 2008 study in 20- to 50-year-olds conducted jointly by the schools of public health at Harvard University and the University of North Carolina at Chapel Hill pinpointed ozone-related reductions in attention, short-term memory and reaction times equivalent to up to 3.5 to five years of age-related decline.

What's to be done about these brain-harming pollutants? "It's not a mystery how to reduce them—we need better policies on traffic congestion and technologies for alternative energy and energy efficiency," Perera says. Fortunately, there are also more immediate ways to reduce your exposure to the toxic chemicals, such as limiting outdoor physical activity on smoggy days. Ozone alerts and air-quality reports have become a routine part of the morning weather forecast and also appear on sites such as weather.com. "Depending on where you live, it becomes a good idea to pay attention to air quality before exercising outdoors," says Lisa Jackson, administrator of the U.S. Environmental Protection Agency. "There is also some benefit to dialing down the intensity if you can't avoid exercising outside—for example, walking instead of running."

Another smart move: avoid walking, running or bike riding on major streets with heavy bus, truck or car traffic whenever possible, Jackson says. Until emissions controls and other EPA policies begin to significantly impact the levels of traffic-related pollutants in the air around us, bathing our brains in as little of the stuff as possible may be our—and our children's—best bet. —*Sunny Sea Gold*

>> MEDICINE

Empathy Heals

Patients whose doctors show concern recover from colds faster

It feels good when someone pays attention to our concerns and our feelings—and it turns out such empathy is good for our health, too. Researchers at the University Wisconsin School of Medicine and Public Health report in *Family Medicine* that patients of doctors who expressed such concern had a cold for one day fewer than patients whose physicians focused on just the facts. In randomized controlled trials the colds of patients assigned to empathetic doctors lasted an average of seven days; those with low empathy docs endured an extra day of cold misery. The doctors' empathy also boosted the patients' immune systems. There was a direct relation between a physician's empathy level and his or her patient's level of IL-8, a chemical that summons immune system cells to fight microbial bad guys. —*Harvey Black*

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>> DEVELOPMENT

Risk-Taking Teens Have More Mature Brains

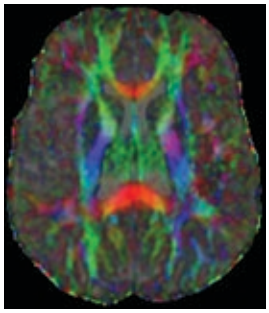
New research finds adultlike structure in the brains of wayward youths

We often hear that teens are irresponsible because their brains are immature. But, contradicting that idea, teen turmoil is completely absent in more than 100 cultures around the world [see "The Myth of the Teen Brain," by Robert Epstein; Scientific American Mind, April/May 2007]. Nevertheless, neuroscience studies do indeed suggest that the gray matter in the frontal cortex of teens, as compared with adults, is not fully developed.

Now a study by neuroscientist Gregory S. Berns and his colleagues at Emory University adds a new wrinkle to the gray matter findings, reporting that teens who are risk takers and drug users actually appear to have a more developed brain than their conservative peers.

The Berns team assessed the risk-taking tendencies of 91 teens between the ages of 12 and 18 with a written test and a drug test. Then, using a relatively new MRI technology called diffusion tensor imaging, the researchers looked at the amount of white matter in the frontal cortex of the teens' brains. White matter contains the protein myelin, which coats neurons' spindly axons as they reach toward other areas of the brain. Myelin is important for efficient signaling between neurons, and it is known to grow considerably between childhood and adulthood.

The investigators found that engaging in dangerous behaviors was associated with increased white matter, a result directly opposite to the gray matter findings. One possible interpretation: people whose brains mature early might be more prone to engage in adult activities. But Berns suggests that the entire teen brain idea might be overhyped. "Nobody denies that the brain develops or that teens take risks," he says, "but how the two observations got intertwined is beyond me."



COURTESY OF GREGORY S. BERNS *Emory University*

This image is an average of diffusion tensor imaging (DTI) scans from all participants in the study. It shows the brain's white matter tracts in a horizontal cross-section view (the eyes on this head would be at the top of the picture). The green lines show the core white matter tracts, with red and yellow portions indicating the parts of the tracts that correlate with risk-taking behavior.

Developmental psychologist Laurence Steinberg of Temple University questions the significance of the new study. Other researchers have found a connection between increased white matter and reduced impulsivity, Steinberg explains, which could mean a reduced likelihood of risk taking—the opposite of the Berns finding. Renowned neuroscientist Michael S. Gazzaniga of the University of California, Santa Barbara, is more impressed. "So much for the much touted model of the teenage brain," Gazzaniga says. "Back to the drawing boards again." —*Robert Epstein*

>> PSYCHOLOGY

Personal Training by Phone

Encouraging physical activity may be as simple as offering small rewards

The promise of a gold star can get grade school students to read more and even take on extra-credit projects. But encouraging positive behavior in adults is more complex, right? Not necessarily, according to recent studies of a mobile phone application called UbiFit. The program, designed by researchers at Intel Research Seattle and the University of Washington, taps into the psychology of motivation by offering seemingly insignificant rewards—graphics of flowers—that people end up striving to attain.

UbiFit gathers information from a small, wearable accelerometer to chart an individual's daily physical activity, tracking various kinds of motion with little input or logging required. Depending on the user's activity level, flowers of different sizes and colors begin to appear on his or her phone's background display. In a study conducted this past winter, participants with this "garden" feature from UbiFit had more success maintaining their fitness regimens over the holidays than those whose software simply tracked activity without offering rewards.

Lead researcher Sunny Consolvo, a computer scientist at Intel, read up on classic psychology theories before starting the project. Consolvo suspected that presenting the data in a simple and subtle way would be effective, but even she was surprised by how much the garden graphic seemed to motivate people. "It even worked on me," she recounts.

UbiFit is not yet available for purchase, but other devices exist that similarly use rewards and encouragement to tap into the psychology of motivation [see the review "Boost Your Motivation," by Melinda Wenner, on page 72].

—*Erica Westly*

UBFIT, A JOINT INTEL LABS SEATTLE AND UNIVERSITY OF WASHINGTON PROJECT

A phone with UbiFit starts out with a background that looks like a blank field (*top left*). When the person carrying the phone engages in physical activity, the phone's accelerometer senses the movement and flowers begin to appear (*bottom left*).

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>> HEALTH

Does D Make a Difference?

New studies show low vitamin D levels may impair cognitive function

The push to prevent skin cancer may have come with unintended consequences—impaired brain function because of a deficiency of vitamin D. The "sunshine vitamin" is synthesized in our skin when we are exposed to direct sunlight, but sunblock impedes this process. And although vitamin D is well known for promoting bone health and regulating vital calcium levels—hence its addition to milk—it does more than that. Scientists have now linked this fat-soluble nutrient's hormonelike activity to a number of functions throughout the body, including the workings of the brain.

"We know there are receptors for vitamin D throughout the central nervous system and in the hippocampus," said Robert J. Przybelski, a doctor and research scientist at the University of Wisconsin School of Medicine and Public Health. "We also know vitamin D activates and deactivates enzymes in the brain and the cerebrospinal fluid that are involved in neurotransmitter synthesis and nerve growth." In addition, animal and laboratory studies suggest vitamin D protects neurons and reduces inflammation.

Two new European studies looking at vitamin D and cognitive function have taken us one step further. The first study, led by neuroscientist David Llewellyn of the University of Cambridge, assessed vitamin D levels in more than 1,700 men and women from England, aged 65 or older. Subjects were divided into four groups based on vitamin D blood levels: severely deficient, deficient, insufficient (borderline) and optimum, then tested for cognitive function.

The scientists found that the lower the subjects' vitamin D levels, the more negatively impacted was their performance on a battery of mental tests. Compared with people with optimum vitamin D levels, those in the lowest quartile were more than twice as likely to be cognitively impaired.

A second study, led by scientists at the University of Manchester in England and published online this past May, looked at vitamin D levels and cognitive performance in more than 3,100 men aged 40 to 79 in eight different countries across Europe. The data show that those people with lower vitamin D levels exhibited slower information-processing speed. This correlation was particularly strong among men older than 60 years.

"The fact that this relationship was established in a large-scale, clinical human study is very important," Przybelski says, "but there's still a lot we don't know."

Although we now know that low levels of vitamin D are associated with cognitive impairment, we do not know if high or optimum levels will lessen cognitive losses. It is also unclear if giving vitamin D to those who lack it will help them regain some of these high-level functions.

Because cognitive impairment is often a precursor for dementia and Alzheimer's disease, vitamin D is a hot topic among Alzheimer's scientists, who are racing to answer these questions. Przybelski, for example, is planning a study of vitamin D supplements in healthy, normal elderly adults living in an assisted-living community to see if it will affect their incidence of Alzheimer's in the long term.

So how much is enough vitamin D? Experts say 1,000 to 2,000 IU daily—about the amount your body will synthesize from 15 to 30 minutes of sun exposure two to three times a week—is the ideal range for almost all healthy adults. Keep in mind, however, that skin color, where you live and how much skin you have exposed all affect how much vitamin D you can produce.

—Diane Welland

GETTY IMAGES

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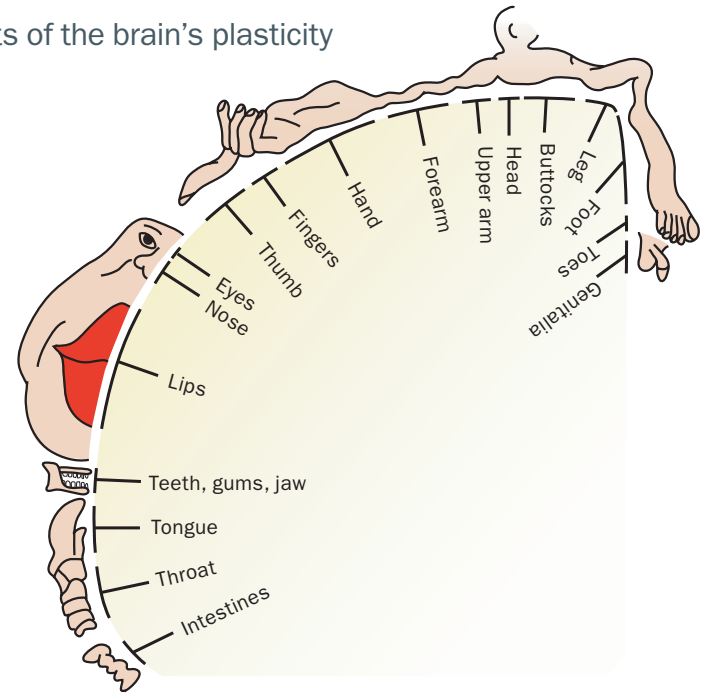
>> NEUROSCIENCE

Evolving Mental Maps

Researchers continue to probe the limits of the brain's plasticity

We all carry in our heads various mental representations of our body—one example is the well-known brain map of our sense of touch, sometimes called a homunculus (*right*). New studies show how such mental maps blur with age and readily extend to accommodate bionic limbs.



GEHIRN & GEIST/SIGANIM; SOURCE: PENFIELD AND RASMUSSEN, 1950

Blurred Bodies

As we age, our sense of touch becomes less accurate—some elderly people have a tough time reading Braille, for example. Looking for the roots of this sensory decline, German researchers at Ruhr University Bochum stumbled on a surprise: rather than shriveling up, the brain's sensory body map—which helps us discriminate Braille letters by determining where the raised bumps are in relation to one another—expands with age, exactly as it does during learning.

What could explain this paradox? The homunculus is made up of brain cells that represent our fingers, arms, and so on, loosely tracing a distorted human figurine along the cerebral cortex. In younger people the map stays sharp thanks to cells that dampen neural activity between areas representing different body parts. During aging, however, these cells presumably start to slack off; like an ink drawing that someone spills water on, the contours of the body map start to bleed. Luckily, studies show that a fuzzy old homunculus can be brought back into focus by stimulating the fingertips with a special apparatus, allowing at least some recovery of sensory precision.

Naturally Bionic

To the brain, electronic hardware is no different from flesh and blood, suggests a study at the University of California, Berkeley. In the experiment, monkeys learned to control a computer cursor—a stand-in for a bionic limb—through microelectrodes wiretapping their motor cortex. Although this feat is nothing new, the researchers showed for the first time that a stable memory of the new accessory had formed in the brain.

During normal development, a baby learns to control its limbs by creating a mental map of the movable parts of its body—a motor homunculus of sorts. The new finding parallels that process, says neuroscientist Jose Carmena, who led the study, "but it's about a prosthetic device, and that's what is profound about it. We're talking about an extension of your body's schema." In other words, once the brain-machine interface gets up to speed, our gray matter might already be set up to achieve effortless, plug-and-play-like control of electronic add-ons. —*Frederik Joelving*

>> LANGUAGE

Why the #$%! Do We Swear?

Expletives may not only be an expression of agony but also a means to alleviate it

Bad language could be good for you, a new study shows. For the first time, psychologists have found that swearing may serve an important function in relieving pain.

The study, published in the journal *NeuroReport*, measured how long college students could keep their hands immersed in cold water. During the exercise, they were told to repeat an expletive of their choice or to chant a neutral word. The 67 volunteers who cursed reported less pain and endured the iciness for about 40 seconds longer on average.

"Swearing is such a common response to pain that there has to be an underlying reason why we do it," says psychologist Richard Stephens of Keele University in England, who led the experiment. And indeed, the findings point to the possible benefit of pain reduction. "I would advise people, if they hurt themselves, to swear," Stephens adds.

One of the first clues that swearing is more than mere language came from a 1965 brain surgery performed at the Omaha Veterans Administration Hospital in Nebraska. To eradicate a growing tumor in a 48-year-old man, doctors split his brain in half—slicing through a thick bridge of nerve fibers—and removed his entire cancer-ridden left hemisphere. When the patient awoke, he found his ability to speak had been devastated. He could utter only a few, isolated words with great effort—hardly surprising because language relies largely on the left half of the cortex. But as he

>> INTELLIGENCE

Morning Sickness Tied to Smart Kids

Hormone levels link vomiting and intelligence

HEIDE BENSER *Corbis*

A new study shows a correlation between nausea and vomiting during pregnancy and the long-term neurocognitive development of those kids. Pediatric researcher Irena Nulman and her team at the Hospital for Sick Children in Toronto found that youngsters whose mothers suffered from morning sickness during pregnancy scored higher on some cognitive tests than did those whose mothers did not start their pregnant days throwing up. All children tested within the normal range, however.

One possible explanation could be differing hormone levels, Nulman says. According to one hypothesis, vomiting reduces caloric intake, decreasing insulin secretion. Low insulin, in turn, boosts levels of other hormones that are known to play a role in the development of a healthy placenta and a healthy blood supply to growing brains. *—Nicole Branan*

realized his verbal shortcomings, he let out a perfect string of curses.

Other findings have since confirmed that people with left-hemisphere injuries that ruin speech may nonetheless maintain a first-rate arsenal of profanities. Conversely, a stroke in certain areas buried deep in the right hemisphere usually spares normal language but may leave the afflicted person unable to use meaningful swearwords. Although the details are murky, bad language seems to hinge on evolutionarily ancient brain circuitry with intimate ties to structures that process emotions.

ISTOCKPHOTO

One such structure is the amygdala, an almond-shaped group of neurons that can trigger a fight-or-flight response in which our heart rate climbs and we become less sensitive to pain. Indeed, the Keele students' heart rates rose when they swore, a finding Stephens says suggests that the amygdala was activated.

That explanation is backed by other experts in the field. Psychologist Steven Pinker of Harvard University, whose book *The Stuff of Thought* (Penguin, 2008) includes a detailed analysis of swearing, compared the situation with what happens in the brain of a cat that somebody accidentally sits on. "I suspect that swearing taps into a defensive reflex in which an animal that is suddenly injured or confined erupts in a furious struggle, accompanied by an angry vocalization, to startle and intimidate an attacker," Pinker says.

But cursing is more than just aggression, explains Timothy Jay, a psychologist at the Massachusetts College of Liberal Arts who has studied our use of profanities for the past 35 years. "It allows us to vent or express anger, joy, surprise, happiness," Jay remarks. "It's like the horn on your car—you can do a lot of things with it. It's built into you."

There is a catch, though: the more we swear, the less emotionally potent the words become, Stephens cautions. And without emotion, all that is left of a swearword is the word itself, unlikely to soothe anyone's pain. *—Frederik Joelving*

Dangerous Liaisons

The damaging theatrics of drama queens may spring from defects etched in the brain. Yet you can limit the havoc they wreak on your life BY OPHELIA AUSTIN-SMALL

BETSIE VAN DER MEER *Getty Images*

SAM PAGED ME at 9 P.M., crying. It had started with his hair, which he was convinced was falling out. And although his work as a teacher's aide had "filled him with love and joy," he was sure his boss had given him a nasty look at the lunch break, and he felt utterly sick inside. Later Sam had phoned his partner, who had seemed distant. Afraid he was about to be dumped, Sam locked himself in the staff bathroom and cried for almost an hour, failing to finish his work and preventing others from using the facilities.

Sam is a drama queen—a person who reacts to everyday events with excessive emotion and behaves in theatrical, attention-grabbing ways. This type is the friend who derails a casual lunch to tell you a two-hour story about the devastating fight she had with her partner or the coworker who constantly obsesses about how he is about to lose his job and needs your support to make it through the day. The drama queen worships you one minute and despises you the next, based on overreactions to minor events.

Living or working with drama queens can be draining and disturbing. Such a colleague can curtail your own productivity at the office or even shut down teams as everyone tries to contain the chaos. If you live with a drama queen, you may be bombarded daily with accusations and showy attempts to apologize, leaving you feeling angry, guilty and exhausted. Some drama queens are violent toward others, cut themselves or threaten suicide. The extreme behavior can lead to depression or anxiety in family members and colleagues.

Scientists have begun to understand some of the causes of these destructive traits, which are difficult to change without professional help. At the extreme end of the spectrum, if this behavior pervades most areas of a person's life, he or she may be diagnosed with a personality disorder. Individuals with borderline personality disorder (BPD), for example, are extremely volatile and impulsive and have wildly tumultuous relationships; those with histrionic personality disorder are highly emotional and attention seeking, with an excessive need for approval. Nevertheless, if you are in a relationship with, or otherwise connected to, a drama queen, a few simple tactics can help you avoid being sucked into his or her spinning world of emotion [*see box on opposite page*].

Some drama queens may have **weaker brain circuitry** for inhibiting inappropriate reactions to negative emotions.

Trauma to Drama

What drives the drama? Childhood trauma might be a trigger in some cases. Psychiatrist Bruce Perry of the Child-Trauma Academy in Houston has found that children who experience trauma—from abuse to natural disasters—undergo changes in brain chemistry affecting regions that make them moody, oversensitive to stimulation, and unable to accurately assess certain social and environmental cues.

Childhood neglect could also be a factor, experts in the field believe. If parents or guardians habitually ignore, discount or dismiss a child's thoughts, feelings and experiences, the child may decide that dramatic presentations—from dressing provocatively to telling stories of wild adventures or crises—are necessary to get attention.

Genes could contribute as well. Excessive behavior runs in families, according to a 2004 study led by psychiatrist John Gunderson of Harvard Medical School. Gunderson's team found that 27 percent of the relatives of BPD patients displayed aspects of the disorder's problematic relationship style as compared with just 17 percent of the relatives of people with other personality disorders. Shared environmental factors—say, particular parenting practices that a child learns—could play a role in this pattern, although Gunderson theorizes that as yet undiscovered genetic variations may also predispose some family members to difficulties with attachment and mood regulation.

Altered Circuitry

Whatever the roots of their personality, the brains of drama queens seem to be constructed differently from those of calmer people. In 2007 psychiatrist Emily Stern and her colleagues at Weill Cornell Medical College used functional magnetic resonance imaging to measure the brain activity of 14 healthy individuals and 16 people with BPD while they performed a task that required reacting to negative, positive and neutral words. The BPD patients displayed diminished activity in part of the brain's prefrontal cortex that controls planning and emotional reactions when they had to inhibit a response—in this case, pressing a button—to a negative word.

Thus, seriously afflicted drama queens seem to have weaker circuitry for inhibiting inappropriate reactions to negative emotions, making it difficult for them to stop themselves from acting out. Drama queens may also have more intense emotions: the amygdala, an area of the brain that processes feelings, was hyperactive in the BPD patients in the Cornell study.

The results of such faulty wiring leave a trail of distress. The volatility gets in the way of efficiency and congeniality at work and prevents stable, happy relationships at home. Dealing with such people can be difficult, although accepting the theatrics as ingrained in the brain, among other strategies, may help you distance yourself from them and temper the consequences. M

OPHELIA AUSTIN-SMALL is a mental health therapist specializing in personality and mood disorders. She is author of *Surprise Motherhood: A Guide to Unexpected Adult Pregnancy* (Lulu.com, 2007).

Defusing the Drama

Handling a drama queen requires planning, composure and tact. Here are some tips.

» **Set boundaries.** Set limits on the length of the interaction and on what you are willing to discuss. Spell out your constraints to the drama queen. In person, say, for example, "Jane, you can visit my desk to chat only at lunch." On the phone, begin a conversation with "I have only 15 minutes to talk."

» **Be consistent.** Do not break your rules by extending a conversation, spreading gossip or inviting the drama queen to dinner. Such lapses suggest that "no" sometimes means "yes" and can encourage his or her pushy behavior. If you agree to a meeting, however, keep your promise. Being unreliable creates more drama.

» **Stay calm.** Avoid reacting dramatically yourself. Using adjectives such as "livid," "perfect" or "tragic" tends to amplify the emotion.

» **Validate, then redirect.** Some people like to talk through a situation, but such analysis only intensifies emotions for drama queens. Acknowledge their problem, then help him or her focus on positive events or, better yet, on what the person can do to improve his or her lot. Say, for example, "Well, of course you are upset, but what's a better way to handle this?"

» **Create a paper trail.** If the drama disrupts your workplace, document every troublesome interaction, noting the date, time and nature of the encounter. At some point, you may want to inform human resources of the problem.

» **Consider cutting ties.** If the relationship becomes toxic despite your efforts, you may need to get out of it, even if doing so means finding another job or separating from your spouse. You may want to visit a counselor to understand how the relationship is affecting you and whether there is value in continuing it.

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GETTY IMAGES

The Will to Power

Neurosurgeons evoke an intention to act

BY CHRISTOF KOCH

What parts of the brain generate the feelings that arise within us whenever we take a decision?

SURELY THERE MUST have been times in high school or college when you laid in bed, late at night, and wondered where your "free will" came from? What part of the brain—if it is the brain—is responsible for deciding to act one way or another? One traditional answer is that this is not the job of the brain at all but rather of the soul. Hovering above the brain like Casper the Friendly Ghost, the soul freely perturbs the networks of the brain, thereby triggering the neural activity that will ultimately lead to behavior.

Although such dualistic accounts are emotionally reassuring and intuitively satisfying, they break down as soon as one digs a bit deeper. How can this ghost, made out of some kind of metaphysical ectoplasm, influence brain matter without being detected? What sort of laws does Casper follow? Science has abandoned strong dualistic explanations in favor of natural accounts that assign causes and responsibility to specific actors and mechanisms that can be further studied. And so it is with the notion of the will.

Sensation and Action

Over the past decade psychologists such as Daniel M. Wegner of Harvard University amassed experimental evidence for a number of conscious sensations that accompany any willful action. The two most important are intention and agency. Prior to voluntary behavior lies a conscious intention. When you decide to lift your hand, this intention is followed by planning of the detailed movement and its execution. Subjectively, you experience a sensation of agency. You feel that you, not the person next to you, initiated this action and saw it through. If a friend were to take your hand and pull it above your head, you would feel your arm being dragged up, but you would not feel any sense of being responsible for it. The important insight here is that the consciously experienced feelings of intention and agency are no different, in principle, from any other consciously experienced sensations, such as the briny taste of chicken soup or the red color of a Ferrari.

And as a plethora of books on visual illusions illustrate, often our senses can be fooled—we see something that is not there. So it is with the sensation of intentionality and agency. Decades of psychology experiments—as well as careful observation of human nature that comes from a lifetime of living—reveal many instances where we think we caused something to happen, although we bear no responsibility for it; the converse also occurs, where we did do something but feel that something or somebody else must have been responsible. Think about the CEO of a company who takes credit—and bonuses worth many millions—if the stock market price of his company rises but who blames anonymous market forces when it tanks. It is a general human failing to overestimate the import of our own actions when things go well for us.

Lest there by any misunderstanding: the sensations of the intention to act and of agency do not speak to the metaphysical debate about whether will is truly free and whether that even is a meaningful statement. Whether free will has some ontological reality or is entirely an illusion, as asserted forcefully by Wegner's masterful monograph, does not invalidate the observation that voluntary

CHRISTOF KOCH (*Koch*); TIM McGUIRE *Corbis* (*man at crossroads*)

The consciously experienced feelings of intention and agency are **no different** from other feelings.

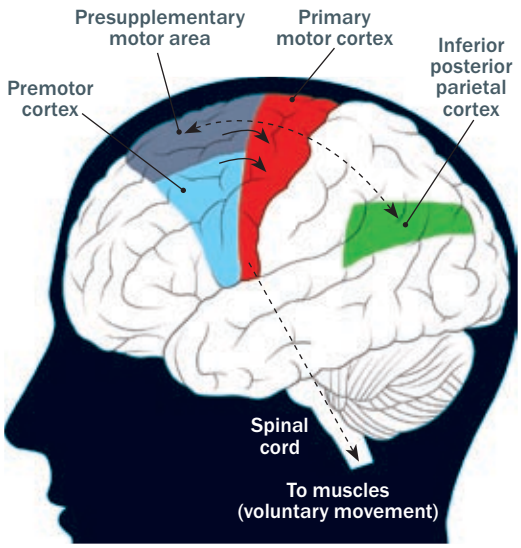
actions are usually accompanied by subjective, ephemeral feelings that are nonetheless as real as anything else to the person who experiences them.

Telling Clues from Surgeries

The quiddity of these sensations has been strengthened considerably by neurosurgeons. During certain types of brain surgery, neural tissue must be removed, either because it is tumorous or because it gives rise to epileptic seizures. How much tissue to remove is a balancing act between the Scylla of leaving remnants of cancerous or seizure-prone material and the Charybdis of removing regions that are critical for speech or other near-essential operations. To probe the function of nearby tissue, the neurosurgeon stimulates it with an electrode that passes pulses of current while the patient—who is awake and under local anesthesia to minimize discomfort—is asked to touch each finger successively with the thumb, count backwards or do some other simple task.

During the course of such explorations in 1991, neurosurgeon Itzhak Fried, now at the University of California, Los Angeles, and his colleagues stimulated the presupplementary motor area, part of the vast expanse of cerebral cortex that lies in front of the primary motor cortex. Activation of different parts of the motor cortex usually triggers movements in different parts on the opposite side of the body, for example, the foot, leg, hip, and so on. The medical team discovered that electrical stimulation of this adjacent region of cortex can, on occasion, give rise to an urge to move a limb. The patient reports that he or she feels a need to move the leg, elbow or arm.

This classical account was elaborated on by a recent study from Michel Desmurget and his colleagues at the Center for Cognitive Neuroscience in Bron, France, that was published in the international journal *Science*. Here it was electrical stimulation of the posterior parietal cortex, gray matter involved in the transformation of visual information into motor commands—as when your eyes scan the scene in front of you and come to rest on the movie marquee—that could produce pure intentions to act. Patients made comments (in French) such as "It felt like I wanted to move my foot. Not sure how to explain," "I had a desire to move my right hand," or "I had a desire to roll my tongue in my mouth." In none of these cases did they actually carry out the movement to which they referred. But the external stimulation caused an unambiguous conscious feeling of wanting to move. And this feeling arose from within, without any prompting by the examiner and not during sham stimulation.



Brain areas involved in the feelings associated with voluntary action include premotor and parietal cortices.

This was different from the cortical sector explored by the earlier Fried study. One difference between the two stimulated regions was that, at higher current levels, the patient actually moved the limb when the target site was the presupplementary motor area. Parietal stimulation, on the other hand, could trigger a sensation that actual movement had occurred, yet without any motion actually occurring (illusion of movement).

The take-home lesson is that the brain has specific cortical circuits that, when triggered, are associated with sensations that arise in the course of wanting to initiate and then carry out a voluntary action. Once these circuits are delimited and their molecular and synaptic signatures identified, they constitute the neuronal correlates of consciousness for intention and agency. If these circuits are destroyed by a stroke or some other calamity, the patient might act without feeling that it is she who is willing the acting!

In the debate concerning the meaning of personal freedom, these discoveries represent true progress, beyond the eternal metaphysical question of free will that will never be answered. M

CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology. He serves on *Scientific American Mind*'s board of advisers.

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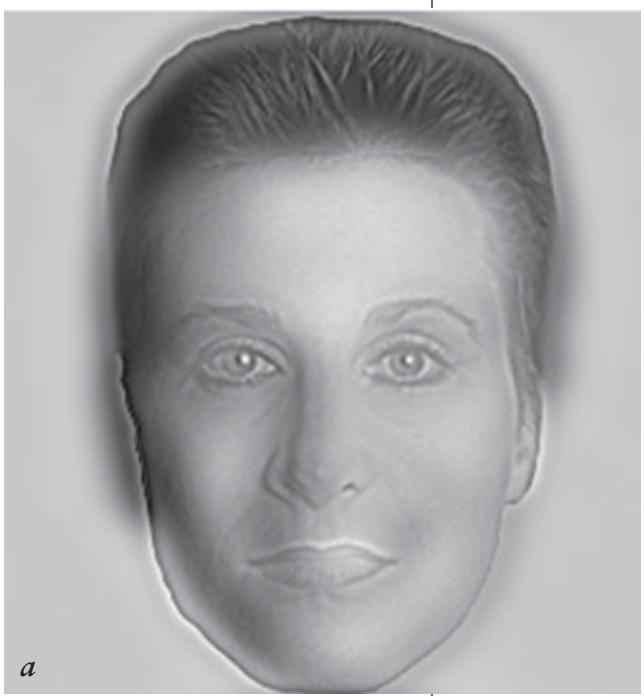
Cracking the da Vinci Code

What do the *Mona Lisa* and President Abraham Lincoln have in common?

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN



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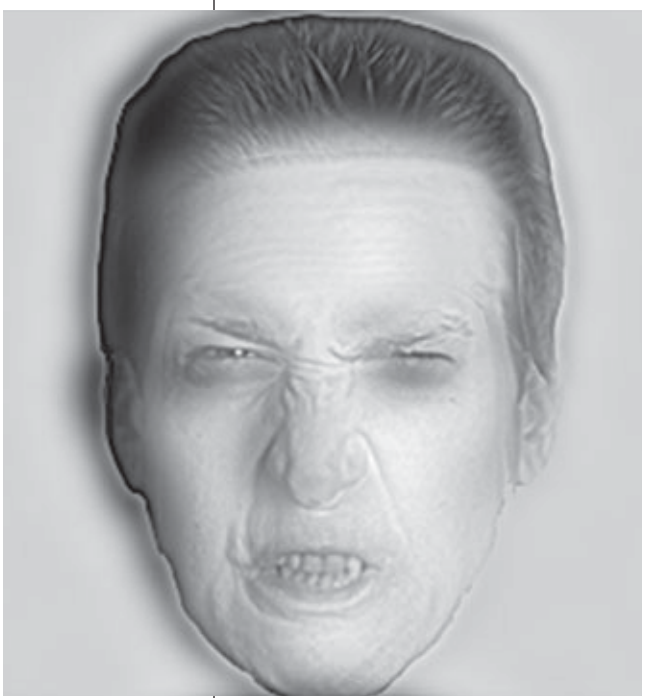


SPANISH PAINTER EL GRECO often depicted elongated human figures and objects in his work. Some art historians have suggested that he might have been astigmatic—that is, his eyes' corneas or lenses may have been more curved horizontally than vertically, causing the image on the retina at the back of the eye to be stretched vertically. But surely this idea is absurd. If it were true, then we should all be drawing the world upside down, because the retinal image is upside down! (The lens flips the incoming image, and the brain interprets the image on the retina as being right-side up.) The fallacy arises from the flawed reasoning that we literally "see" a picture on the retina, as if we were scanning it with some inner eye.

No such inner eye exists. We need to think, instead, of innumerable visual mechanisms that extract information from the image in parallel and process it stage by stage, before their activity culminates in perceptual experience. As always, we will use some striking illusions to help illuminate the workings of the brain in this processing.

Angry and Calm

Compare the two faces shown in *a*. If you hold the page about nine to 12 inches away, you will see that the face on the right is frowning and the one on the left has a placid expression.

But if you move the figure, so that it is about six or eight feet away, the expressions change. The left one now smiles, and the right one looks calm.

How is this switch possible? It seems almost magical. To help you understand it, we need to explain how the images were constructed by Philippe G. Schyns of the University of Glasgow and Aude Oliva of the Massachusetts Institute of Technology.

A normal portrait (photographic or painted) contains variations in what neuroscientists such as ourselves term "spatial frequency." We will discuss two types of spatial frequency: The first is "high"—with sharp, fine lines or details present in the picture. The second is "low"—conveyed by blurred edges or large objects. (In fact, most images contain a spectrum of frequencies ranging from high to low, in varying ratios and

Up close, one face frowns and the other looks calm. Viewed from farther away, **the two faces change**. How?

PHILIPPE G. SCHYNS *University of Glasgow* AND AUDE OLIVA *Massachusetts Institute of Technology*, ADAPTED FROM "DR. ANGRY AND MR. SMILE: WHEN CATEGORIZATION FLEXIBLY MODIFIES THE PERCEPTION OF FACES IN RAPID VISUAL PRESENTATIONS," BY P. G. SCHYNS AND A. OLIVA IN *COGNITION*, VOL. 69, NO. 3; 1999

Squint, and the image blurs, eliminating the sharp edges. **Presto!** Lincoln becomes instantly recognizable.

contrasts, but that is not important for the purposes of this column.)

Using computer algorithms, we can process a normal portrait to remove either high or low spatial frequencies. For instance, if we remove high frequencies, we get a blurred image that is said to contain "low spatial frequencies in the Fourier space." (This mathematical description need not concern us further here.) In other words, this procedure of blurring is called low-pass filtering, because it filters out the high spatial frequencies (sharp edges or fine lines) and lets through only low frequencies. High-pass filtering, the opposite procedure, retains sharp edges and outlines but removes large-scale variations. The result looks a bit like an outline drawing without shading.

These types of computer-processed images are combined together, in an atypical manner, to create the mysterious faces shown in *a*. The researchers began with normal photographs of three faces: one calm, one angry and one smiling. They filtered each face to obtain both high-pass (containing sharp, fine lines) and low-pass (blurred, so as to capture large-scale luminance variations) images. They then combined the high-pass calm face with the low-pass smiling face to obtain the left image. For the right image, they overlaid the high-pass frowning face with the low-pass calm face.

What happens when the figures are viewed close-up? And why do the expressions change when you move the page away? To answer these questions, we need to tell you two more things about visual processing. First, the image needs to be close for you to see the sharp features. Second, sharp features, when visible, "mask"—or deflect attention away from—the large-scale objects (low spatial frequencies).

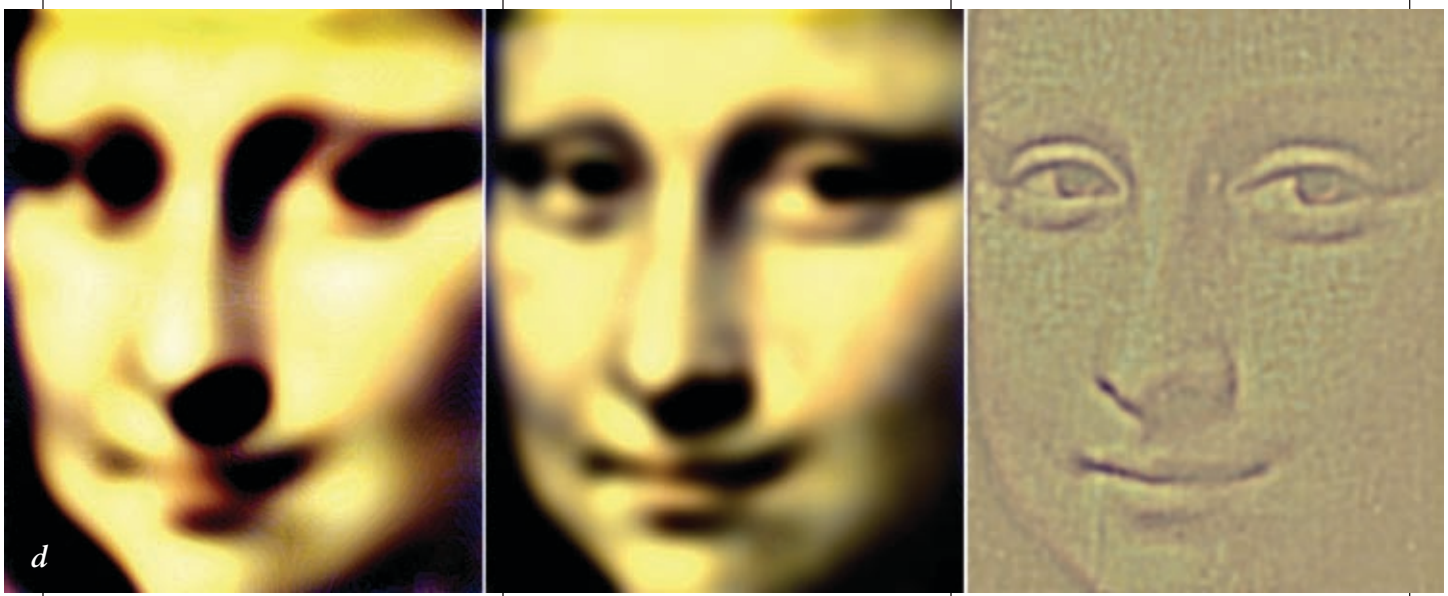
So when you bring the picture near, the sharp features become more visible, masking the coarse features. As a result, the face on the right looks like it is frowning and the one on the left, like it is relaxed. You simply do not notice the opposite emotions that the low spatial frequencies convey. Then, when you move the page farther away, your visual system is no longer able to resolve the fine details. So the expression conveyed by these fine features disappears, and the expression conveyed by low frequencies is unmasked and perceived.

The experiment shows vividly an idea originally postulated by Fergus Campbell and John Robson of the University of Cambridge: information from different spatial scales is extracted in parallel by various neural channels, which have wide ranges of receptive field sizes. (The receptive field of a visual neuron is the part of the visual field and corresponding tiny patch of retina to which a stimulus needs to be presented to activate it.) It also shows that the channels do not work in isolation from one another. Rather they interact in interesting ways (for example, the sharp edges picked up by small receptive fields mask the blurred large-scale variations signaled by large receptive fields).

Honest Abe

Experiments of this kind go back to the early 1960s, when Leon Harmon, then working at Bell Laboratories, devised the famous Abraham Lincoln effect. Harmon produced the picture of Honest Abe (*b*) by taking a regular picture and digitizing it into coarse pixels (picture elements). Even when viewed close-up, there is enough information in the blocky brightness variations to recognize Lincoln. But these data, as we noted

The **elusive smile** can be seen only when you look away from the mouth. Attend to it out of the corner of your eye.



already, are masked by the sharp edges of the pixels. When you move far away from the photograph or squint, the image blurs, eliminating the sharp edges. Presto! Lincoln becomes instantly recognizable. The great artist Salvador Dalí was sufficiently inspired by this illusion to use it as a basis for his paintings, an unusual juxtaposition of art and science (*c*).

Mysterious *Mona Lisa*

Finally, consider the mysterious smile of Leonardo da Vinci's *Mona Lisa*. Philosophers and art historians who specialize in aesthetics often refer to her expression as "enigmatic" or "elusive," mainly because they do not understand it. Indeed, we wonder whether they prefer not to understand it, because they seem to resent any attempts to explain it scientifically, apparently for fear that such analysis might detract from its beauty.

But recently neurobiologist Margaret Livingstone of Harvard Medical School made an intriguing observation; she cracked the da Vinci code, you might say. She noticed that when she looked directly at Mona Lisa's mouth (*d*, *center panel*), the smile was not apparent (quite a disappointment). Yet as she moved her gaze away from the mouth, the smile appeared, beckoning her eyes back. Looking again at the mouth, she saw that the smile disappeared again. In fact, she noted, the elusive smile can be seen only when you look away from the mouth. You have to attend to it out of the corner of your eye, rather than fixating on it directly. Because of the unique shading (placement of low spatial frequencies) at the corners of the mouth, a smile is perceived only when the low spatial frequencies are dominant—that is, when you look indirectly at the masterpiece.

To confirm this notion, she performed a low-pass filtering (*left panel*) and a high-pass filtering (*right panel*) of the *Mona Lisa*. Notice that with the low-pass (blurred) image the smile is more obvious than in the original—it can be seen even if you look directly at the mouth. With the high-pass (outlinelike) image, however, no smile is apparent, even if you look away from the mouth. Putting these two images back together restores the original masterpiece and the elusive nature of the smile. As with the changing faces, we can now better appreciate what Leonardo seems to have stumbled on and fallen in love with—a portrait that seems alive because its fleeting expression (thanks to quirks of our visual system) perpetually tantalizes the viewer.

Taken collectively, these experiments show that there is more to perception than what meets the eye. More specifically, they demonstrate that information at different scales, such as fine versus coarse, may be extracted initially from an image by separate neural channels and recombined at different stages of processing to create the final impression of a single unified picture in your mind. **M**

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. This column is reprinted from an earlier issue of *Scientific American Mind*.

MARGARET LIVINGSTONE *Harvard Medical School*

(Further Reading)

◆ **Dr. Angry and Mr. Smile: When Categorization Flexibly Modifies the Perception of Faces in Rapid Visual Presentations.** Philippe G. Schyns and Aude Oliva in *Cognition*, Vol. 69, No. 3, pages 243–265; 1999.

(calendar)

November

Dementia, you thief
Leaving so little behind
All is forgotten.

1 This haiku-style poem by Max Natick was a winning entry from last year's *Neuroscience for Kids Poetry Contest,* for ages five to 17. Winners from 2008 wrote haikus, limericks and rhyming poems about the brain—how it works and what happens when it's impaired. Contest entries are accepted through February 1, 2010, and prizes include educational neuroscience books and games.
U.S.
http://faculty.washington.edu/chudler/contest89.html

2–5 Pathological gambling, sex and shopping are a few of the headlining topics that will be discussed at the four-day **U.S. Psychiatric and Mental Health Congress.** Physicians will come together to learn about cutting-edge research in these fields and about mental health issues, including depression, bipolar disorder and schizophrenia.
Las Vegas
www.cmellc.com/psychcongress

4 Sigmund Freud, the famous Austrian neurologist and founder of psychoanalysis, first published his book ***Interpretation of Dreams*** on this day in 1899. Although many of Freud's ideas have since been modified or rejected, researchers in the emerging field of neuropsychoanalysis have started to argue in favor of his theories, pointing out brain structures relating to Freudian concepts such as libido, the unconscious, and repressed desire.

19–22 How do you cope with unemployment? What can you do to worry less before bedtime and sleep better? Experts will tackle these questions and more at the 43rd annual convention of the **Association for Behavioral and Cognitive Therapies,** with the goal of improving treatment and prevention methods for depression and anxiety disorders.
New York City
www.abct.org

Through December

Alzheimer's disease affects five million Americans—and the number is growing. Remember loved ones lost and raise money for a cure by joining a Memory Walk, just one of the many fund-raising and educational events taking place in cities all over the country during the months around **National Alzheimer's Disease Awareness Month** (which is November, but events continue until the end of the year).
U.S.
www.alz.org

December

10–12 To what extent are our mental processes hardwired into the brain? And how does that brain produce individuality? These are two of the intriguing questions psychologists will address in the **Mini-School of Neuroscience,** hosted by the Neuroinsight Foundation for Brain Research Initiatives. The intensive course is open to the public, with a curriculum based on Eric R. Kandel, James H. Schwartz and Thomas M. Jessell's book *Principles of Neural Science.*
Alexandria, Egypt
http://neurosci.med2009.googlepages.com/mini-schoolofneuroscience

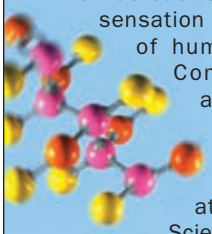
Brain and **Body**

Several museum exhibits, aimed at children but fun for adults, explore the science of what makes us human.

Through December

Although we may look different, human beings are more genetically similar to one another than the members of any other living species are. In fact, no single gene or group of genes supports the idea of race. At the California Science Center, the new exhibit **RACE: Are We So Different?** explores the biology of race as well as our personal and cultural experience of it. Hands-on activities, including a three-dimensional computer-animated video of our genes, encourage guests to challenge and discuss their thoughts on the controversial topic. The exhibit is scheduled to tour the U.S. through the end of 2012.
Los Angeles
www.understandingrace.org

Permanent



How do odor chemicals trigger the sensation of smell in the brain of humans and animals? Computer simulations and hands-on displays allow visitors to **Marvelous Molecules—The Secret of Life** at the New York Hall of Science to peek inside the molecular structure of living things to see how chemicals affect the brain and how DNA passes on genetic traits. Marvelous Molecules is one of the first ever interactive exhibits to explore such questions about human chemistry.
New York City
www.nyhallsci.org/marvelousmolecules

Ongoing

Challenge your mind by solving a medical mystery. Learn how to diagnose patients with different infectious diseases and also explore how illnesses spread and how our body fends them off. **The Cell Lab at the Science Museum of Minnesota** allows kids from kindergarten to 12th grade to play science detectives while introducing them to human physiology, genetics and cell biology.
St. Paul, Minn.
www.smm.org/visit/humanbody

MIKE AGLIOLO *Photo Researchers, Inc. (illustration of brain and clouds);* GEORGE MATTEI *Photo Researchers, Inc. (x-ray of skull);* DAVID MACK *Photo Researchers, Inc. (glucose molecular model)*

Compiled by Frederik Joelving and Victoria Stern. Send items to editors@SciAmMind.com

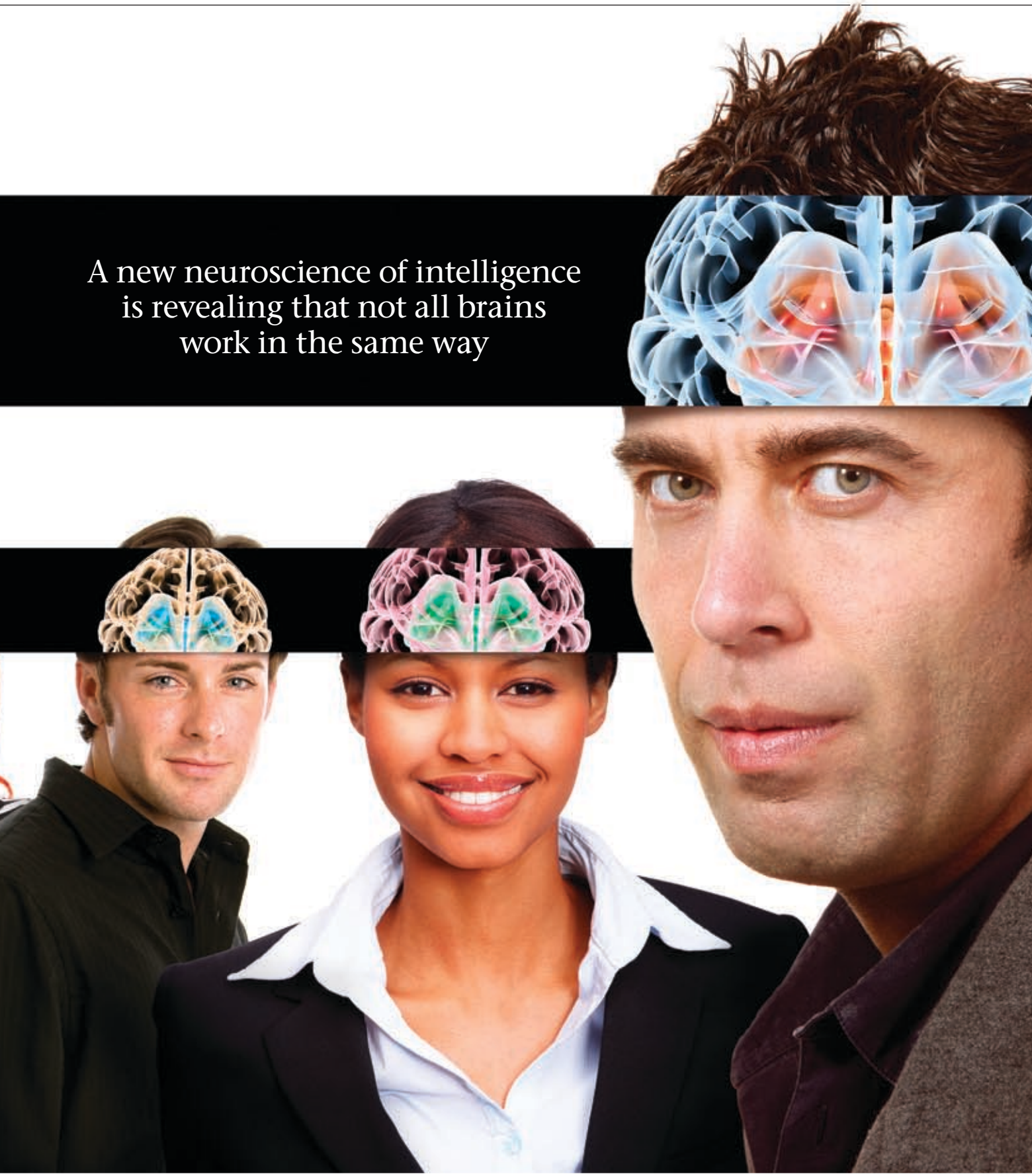
What Does a Smart Brain Look Like?

By Richard J. Haier

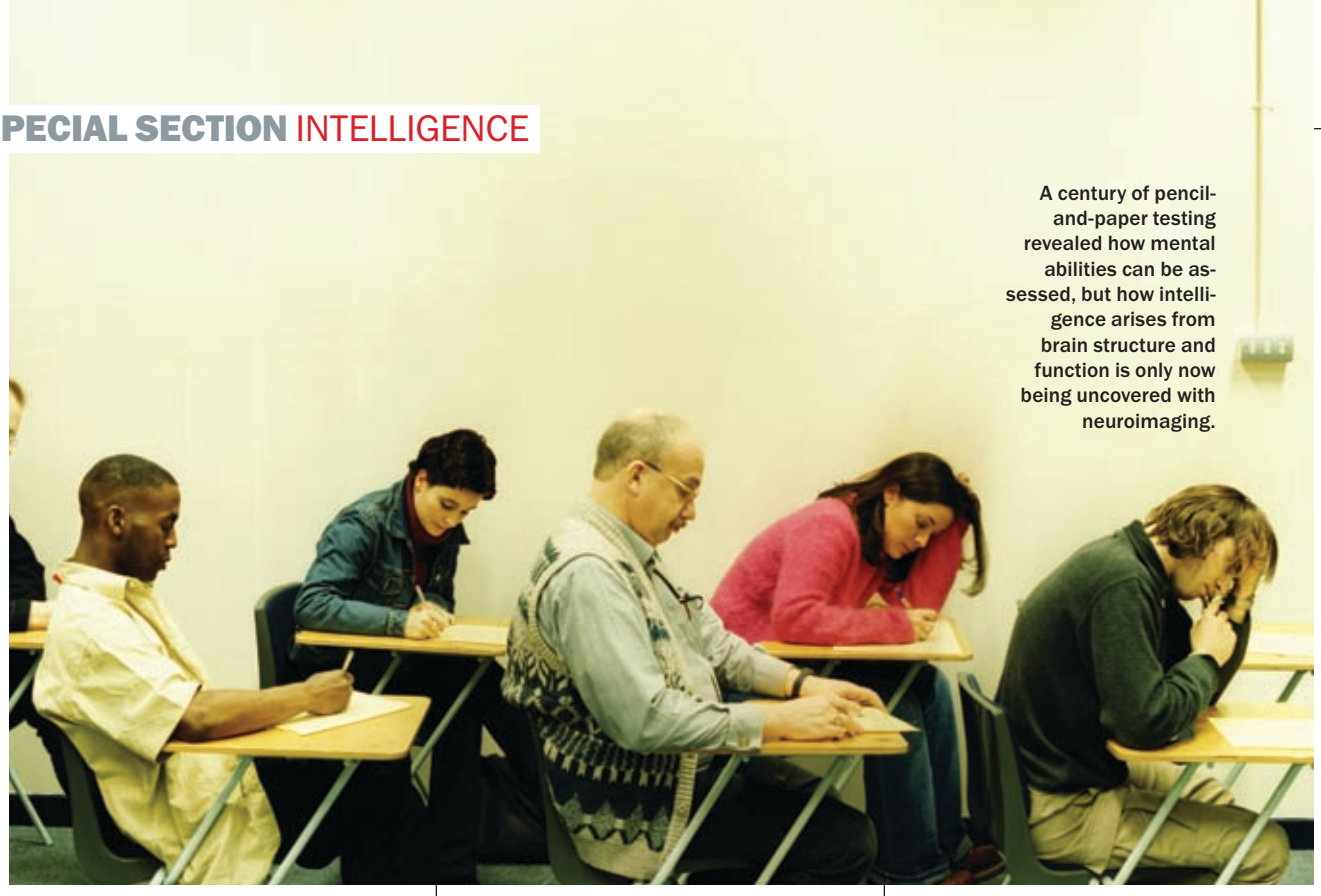
AARON GOODMAN (*photoillustration*); PASIEKA/SPL/PHOTO RESEARCHERS, INC. (*brain images*)

We all know someone who is not as smart as we are—and someone who is smarter. At the same time, we all know people who are better or worse than we are in a particular area or task, say, remembering facts or performing rapid mental math calculations. These variations in abilities and talents presumably arise from differences among our brains, and many studies have linked certain very specific tasks with cerebral activity in localized areas. Answers about how the brain as a whole integrates activity among areas, however, have proved elusive. Just what does a "smart" brain look like?

Now, for the first time, intelligence researchers are beginning to put together a bigger picture. Imaging studies are uncovering clues to how neural structure and function give rise to individual differences in intelligence. The results so far are confirming a view many experts have had for decades: not all brains work in the same way. People with the same IQ may solve a problem with



A new neuroscience of intelligence is revealing that not all brains work in the same way



A century of pencil-and-paper testing revealed how mental abilities can be assessed, but how intelligence arises from brain structure and function is only now being uncovered with neuroimaging.

PAUL THOMAS *Getty Images*

equal speed and accuracy, using a different combination of brain areas. [For more on IQ and intelligence, see "Rational and Irrational Thought: The Thinking That IQ Tests Miss," by Keith E. Stanovich, on page 34.]

Men and women show group average differences on neuroimaging measures, as do older and younger groups, even at the same level of intelligence. But newer studies are demonstrating that individual differences in brain structure and function, as they relate to intelligence, are key—and the latest studies have exposed only the tip of the iceberg. These studies hint at a new definition of intelligence, based on the size of certain brain areas and the efficiency of information flow among them. Even more tantalizing, brain scans soon may be able to reveal an individual's aptitude for certain academic subjects or jobs, enabling accurate and useful education and career counseling. As we learn more about intelligence, we will better understand how to help individuals fulfill or perhaps enhance their intellectual potential and success.

FAST FACTS

Smart Brains Revealed

1» **Brain structure and metabolic efficiency may underlie individual differences in intelligence, and imaging research is pinpointing which regions are key players.**

2» **Smart brains work in many different ways. Women and men who have the same IQ show different underlying brain architectures.**

3» **The latest research suggests that an individual's pattern of gray and white matter might underlie his or her specific cognitive strengths and weaknesses.**

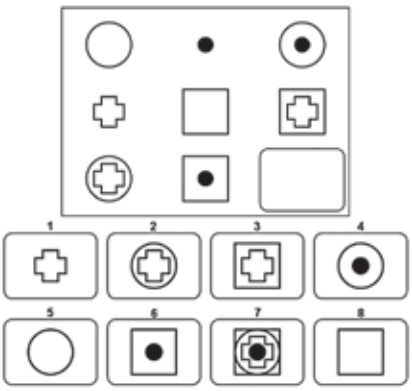
For 100 years intelligence research relied on pencil-and-paper testing for metrics such as IQ. Psychologists used statistical methods to characterize the different components of intelligence and how they change over people's lifetimes. They determined that virtually all tests of mental ability, irrespective of content, are positively related to one another—that is, those who score high on one test tend to score high on the others. This fact implies that all tests share a common factor, which was dubbed *g*, a general factor of intelligence. The *g* factor is a powerful predictor of success and is the focus of many studies. [For more on *g*, see "Solving the IQ Puzzle," by James R. Flynn; SCIENTIFIC AMERICAN MIND, October/November 2007.]

In addition to the *g* factor, psychologists also have established other primary components of intelligence, including spatial, numerical and verbal factors, reasoning abilities known as fluid intelligence, and knowledge of factual information, called crystallized intelligence. But the brain mechanisms and structures underlying *g* and the other factors could not be inferred from test scores or even individuals with brain damage and thus remained hidden.

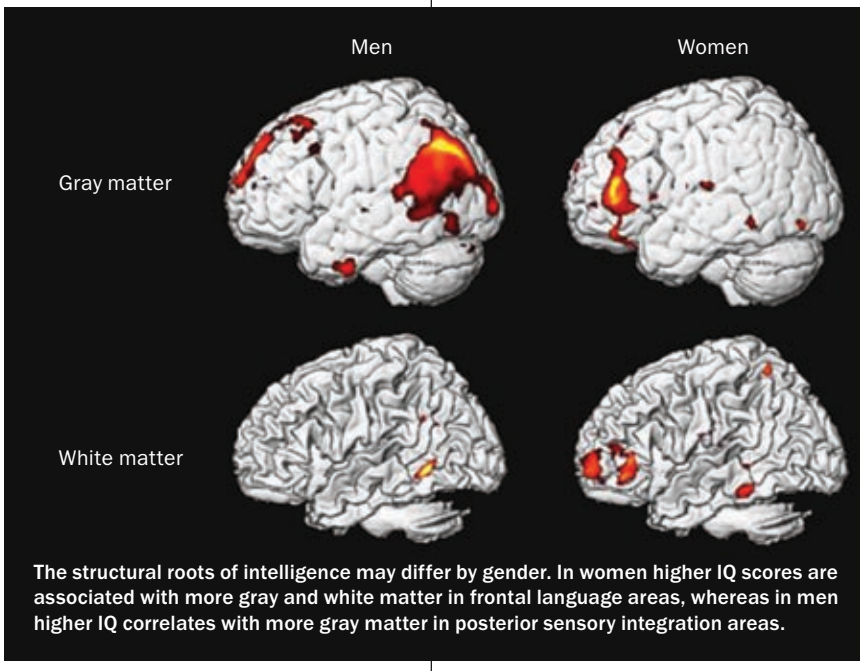
The advent of neuroscience techniques about 20 years ago finally offered a way forward. New methods, particularly neuroimaging, now allow a different approach to defining intelligence based on physical properties of the brain. In 1988 my colleagues and I at the University of California, Irvine, conducted one of the first studies to use such techniques. Using positron-emission tomography (PET), which produces images of metabolism in the brain by detecting the amount of low-level radioactive glucose used by neurons as they fire, we traced the brain's energy use while a small sample of volunteers solved nonverbal abstract reasoning problems on a test called the Raven's Advanced Progressive Matrices [*see illustration at right*].

This test is known to be a good indicator of *g*, so we were hoping to answer the question of where general intelligence arises in the brain by determining which areas showed increased activation while solving the test problems. To our surprise, greater energy use (that is, increased glucose metabolism) was associated with *poorer* test performance. Smarter people were using less energy to solve the problems—their brains were more efficient.

The next obvious question was whether energy efficiency can arise through practice. In 1992 we used PET before and after subjects learned the computer game Tetris (a fast paced visuospatial puzzle), and we found less energy use in several brain areas after 50 days of practice and increased skill. The data suggest that over time the brain learns what areas are not necessary for better performance, and activity in those areas diminishes—leading to greater overall efficiency. Moreover, the individuals in the study with high *g* showed more brain efficiency after practice than the people with lower *g*.



Which of the eight options correctly completes the matrix? This type of abstract reasoning problem is similar to those on the Raven's test, a good indicator of general intelligence. (The answer is number 7.)



The structural roots of intelligence may differ by gender. In women higher IQ scores are associated with more gray and white matter in frontal language areas, whereas in men higher IQ correlates with more gray matter in posterior sensory integration areas.

By the mid-1990s we were focusing on efficiency as a key concept for understanding intelligence. But then, in 1995, we discovered a difference in the way male and female brains work, giving us our first clue to what we know today: the concept of efficiency depends on the type and difficulty of tasks involved, and there are individual and group differences in brain function during problem solving, depending on who is doing the thinking. In the 1995 study we tested a specific mental ability—mathematical reasoning. We selected college students with either very high or average SAT-Math scores and used PET to investigate their brain function while they solved mathematical reasoning problems. Unlike the *g* studies, this study showed the people with high math ability using *more* brain energy in a certain region (the temporal lobes), but this was true only for the men and not for the women—even though both men and women performed at the same level on the test.

Gender Matters

These observations have now been replicated by us and other researchers, especially in studies using advanced electroencephalographic (EEG) mapping techniques. In addition to these experiments showing differences in brain function, brain *structure* also seems to play a role—studies have suggested that other gender differences in cognition, such as the tendency for men to have better visuospatial ability, may be rooted in architecture.

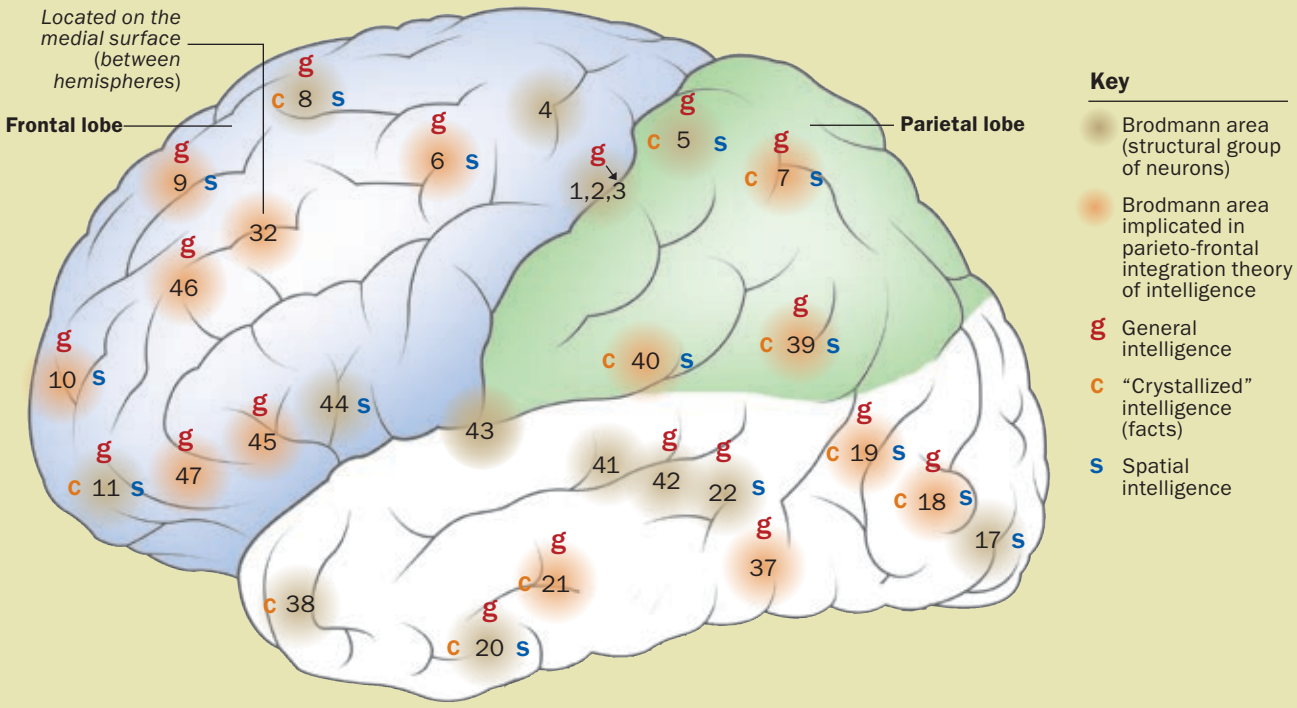
For example, in a series of papers published in *NeuroImage* starting in 2004, we used structural MRI scans to investigate correlations between gray and white matter volume and scores on intelligence tests. Gray matter, made up of neuron cell bodies, does the computa-

(The Author)

RICHARD J. HAIER is professor emeritus in the School of Medicine at the University of California, Irvine.

COURTESY OF RACHAEL GRAZIOPLENE (*top*); SCIENTIFIC AMERICAN MIND; SOURCE: R. E. JUNG ET AL. IN *NEUROIMAGE*, VOL. 26, NO. 3; 2005 (*bottom*)

The Neural Roots of Intelligence



Brain-imaging studies reveal many areas in which the amount of gray matter (neuron bodies) correlates with intelligence test scores. The color patches above indicate the approximate location of the Brodmann areas—structural groupings of neurons numbered according to historical tradition. The letters on each Brodmann area indicate which intelligence factors it is associated with: general (g); spatial (s); and crystallized (c), or factual knowledge. Every individual has a unique pattern of gray matter in these areas [*see graph on opposite page*], giving rise to different cognitive strengths and weaknesses.

Fourteen of the Brodmann areas (*colored orange above*) are consistently implicated in studies of intelligence-related brain structure and function. Neuropsychologist Rex E. Jung of the University of New Mexico and I reviewed the studies and identified this network, calling it the parieto-frontal integration theory (P-FIT) because areas in the parietal (*green*) and frontal (*blue*) lobes were consistent across the most studies. Most of the P-FIT areas are involved in computation (frontal areas) and sensory integration (parietal areas), the processing and conscious understanding of sensory information. —*R.J.H.*

tional work of the brain. White matter enables communication among regions of gray matter via axons, brain cells' long, wirelike appendages. Our studies point to a network of areas distributed throughout the brain where more gray or white matter is related to higher IQ scores. The specific areas in this network are different in men and women, suggesting there are at least two different brain architectures that produce equivalent performance on IQ tests. In general, we found that in women more gray and white matter in frontal brain areas, especially those associated with language, was correlated with IQ scores; in men IQ scores correlated with gray matter in frontal areas and, especially, in posterior areas that integrate sensory information [*see bottom illustration on preceding page*].

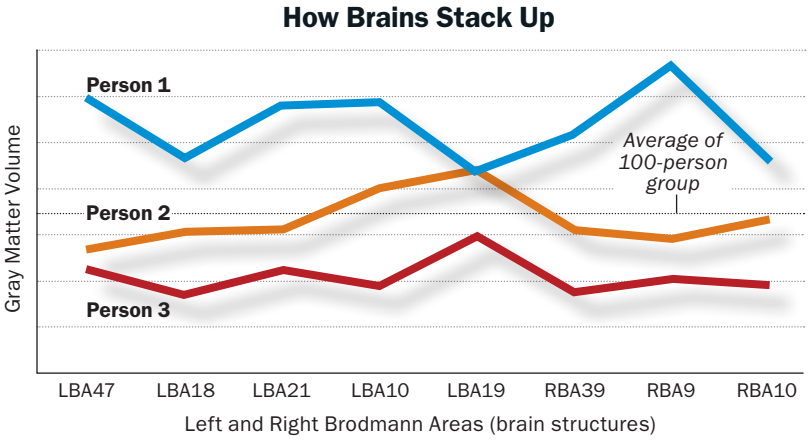
Children also show different developmental brain patterns related to IQ, depending on their gender. In a series of imaging studies with large samples, published from 2006 to 2008, neuroscientist Vincent J. Schmithorst of the Cincinnati Children's Hospital Medical Center and his colleagues found that as girls age they show increasing organization—that is, well-defined paths between disparate brain regions—in their right hemisphere. Boys, in contrast, show this developmental trend in their left hemisphere. We do not yet know how these findings relate to behavioral or learning differences, but the research points the way for future studies to determine how brain development relates to boys' and girls' cognition and academic achievement. [For more on gender differences, see "Sex, Math, and Scientific Achievement," by Diane F. Halpern, Camilla P. Benbow, David C. Geary, Ruben C. Gur, Janet Shibley Hyde and Morton Ann Gernsbacher;

SCIENTIFIC AMERICAN MIND; SOURCES: R. E. JUNG AND R. J. HAIER IN *BEHAVIORAL AND BRAIN SCIENCES*, VOL. 30, NO. 2; 2007, AND K. MARTÍNEZ AND R. COLOM IN *PERSONALITY AND INDIVIDUAL DIFFERENCES*, VOL. 46; 2009

Scientific American Mind, December 2007/January 2008.]

A New Definition

Gender differences were merely the first indication that not all brains work the same way. In 2003 we investigated whether we could observe functional variations during passive mental activity without a task assigned. Again we used PET in two groups of volunteers selected for high or average scores on the Raven's test. Both groups watched the same videos passively with no problem solving or other task demands. The group with high test scores showed different brain activations in posterior visual-processing areas as compared with the average group. The data suggest that early stages of information processing are more engaged in individuals with higher intelligence, perhaps suggesting that the smarter people in the study were not watching the videos "passively" after all—they were actively processing what they were seeing.



Brain profiles of three individuals show the amount of gray matter each has in areas associated with intelligence, called P-FIT areas [*for more information about these brain areas, see box on opposite page*]. The person who scored the highest in the 100-person study group on tests of general intelligence, or *g*, has far more than the group's average amount of gray matter in every area (*blue line*). The other two individuals (*red* and *orange lines*) had identical, average *g* scores, but their pattern of gray matter differs. Further research could reveal how such differences correspond to an individual's cognitive strengths and weaknesses.

primary location for intelligence. In particular, parts of the parietal lobes, located under the crown of the head and known to be involved in sensory integration, play a significant role. Because area was especially associated with IQ scores. The findings support the idea that general intelligence not only arises from gray matter volume but also depends to a large extent on the white

Every individual uses some combination of intelligence-related brain areas in a unique way.

Although more and more evidence shows that problem solving and even passive sensory processing does not look exactly the same in every brain, we still are able to identify a network of areas that seem to give rise to intelligence in general. In fact, defining the crucial regions and connections will help us delineate exactly how each person's brain works—every individual uses some combination of these areas in a unique way.

In 2007 neuropsychologist Rex E. Jung of the University of New Mexico and I reviewed the 37 neuroimaging studies on intelligence that existed at that point. In the journal *Behavioral and Brain Sciences,* we identified salient brain areas found in both structural and functional studies with some consistency. The 14 areas are distributed throughout the brain, refuting the long-held notion that the frontal lobes alone are the eas in the parietal and frontal lobes were most represented across the studies we reviewed, we called our theory of intelligence based on this network the parieto-frontal integration theory (P-FIT). The 14 P-FIT areas are involved in attention, memory, language and sensory processing [*see box on opposite page*].

Identifying the P-FIT network implies a new definition of general intelligence based on the brain's measurable characteristics. Both the amount of gray matter in certain P-FIT areas and the rate of information flow among these areas are likely to play key roles in intelligence. Earlier this year studies at University Medical Center Utrecht in the Netherlands and the Chinese Academy of Sciences in Beijing used functional MRI to determine the efficiency of connections throughout the brain, pinpointing P-FIT areas where connectivity matter connections between crucial gray matter areas. More efficient connections allow information to flow faster—and quick processing times seem to go hand in hand with a high IQ.

Everyone Is Unique

But IQ scores do not tell the whole story—not even close. Intelligence seems to arise from varying combinations of the P-FIT brain areas in different people, which may explain each person's individual strengths and weaknesses. The challenges of identifying these patterns are well illustrated by the extremely rare cases of autistic savants. Daniel Tammet, for example, is an autistic young adult with uncommonly high IQ scores. He sees numbers as colors and shapes, which allowed him to memorize the value of pi to 22,514 digits. He also learned to converse fluently in Icelandic after only sev-

en days of instruction. Tammet leads an independent life and wrote a best-selling autobiography describing his extraordinary numerical and language ability. What would his "brain profile" show? [For more on Daniel Tammet, see "Think Better: Tips from a Savant," by Jonah Lehrer; SCIENTIFIC AMERICAN MIND, April/May/June 2009.]

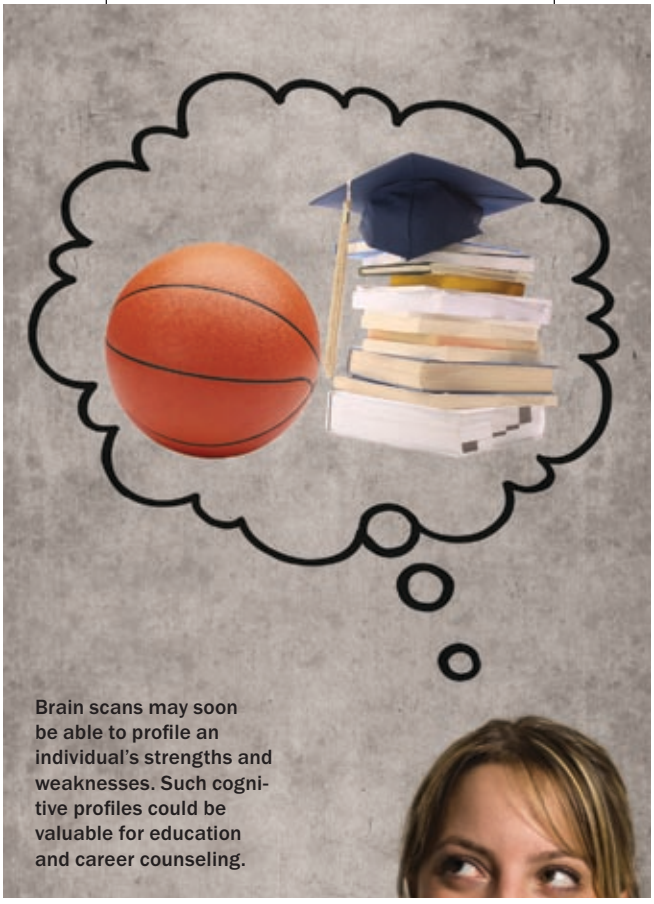
Although we are not currently able to deduce from a scan of Tammet's brain how his extraordinary abilities arise, the most recent wave of neuroimaging studies has given us clues to how we might one day do exactly that. New studies have found correlations between gray matter in certain areas and specific intelligence factors.

A learning program could be tailored based on an individual student's brain characteristics.

In March psychologist Roberto Colom of the Autonomous University of Madrid and his collaborators (including me) reported on the relation between gray matter volume and different intelligence factors in 100 young adults. Each person completed a battery of nine cognitive tests known to indicate different intelligence factors, including *g*, fluid intelligence, crystallized intelligence and a spatial factor. We found a positive correlation between scores on the *g* factor and the amount of gray matter in several areas predicted by P-FIT. And once we accounted for the common *g* factor, we found that gray matter volume in certain brain areas was related to the other specific intelligence factors. For details of which areas are connected to each factor, see the box on page 30.

One of the most tantalizing ideas to come out of this recent research is the possibility of matching an individual's gray and white matter pattern to his or her *g* and to other specific intelligence factors. In other words, the tissue in P-FIT areas may predict a person's unique pattern of cognitive strengths and weaknesses across a range of mental abilities. These differing brain profiles may explain why two people with an identical IQ score may show very different cognitive abilities. The data from Madrid illustrate this idea nicely [*see illustration on preceding page*]. The person in our volunteer group with the highest *g* score showed far more gray matter than the group's average amount in several P-FIT areas—perhaps not surprisingly. But it is interesting to note that two people with identical *g* scores of 100, the average for the group tested in the study, exhibited different cognitive profiles, suggesting different cognitive strengths and weaknesses.

The idea that we all have our own pattern of variations in brain areas that contribute to different intelligence factors is underscored dramatically by a structural MRI study in March of 241 patients with brain lesions. Psychologist Jan Gläscher of the California Institute of Technology and his colleagues showed that the site of each lesion was correlated with specific factor scores. For example, perceptual organization suffered—patients had trouble consciously understanding raw information from their senses—when their right parietal lobe was damaged.



Brain scans may soon be able to profile an individual's strengths and weaknesses. Such cognitive profiles could be valuable for education and career counseling.

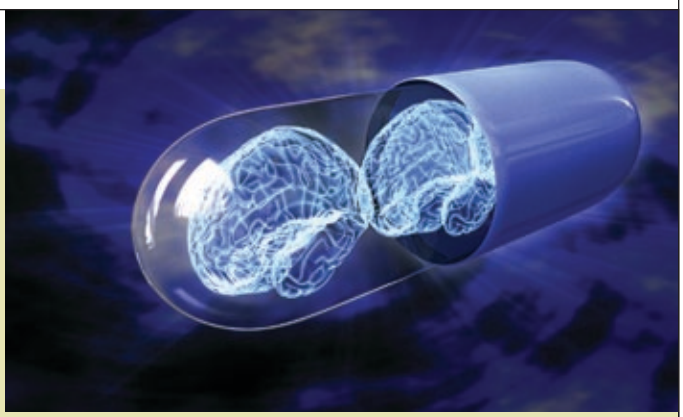
BURAK PEKAKCAN /*Stockphoto (thought bubble)*; GETTY IMAGES (*basketball*); SHARON DOMINICK /*Stockphoto (books and mortarboard)*

A Smarter Future

These most recent studies suggest that neuroimaging could one day become a supplement or even a substitute for traditional paper-and-pencil intelligence testing. An individual brain profile could be valuable. In education, for example, a learning program could be tailored for an individual student, at any age, based on that student's brain characteristics. Perhaps vocational success could also be predicted—are there patterns of gray matter across some areas, for example, that make for the best teachers, fighter pilots, engineers or tennis players? People seeking a better life with vocational and career consultation certainly will want the choice of having a brain assessment if there are data to support its usefulness.

But it is worth remembering that, contrary to older dogma,

Boosting Healthy Brains



The latest research into the neural roots of intelligence may lead to better drugs and tools for cognitive enhancement. In the future, drugs may enhance the neurotransmitters that regulate communication among the salient brain areas underlying general intelligence or more specific mental abilities. Other drugs could stimulate gray matter growth or white matter integrity in relevant areas. Certainly such advances would be welcome as potential treatments for mental retardation and developmental disabilities. They may also be welcome by any individual looking for more intelligence.

If an effective "IQ pill" becomes available, are the societal and ethical issues the same as for performance-enhancing drugs in sports, or is there a moral imperative that more intelligence is always better than less? Apparently, many scientists agree with the latter. An online survey of 1,427 scientists conducted in 2008 by *Nature* found that 20 percent of respondents already use prescription drugs to enhance "concentration" rather than for treating a medical condition. Almost 70 percent of 1,258 respondents who answered the question said they would be willing to risk mild side effects to "boost their brainpower" by taking cognition-enhancing drugs. Eighty percent of all the scientists who responded—even those who did not use these drugs—defended the right of "healthy humans" to take them as work boosters, and more than half said their use should not be restricted, even for university entrance exams. More than a third said that they would feel pressure to give their children such drugs if they knew other kids at school were also taking them. Few appear to favor the "ignorance is bliss" position.

Intelligence is a critical resource for the development of civilization. As the global economy evolves and small countries compete with larger countries, assessing, developing and even enhancing intellectual talent may well become the neuroscience challenge for the 21st century. —*R.J.H.*

the brain is not set in stone or in genetic immutability. Exactly the opposite is true. The brain is plastic—it changes. A brain profile detailing a person's strengths would offer a guide rather than a prescription—perhaps suggesting ways to practice skills or improve education so that a person could become better suited for the activities or careers he or she is most interested in. Fascinating recent studies show that learning to juggle increases the amount of gray matter in brain areas relevant to motor activity. When the training stops, the additional gray matter disappears. Because regional gray matter is related to intelligence, can training beyond conventional education approaches be directed at specific brain areas to increase intelligence? We do not yet know, but the prospect is exciting.

The next phase of neurointelligence research may include studies designed to answer such questions, including education experiments to determine whether different strategies produce specific brain changes and whether students selected on the basis of their individual brain characteristics are more likely to maximize learning in a particular subject with one educational strategy versus another. The goal would be to enhance current educational decision making by adding customized information about each student's brain. How any specific brain characteristic develops and how it may be influenced are critical, but separate, questions for research.

Whether everyone agrees on precisely the same definition of intelligence or not, progress in neuroscience is inexorable. We will continue to discover how the brain manages the complex information processing that undoubtedly underlies all notions of intelligence. Given the ravages of brain disease, aging, the technical needs of modern societies, the challenges of education and the joy of experiencing the world through intellect, there is some urgency to understand how smart brains work. It is not too early for discussion about the implications of the search for neurointelligence and our willingness to go where the data lead. M

(Further Reading)

- **Why Aren't More Women in Science?** Stephen J. Ceci and Wendy M. Williams. American Psychological Association, 2006.
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RATIONAL AND IRRATIONAL THOUGHT:

THE THINKING THAT IQ TESTS MISS

By Keith E. Stanovich

No doubt you know several folks with perfectly respectable IQs who just don't seem all that sharp. The behavior of such people tells us that we are missing something important by treating intelligence as if it encompassed all cognitive abilities. I coined the term "dysrationalia" (analogous to "dyslexia"), meaning the inability to think and behave rationally despite having adequate intelligence, to draw attention to a large domain of cognitive life that intelligence tests fail to assess. Although most people recognize that IQ tests do not measure important mental faculties, we behave as if they do. We have an implicit assumption that intelligence and rationality go together—or else why would we be so surprised when smart people do foolish things?

It is useful to get a handle on dysrationalia and its causes because we are beset by problems that require increasingly more accurate, rational responses. In the 21st century, shallow processing can lead physicians to choose less effective medical treatments, can cause people to fail to adequately assess risks in their environment, can lead to the misuse of information in legal proceedings, and can make parents resist vaccinating their children. Millions of dollars are spent on unneeded projects by government and private industry when decision makers are dysrationalic, billions are wasted on quack remedies, unnecessary surgery is performed and costly financial misjudgments are made.

IQ tests do not measure dysrationalia. But as I show in my new book, *What Intelligence Tests Miss: The Psychology of Rational Thought*, there are ways to measure it and ways to correct it. Decades of research in cognitive psychology have suggested two causes of dysrationalia. One is a processing problem, the other a content problem. Much is known about both of them.

The Case of the Cognitive Miser

The processing problem comes about because we tend to be cognitive misers. When approaching a problem, we can choose from any of several cognitive mechanisms. Some mechanisms have great computational power, letting us solve many problems with great accuracy, but they are slow, require much concentration and can interfere with other cognitive tasks. Others are comparatively low in computational power, but they are fast, require little concentration and do not interfere with other ongoing cognition. Humans are cognitive misers because our basic tendency is to default to the processing mechanisms that require less computational effort, even if they are less accurate.

Are you a cognitive miser? Consider the following problem, taken from the work of Hector Levesque, a computer scientist at the University of Toronto. Try to answer it yourself before reading the solution.

1 **Jack is looking at Anne, but Anne is looking at George. Jack is married, but George is not. Is a married person looking at an unmarried person?**

A) Yes B) No C) Cannot be determined

More than 80 percent of people choose C. But the correct answer is A. Here is how to think it through logically: Anne is the only person whose marital status is unknown. You need to consider both possibilities, either married or unmarried, to determine whether you have enough information to draw a conclusion. If Anne is married, the answer is A: she would be the married person who is looking at an unmarried person (George). If Anne is not married, the answer is still A: in this case, Jack is the married person, and he is looking at Anne, the unmarried person. This thought process is called fully disjunctive reasoning—reasoning that considers all possibilities. The fact that the problem does not reveal whether Anne is or is not married suggests to people that they do not have enough information, and they make the easiest inference (C) without thinking through all the possibilities.

Most people can carry out fully disjunctive reasoning when they are explicitly told that it is necessary (as when there is no option like "cannot be determined" available). But most do not au-

ISTOCKPHOTO (*silhouette of man*); STEFAN SCHULZE /*Stockphoto* (*wedding rings*)

We assume INTELLIGENCE AND RATIONALITY shouldn't be surprised when smart people do

tomatically do so, and the tendency to do so is only weakly correlated with intelligence.

Here is another test of cognitive miserliness, as described by Nobel Prize–winning psychologist Daniel Kahneman and his colleague Shane Frederick.

= $1.10

2 **A bat and a ball cost $1.10 in total. The bat costs $1 more than the ball. How much does the ball cost?**

Many people give the first response that comes to mind—10 cents. But if they thought a little harder, they would realize that this cannot be right: the bat would then have to cost $1.10, for a total of $1.20. IQ is no guarantee against this error. Kahneman and Frederick found that large numbers of highly select university students at the Massachusetts Institute of Technology, Princeton and Harvard were cognitive misers, just like the rest of us, when given this and similar problems.

Another characteristic of cognitive misers is the "my side" bias—the tendency to reason from an egocentric perspective. In a recent study my colleague Richard West of James Madison University and I presented a group of subjects with the following thought problem.

3 **Imagine that the U.S. Department of Transportation has found that a particular German car is eight times more likely than a typical family car to kill occupants of another car in a crash. The federal government is considering restricting sale and use of this German car. Please answer the following two questions: Do you think sales of the German car should be banned in the U.S.? Do you think the German car should be banned from being driven on American streets?**

Then we presented a different group of subjects with the thought problem stated a different way—more in line with the true data from the Department of Transportation, which had found an increased risk of fatalities not in a German car but in an American one.

Imagine that the Department of Transportation has found that the Ford Explorer is eight times more likely than a typical family car to kill occupants of another car in a crash. The German government is considering restricting sale or use of the Ford Explorer. Please answer the following two questions: Do you think sales of the Ford Explorer should be banned in Germany? Do you think the Ford Explorer should be banned from being driven on German streets?

Among the American subjects we tested, we found considerable support for banning the car when it was a German car being banned for American use: 78.4 percent thought car sales should be banned, and 73.7 percent thought the car should be kept off the streets. But for the subjects for whom the question was stated as whether an American car should be banned in Germany, there was a statistically significant difference: only 51.4 percent thought car sales should be banned, and just 39.2 percent thought the car should be kept off German streets, even

FAST FACTS

Who Are You Calling "Smart"?

1» Traditional IQ tests miss some of the most important aspects of real-world intelligence. It is possible to test high in IQ yet to suffer from the logical-thought defect known as dysrationalia.

2» One cause of dysrationalia is that people tend to be cognitive misers, meaning that they take the easy way out when trying to solve problems, often leading to solutions that are illogical and wrong.

3» Another cause of dysrationalia is the mindware gap, which occurs when people lack the specific knowledge, rules and strategies needed to think rationally.

4» Tests do exist that can measure dysrationalia, and they should be given more often to pick up the deficiencies that IQ tests miss.

ISTOCKPHOTO (*bat and ball*); STEFAN SCHULZE/*iStockphoto* (*car*)

go together. But we foolish things.

though the car in question was presented as having exactly the same poor safety record.

This study illustrates our tendency to evaluate a situation from our own perspective. We weigh evidence and make moral judgments with a my-side bias that often leads to dysrationalia that is independent of measured intelligence. The same is true for other tendencies of the cognitive miser that have been much studied, such as attribute substitution and conjunction errors; they are at best only slightly related to intelligence and are poorly captured by conventional intelligence tests.

The Mindware Gap

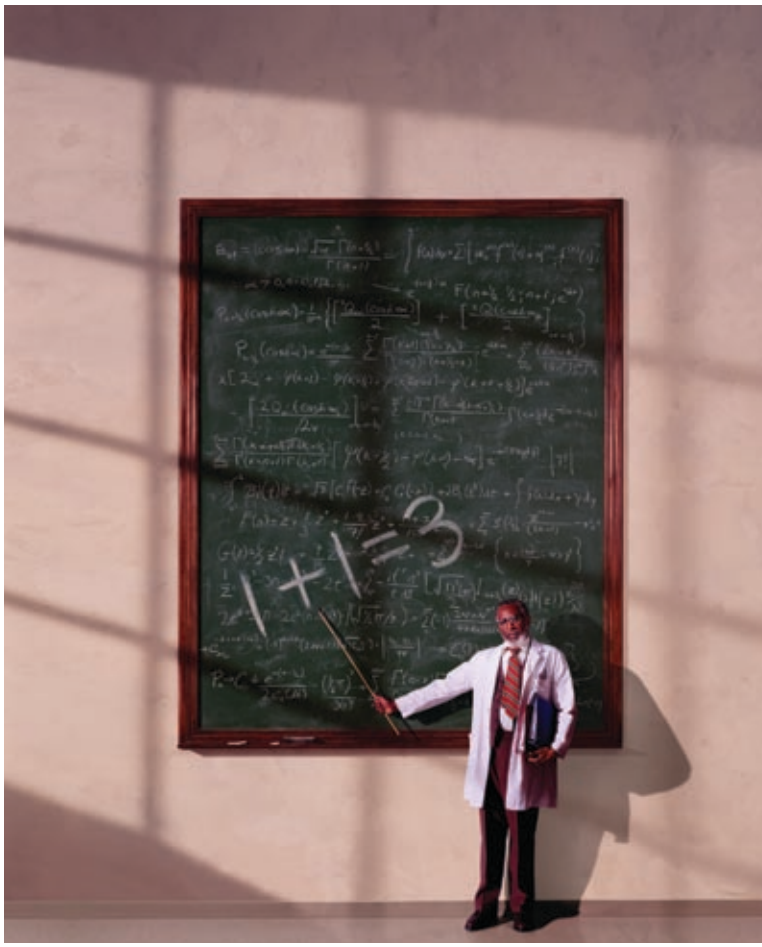
The second source of dysrationalia is a content problem. We need to acquire specific knowledge to think and act rationally. Harvard cognitive scientist David Perkins coined the term "mindware" to refer to the rules, data, procedures, strategies and other cognitive tools (knowledge of probability, logic and scientific inference) that must be retrieved from memory to think rationally. The absence of this knowledge creates a mindware gap—again, something that is not tested on typical intelligence tests.

One aspect of mindware is probabilistic thinking, which can be measured. Try to answer the following problem before you read on.

4 **Imagine that XYZ syndrome is a serious condition that affects one person in 1,000. Imagine also that the test to diagnose the disease always indicates correctly that a person who has the XYZ virus actually has it. Finally, suppose that this test occasionally misidentifies a healthy individual as having XYZ. The test has a false-positive result of 5 percent, meaning that the test wrongly indicates that the XYZ virus is present in 5 percent of the cases where the person does not have the virus.**

Next we choose a person at random and administer the test, and the person tests positive for XYZ syndrome. Assuming we know nothing else about that individual's medical history, what is the probability (expressed as a percentage ranging from zero to 100) that the individual really has XYZ?

The most common answer is 95 percent. But that is wrong. People tend to ignore the first part of the setup, which states that only one person in 1,000 will actually have XYZ syndrome. If the other 999 (who do not have the disease) are tested, the 5 percent false-positive rate means that approximately 50 of them (0.05 times 999) will be told they have XYZ. Thus,



for every 51 patients who test positive for XYZ, only one will actually have it. Because of the relatively low base rate of the disease and the relatively high false-positive rate, most people who test positive for XYZ syndrome will not have it. The answer to the question, then, is that the probability a person who tests positive for XYZ syndrome actually has it is one in 51, or approximately 2 percent.

A second aspect of mindware, the ability to think scientifi-

(The Author)

KEITH E. STANOVICH is professor of human development and applied psychology at the University of Toronto. He is author of six books about cognition, most recently *What Intelligence Tests Miss: The Psychology of Rational Thought* (Yale University Press, 2009). In 1997 Stanovich was given the Sylvia Scribner Award from the American Educational Research Association, and in 2000 he received the Distinguished Scientific Contribution Award from the Society for the Scientific Study of Reading.

STEVEN BRONSTEIN *Getty Images (man at chalkboard)*; ISTOCKPHOTO *(hypodermic)*

The idea that IQ TESTS DO NOT MEASURE all the critics of intelligence tests have been making that

cally, is also missing from standard IQ tests, but it, too, can be readily measured.

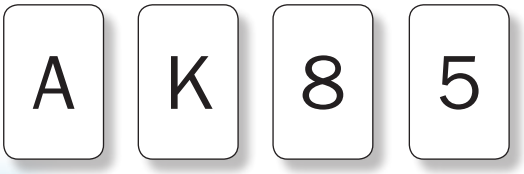
5 **An experiment is conducted to test the efficacy of a new medical treatment. Picture a 2 × 2 matrix that summarizes the results as follows:**

	Improvement	No Improvement
Treatment Given	200	75
No Treatment Given	50	15

As you can see, 200 patients were given the experimental treatment and improved; 75 were given the treatment and did not improve; 50 were not given the treatment and improved; and 15 were not given the treatment and did not improve. Before reading ahead, answer this question with a yes or no: Was the treatment effective?

Most people will say yes. They focus on the large number of patients (200) in whom treatment led to improvement and on the fact that of those who received treatment, more patients improved (200) than failed to improve (75). Because the probability of improvement (200 out of 275 treated, or 200/275 = 0.727) seems high, people tend to believe the treatment works. But this reflects an error in scientific thinking: an inability to consider the control group, something that (disturbingly) even physicians are guilty of. In the control group, improvement occurred even when the treatment was *not* given. The probability of improvement with no treatment (50 out of 65 not treated, or 50/65 = 0.769) is even higher than the probability of improvement with treatment, meaning that the treatment being tested can be judged to be completely ineffective.

Another mindware problem relates to hypothesis testing. This, too, is rarely tested on IQ tests, even though it can be reliably measured, as the late Peter C. Wason of University College London has shown. Try to solve the following puzzle, called the four-card selection task, before reading ahead.



6 **As seen in the diagram, four cards are sitting on a table. Each card has a letter on one side and a number on the other. Two of the cards are letter-side up, and two of the cards are number-side up. The rule to be tested is this: for these four cards, if a card has a vowel on its letter side, it has an even number on its number side. Your task is to decide which card or cards must be turned over to find out whether the rule is true or false. Indicate which cards must be turned over.**

Most people get the answer wrong, and it has been devilishly hard to figure out why. About half of them say you should pick A and 8: a vowel to see if there is an even number on its reverse side and an even number to see if there is a vowel on its reverse. Another 20 percent choose to turn over the A card only, and another 20 percent turn over other incorrect combinations. That means that 90 percent of people get it wrong.

Let's see where people tend to run into trouble. They are okay with the letter cards: most people correctly choose A. The difficulty is in the number cards: most people mistakenly choose 8. Why is it wrong to choose 8? Read the rule again: it says that a vowel must have an even number on the back, but it says nothing about whether an even number must have a vowel on the back or what kind of number a consonant must have. (It is because the rule says nothing about consonants, by the way, that there is no need to see what is on the back of the K.) So finding a consonant on the back of the 8 would say nothing about whether the rule is true or false. In contrast, the 5 card, which most people do not choose, is essential. The 5 card might have a vowel on the back. And if it does, the rule would be shown to be false, because that would mean that not all vowels have even numbers on the back. In short, to show that the rule is not false, the 5 card must be turned over.

When asked to prove something true or false, people tend to focus on confirming the rule rather than falsifying it. This is why they turn over the 8 card, to confirm the rule by observing a vowel on the other side, and the A card, to find the confirming even number. But if they thought scientifically, they would look for a way to falsify the rule—a thought pattern that would immediately suggest the relevance of the 5 card (which might contain a disconfirming vowel on the back). Seeking falsifying evidence is

JOE BELANGER *Stockphoto (pill bottle)*

key human faculties is not new; point for years.

a crucial component of scientific thinking. But for most people, this bit of mindware must be taught until it becomes second nature.

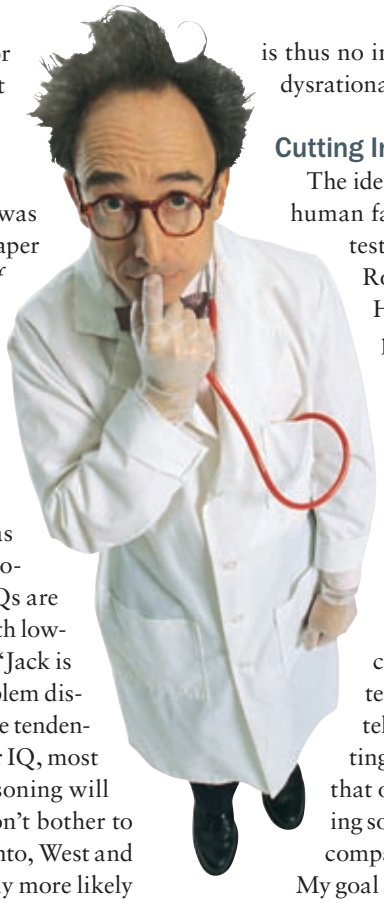
Dysrationalia and Intelligence

The modern period of intelligence research was inaugurated by Charles Spearman in a famous paper published in 1904 in the *American Journal of Psychology*. Spearman found that performance on one cognitive task tends to correlate with performance on other cognitive tasks. He termed this correlation the positive manifold, the belief that all cognitive skills will show substantial correlations with one another. This belief has dominated the field ever since.

Yet as research in my lab and elsewhere has shown, rational thinking can be surprisingly dissociated from intelligence. Individuals with high IQs are no less likely to be cognitive misers than those with lower IQs. In a Levesque problem, for instance (the "Jack is looking at Anne, who is looking at George" problem discussed earlier), high IQ is no guarantee against the tendency to take the easy way out. No matter what their IQ, most people need to be told that fully disjunctive reasoning will be necessary to solve the puzzle, or else they won't bother to use it. Maggie Toplak of York University in Toronto, West and I have shown that high-IQ people are only slightly more likely to spontaneously adopt disjunctive reasoning in situations that do not explicitly demand it.

For the second source of dysrationalia, mindware deficits, we would expect to see some correlation with intelligence, because gaps in mindware often arise from lack of education, and education tends to be reflected in IQ scores. But the knowledge and thinking styles relevant to dysrationalia are often not picked up until rather late in life. It is quite possible for intelligent people to go through school and never be taught the tools of mindware, such as probabilistic thinking, scientific reasoning, and other strategies measured by the XYZ virus puzzle and the four-card selection task described earlier.

When rational thinking is correlated with intelligence, the correlation is usually quite modest. Avoidance of cognitive miserliness has a correlation with IQ in the range of 0.20 to 0.30 (on the scale of correlation coefficients that runs from 0 to 1.0). Sufficient mindware has a similar modest correlation, in the range of 0.25 to 0.35. These correlations allow for substantial discrepancies between intelligence and rationality. Intelligence is thus no inoculation against any of the sources of dysrationalia I have discussed.



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Cutting Intelligence Down to Size

The idea that IQ tests do not measure all the key human faculties is not new; critics of intelligence tests have been making that point for years. Robert J. Sternberg of Tufts University and Howard Gardner of Harvard talk about practical intelligence, creative intelligence, interpersonal intelligence, bodily-kinesthetic intelligence, and the like. Yet appending the word "intelligence" to all these other mental, physical and social entities promotes the very assumption the critics want to attack. If you inflate the concept of intelligence, you will inflate its close associates as well. And after 100 years of testing, it is a simple historical fact that the closest associate of the term "intelligence" is "the IQ test part of intelligence." This is why my strategy for cutting intelligence down to size is different from that of most other IQ-test critics. We are missing something by treating intelligence as if it encompassed all cognitive abilities.

My goal in proposing the term "dysrationalia" is to separate intelligence from rationality, a trait that IQ tests do not measure. The concept of dysrationalia, and the empirical evidence indicating that the condition is not rare, should help create a conceptual space in which we value abilities at least as important as those currently measured on IQ tests—abilities to form rational beliefs and to take rational action. **M**

(Further Reading)

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Why We Worry

Chronic worrying stems from a craving for control. But the more we fret, the less our bodies are able to cope with stress

By Victoria Stern

The young girl wanted to unburden herself about her problem. She told her doctor that she worried excessively and that she felt overwhelmed by these thoughts. One memory that she described to Douglas Mennin, director of the Yale Anxiety and Mood Services at Yale University, was particularly telling. Her grandmother had shared intense feelings about the recent passing of a good friend. As the young girl listened, her mind wandered to thoughts of her grandmother dying. The worry soon spiraled into concerns about the girl's own death. She became so disturbed, she cut short her visit to her grandmother and ran home.

Psychologists believe that worry, defined as a person's negative thoughts about a future event, evolved as a constructive problem-solving behavior [*see box on page 47*]. But excessive fretting—as happened with the girl—does more harm than good. Chronic worriers operate under the

misperception that their overthinking and attempts at controlling every situation allow them to problem-solve and plan for the future. Instead their thought pattern hinders cognitive processing and also causes overstimulation of emotion- and fear-processing areas in the brain. The hypervigilance that is the result can lead to cardiovascular problems, ultimately rendering the body unable to cope properly with stress.

People agonize about matters that rarely occur. Worriers nonetheless often report that they believe overthinking about a possible negative event prevented it from taking place.

An improved understanding of how excessive worry (the thought-driven aspect), which is linked with anxiety (the emotional element), affects our mental and physical functions can help us cope with this often self-induced foible.

Craving Control

Worry began to draw the attention of researchers about 25 years ago, when they started to fine-tune their understanding of the spectrum of anxiety-related pathologies. In the early 1980s psychologist Thomas Borkovec of Pennsylvania State University, a pioneer in this field, became interested in the trait while investigating sleep disorders. He found that intrusive cognitive activity at bedtime—worrying—was a factor in insomnia.

By 1990 Borkovec and his colleagues developed the Penn State Worry Questionnaire, a diagnostic tool that helped researchers show excessive fretting to be a feature of all anxiety disorders, especially generalized anxiety disorder (GAD). Psychologists revised the official psychiatric guidelines (then the *Diagnostic and Statistical Manual of Mental Disorders III)* to reflect this understanding, calling worry the cardinal feature of GAD and making chronic worry a recognized mental health problem. It is now known to affect 2 to 3 percent of the U.S. population, according to the National Institute of Mental Health.

Borkovec defined three main components of garden-variety worry: overthinking, avoidance of negative outcomes and inhibition of emotions. Mennin explains that worry piggybacks on humans' innate tendency to think about the future: "they crave control." He says "chronic worriers see the world as

FAST FACTS

Spiraling Out of Control

1» Worrying about the future is a natural tendency, but for some people it is a constant, unwelcome state of mind. These chronic worriers crave a sense of control they can never seem to find.

2» Spending too much time fretting actually undermines the body's ability to react to stress, weakening the cardiovascular system and disrupting normal emotional functioning.

3» When overworrying seriously threatens a person's health and happiness, drugs or psychotherapy can help.

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an unsafe place and want to fight this sense of unrest." Overworriers feel that fretting gives them this control, and they tend to avoid situations they can't have power over. In a 1995 study Borkovec found that people agonized about matters that rarely occurred. The participants, nonetheless, often reported that they believed the overthinking about a possible negative event had prevented it from taking place.

Unsurprisingly, worriers show increased activity in areas of the brain associated with executive functions, such as planning, reasoning and impulse control. In 2005 psychologist Stefan Hofmann of Boston University used an electroencephalogram (EEG) to measure activity in the prefrontal cortex, before and after 27 undergraduates were told to give a speech in public. He confirmed previous evidence that activity in the left frontal cortex increases for people who worry compared with those who do not, suggesting that the left frontal cortex plays a prominent role in worrying.

Trying too hard to be in command of a given situation or their own thoughts may backfire when worriers are instead overrun with repetitive apprehensions. Research shows that the more we dwell on negative thoughts, the more those threats feel real and the more they will repeat in our skulls, sometimes uncontrollably.

In 1987 Daniel M. Wegner, a psychologist at Harvard University, found that when people were told not to think about a white bear, they tended to mention it about once a minute. In the experiment, Wegner left a participant in a room with a microphone and a bell and asked the volunteer to talk freely about any topic. At one point, he interrupted the person's monologue and told him to continue talking—but this time, *not* to think of a white bear. If the subject did think of a white bear, he had to ring the bell. On average, people rang the bell more than six times in the next five minutes and even said "white bear" out loud several times.

"By trying to put a worry or a thought out of our mind, it only makes the worry worse," Wegner says. "Just like when a song gets stuck in your head, you think you ought to be able to get rid of it, but you only end up making it stick more by trying to push it away." Two mental processes may be at play here, according to Wegner. First, by consciously looking for distractions from the white bear (or your nagging worry), you remain somewhat aware of the undesired thought. The second reason suppression fails is that often you are making an unconscious effort to catch yourself thinking of the forbidden thought, ultimately sensitizing your brain to it.

Two emotion-processing areas of the brain are

Are You an **Unhealthy Worrier?**

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As Robert Leahy, director of the American Institute for Cognitive Therapy, writes in *The Worry Cure* (Harmony, 2005), 38 percent of people say they worry every day, and more than 19 million Americans are chronic worriers.

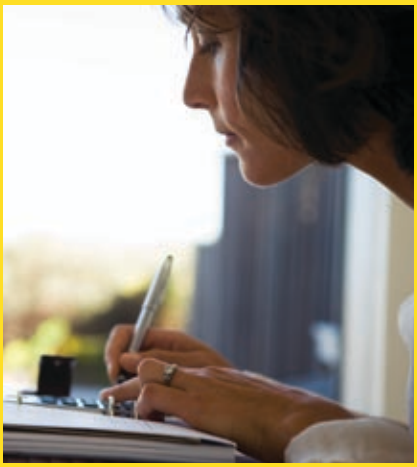
Take the quiz below to give you a sense of how much you worry. This quiz is an abridged version of a standard worry questionnaire called the Worry Domain Questionnaire, which breaks down worry into five categories—relationships, lack of confidence, aimless future, work and finances—to help pinpoint the areas that cause the most worry.

I worry that ...
Not at all (0)
A little (1)
Moderately (2)
Quite a bit (3)
Extremely (4)

___ I cannot be assertive or express my opinions.
___ My future job prospects are not good.
___ I'll never achieve my ambitions.
___ I will not keep my workload up-to-date.
___ Financial problems will restrict holidays and travel.
___ I have no concentration.
___ I am unable to afford things.
___ I feel insecure.
___ I cannot afford to pay my bills.
___ My living conditions are inadequate.
___ Life may have no purpose.
___ I don't work hard enough.
___ Others will not approve of me.
___ I find it difficult to maintain a stable relationship.
___ I lack confidence.
___ I will lose close friends.
___ I am unattractive.
___ I might make myself look stupid.
___ I haven't achieved much.
___ I make mistakes at work.

Results: If you scored 52 points or higher, you may have an unhealthy amount of worry in your life. It might be helpful for you to try some self-relaxing tips [*see box on next page*] or talk to your doctor. —*V.S.*

Relax! Here's How



Robert Leahy offers six simple tips and tricks you can use to cope with the stresses of everyday life.

1. Identify productive and unproductive worry
First, determine whether your worries will help you find practical solutions to a dilemma. If "yes, my worries can be constructive," write a to-do list with explicit steps to help solve the problem. If the answer is "no, my worries are not helping me," use some of the techniques below to help deal with unproductive worries.

2. Keep an appointment with your worries
Write down your unproductive worries throughout the day and set aside a chunk of time, say 6 to 6:30 P.M., dedicated specifically to thinking about them. By 6, "you may find you're not interested in those worries anymore," Leahy says. "Many people find that what they thought they needed an answer to earlier, they don't care about later in the day."

3. Learn to accept uncertainty
Worriers have a hard time accepting they can never have complete control in their lives. Leahy says that quietly repeating a worry for 20 minutes ("I may never fall asleep" or "I could lose my job") reduces its power. "Most people get bored by their worries and don't even make it to 20 minutes," he notes.

4. Be mindful
Mindfulness, a technique based on Buddhist teachings, preaches staying in the present moment and experiencing all emotions even when they are negative. Leahy explains there are ways to be mindful throughout your day, while deeply immersed in your favorite song or in conversation with friends. Try living in the now by practicing deep breathing. Let your body relax and the tension in your muscles melt away.

5. Reframe your worry
What happens if a worry comes true? Could you survive losing your job or being dumped? Reframing how you evaluate disappointments in life can take the sting out of failure, Leahy says. Create a positive spin by asking yourself what you have learned from your bad experiences. Make a list of things for which you are grateful.

6. Put worries in perspective
Examine past worries. Do you have a hard time remembering what they are? Very likely this means that those worries never came true or that you were able to cope and forget, Leahy says. —*V.S.*

also involved in worry: the anterior insula and the amygdala. A 2008 *Psychological Science* study that used functional MRI found that when participants anticipated losing a significant amount of money in the future, activity increased in their anterior insula. That area not only becomes more active in response to worry, but the inclination to worry is also reinforced, because people believe that the act helps them avoid potential losses. The researchers concluded that sometimes, when it comes to making daring monetary decisions, overthinking may turn out to be a good thing.

In 2009 Jack Nitschke, a clinical psychologist at the University of Wisconsin–Madison School of Medicine and Public Health, reported using fMRI to measure activity in the amygdala while GAD patients and healthy subjects viewed pictures of items that were negative (for instance, mutilated bodies) or neutral (say, a fire hydrant). A few seconds before seeing the images, patients received a cue to let them know whether to expect a negative or neutral photograph. Although GAD and healthy subjects experienced no difference in amygdala activation when shown either type of picture, GAD patients displayed unusually high levels of amygdala activity to both negative and neutral *cues*—suggesting that merely anticipating the possibility of something negative in the future recruits specific neural circuitry, Nitschke says.

Stunted Emotions

Although worry hijacks aspects of our emotional circuitry, chronic worriers seek to control their emotions—and their fretting does tend to numb emotional responses. For instance, it is fairly well established that damage to the frontal lobe—which, as the Boston University study showed, has been demonstrated to be more active in worriers who are thinking about the future—is associated with blunted, or an absence of, emotions.

In another emotion-damping mechanism, several studies have confirmed that excess fretting reduces activity in the sympathetic nervous system in response to a threat. This branch of the nervous system normally allows the body to react quickly to impending danger by accelerating breathing and also increasing heart rate to oxygenate muscles to fight or flee.

In one classic study from 1990 Borkovec showed by observing heart rates how worry can dull emotional reactions. He found that people with anxiety about public speaking did not experience variations in their heart rate when relaxing, remaining neutral (that is, neither worrying nor relaxing) or engaging in worry before viewing scary images. After seeing

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the images, however, subjects in the worry group displayed significantly less variation in heart rate than those in the neutral or relaxed condition, despite reporting feeling more fearful.

At the same time, worry hinders a person's physical reaction to a threat by amplifying activity in the parasympathetic nervous system. When working properly, this part of the nervous system quiets the body as it recovers from a stressful experience. I experienced this system in operation when I participated in a study in Mennin's laboratory at Yale.

Fretting can tax the body and promote cardiovascular problems. Worry is associated with an elevated resting heart rate and low heart rate variability.

The scene was a lone arm suspended in midair. A hand carrying a razor started slicing it. Blood seeped out of the wound as the razor dug deeper, exposing a mass of blood and cartilage. I wanted nothing more than to look away.

Amelia Aldao, the Ph.D. student conducting the experiment, wanted to measure my physiological reaction to various film segments, each one meant to elicit a distinct emotion (for instance, disgust in the case of the mutilated arm).

Aldao recorded with electrocardiography how I dealt with a variety of emotions (this Yale study was the first to expand beyond fear), removed the electrodes from my body and led me into the adjacent room. She did some quick calculations on her computer and out popped a few of my stats. Good news. My heart rate variability was high, and my average heart rate measured about 58 beats per minute. These values indicated that my heart could cope well with intense emotions.

(The Author)

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In contrast, by consciously trying to be ready for the worst, worriers are actually compromising their body's ability to react to a truly traumatic event. In 2006 researchers at Columbia University, the National Institute on Aging and Leiden University in the Netherlands reviewed more than two dozen studies and found that overworrying can tax the body and promote cardiovascular problems.

Worry hinders a person's reaction to a threat by amplifying activity in the parasympathetic nervous system, which quiets the body as it recovers from a stressful experience.

Overall, increased worry was associated with an elevated resting heart rate but low heart rate variability. Excessive worriers and GAD patients experienced lower heart rate variability during periods of worry; in other words, their hearts returned to a resting rate more slowly than those of healthy worriers did.

Prolonged periods of stress even weakened participants' endocrine and immune function. Some studies reported that excess worry is linked to elevated levels of the stress hormone cortisol, which slows immune responses and may make chronic worriers more susceptible to disease.

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The Benefits of Worry

If worry is an integral part of what makes us human, can it also serve a positive function? Psychologist Graham Davey of the University of Sussex in England was one of the first experts to suggest potential plus sides to worry. In a 1994 study Davey explored a range of consequences stemming from this natural tendency; he found people reported that although fretting can make things worse, it can also be constructive, helping to motivate them to take action, resolve problems and reduce anxiety.

More recent research supports the idea that elevated levels of worry can improve performance. In 2005 psychologist Maya Tamir, then at Stanford University, showed that neurotic students were more likely to believe that increasing their level of worry when working on a cognitively demanding task, such as a test, would allow them to excel. Worrying before the test indeed helped the more neurotic individuals do better, whereas the pretest level of worry did not particularly influence the overall experience or outcomes for the less neurotic participants.

Not only can worry benefit performance, but it may also encourage action. A 2007 study in the journal *Cognition and Emotion* revealed that smokers may be more convinced to quit if they worry about the risks of smoking. The promising results prompted the study authors to suggest potential strategies, such as having doctors remind smokers about the downsides, capitalizing on the worry-motivation relationship to encourage smokers to dispense with cigarettes.

Although it is difficult to determine the precise line between healthy, beneficial worry and unhealthy, detrimental worry, Michel Dugas, a psychologist at Concordia University in Montreal, likes to think of worry as a bell curve whereby moderate levels are associated with improved functioning, but excess levels are associated with a decline in performance.

Christine Calmes, a postdoctoral fellow at the VA Capitol Mental Illness Research, Education and Clinical Center in Baltimore, believes that successful people operate a little higher on the worry scale. As long as fretting doesn't get the better of someone, it can work to his or her advantage. "It's all about how people cope with the worry," Calmes says. "If it's incapacitating, then it's not okay. But if worrying motivates people to go above and beyond—put in longer hours, attend to details that others may miss—then it's a good thing." —*V.S.*

Seeking Solutions

Everybody worries now and again [*see box on page 43*], but if it becomes a pathology, assistance is available. First-line treatments for generalized anxiety disorder currently include drugs and a form of psychotherapy called cognitive-behavior therapy (CBT).

Antidepressants such as Zoloft and Prozac may also help by boosting levels of serotonin, a brain-signaling chemical that enhances mood, sexual desire, memory and learning. Doctors may prescribe antianxiety drugs such as Valium and Xanax. These drugs inhibit a neurotransmitter called GABA, which can dull feelings of anxious arousal and thus a person's desire to worry.

Drugs do not remedy the underlying psychological problems, but CBT may bring relief. Therapists teach patients to detect early cues of unhealthy worry and integrate techniques into their daily life to revise these negative thought patterns. CBT also includes a relaxation component to soothe the muscle tension associated with excess worry.

Gaining deeper insight into how people manage their thoughts about the future will help even healthy worriers cope with the stresses and concerns they confront in everyday life [*see box above*]. The key for most of us is not letting our worries become problems themselves. M

(Further Reading)

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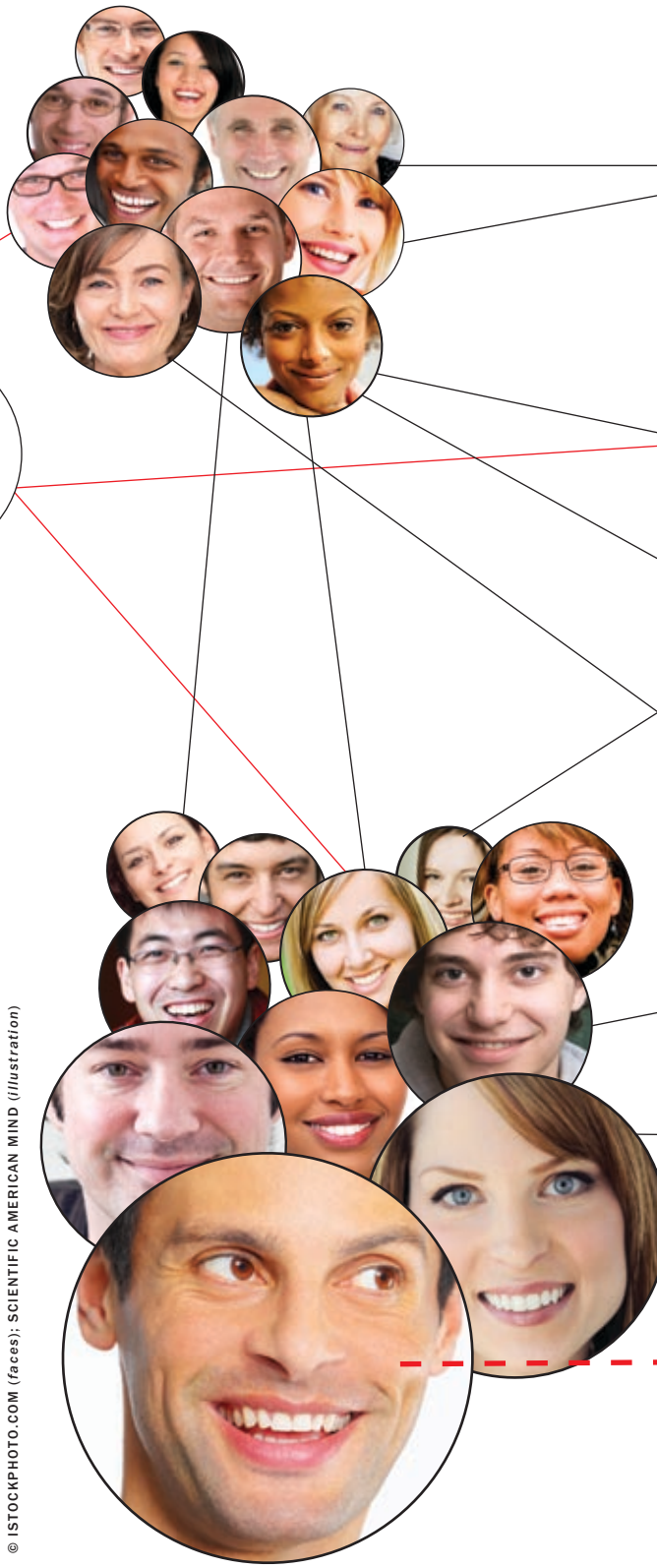
Love the One You're With

Combing through your social network is the most fruitful—and most common—way of finding the love of your life

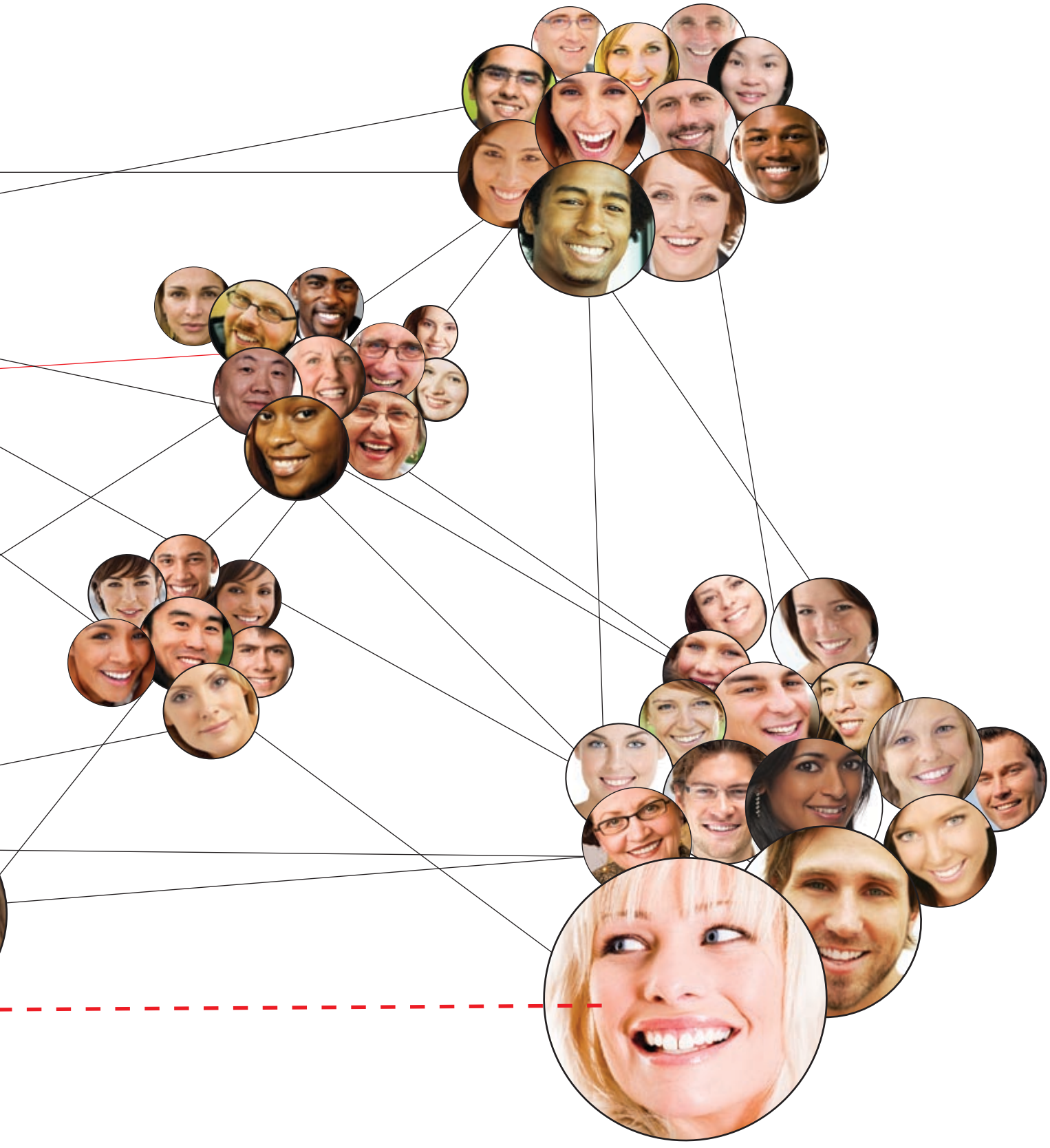
By Nicholas A. Christakis and James H. Fowler



© ISTOCKPHOTO.COM (*faces*); SCIENTIFIC AMERICAN MIND (*illustration*)

Nicholas and his wife, Erika, like to joke that they had an arranged marriage, South Asia–style. Although they lived within four blocks of each other for two years and were both students at Harvard, their paths never crossed. Erika had to go all the way to Bangladesh so that Nicholas could find her. In the summer of 1987 he went to Washington, D.C., where he had grown up and gone to high school, to care for his ailing mother. He was a medical student, single and, he foolishly thought, not ready for a serious relationship. His old high school friend, Nasi, was also home for the summer. Nasi's girlfriend, Bemy, who had come to know Nicholas well enough that her gentle teasing was a source of amusement for all of them, was also there. She had, as it turned out, just returned from a year in rural Bangladesh, doing community development work.

Adapted from the book *Connected: The Surprising Power of Our Social Networks and How They Shape Our Lives,* by Nicholas A. Christakis and James H. Fowler.



In the wood and tin hut where Bemy had spent her year abroad was a beautiful young American woman with whom she shared both a burning desire to end poverty and a metal bucket to wash her hair. You probably know where this story is going. One afternoon, in the middle of the monsoon, while writing a postcard to Nasi, Bemy suddenly turned to her friend Erika and blurted out: "I just thought of the man you're going to marry." That man was Nicholas. Erika was incredulous. But months later she agreed to meet him in D.C., and the four of them had dinner at Nasi's house. Nicholas was, of course, immediately smitten. Erika was "not unimpressed," as she later put it. That night, after getting home, she woke up her sister to announce that she had indeed met the man she was going to marry. Three dates later Nicholas told Erika he was in love. And that is how he came to marry a woman who was three degrees removed from him all along—she was connected to him through two intermediate social ties, a friend of a friend of a friend—someone who had lived practically next door, whom he had never previously met, but who was just perfect for him.

Such a story—with varying degrees of complexity and romance—occurs all the time in our society. In fact, a simple Google search of "How I Met My Wife/Husband" turns up thousands of narratives, lovingly preserved on the Internet. The romantic essence of these stories is that they seem to involve both luck and destiny. But if you think about it, these meetings are actually not so chancy. What all these stories really have in common is that the future partners started out with two or three degrees of separation between them before the gap was inexorably closed.

Matchmakers

We think of falling in love as something deeply personal and hard to explain. Indeed, most Americans believe that their choice of partner is an *individual* choice and really no one else's business. Some people select their partners impulsively and spontaneously; others, quite deliberately. Either way, partner choice is typically seen as a personal decision. This view of relationships is consistent with our general tendency to see life decisions as individual choices. We like to believe we are at the helm of our

Introductions can lead you to love. In one large national survey, about 68 percent of the people sampled were introduced to their spouses by someone they knew.

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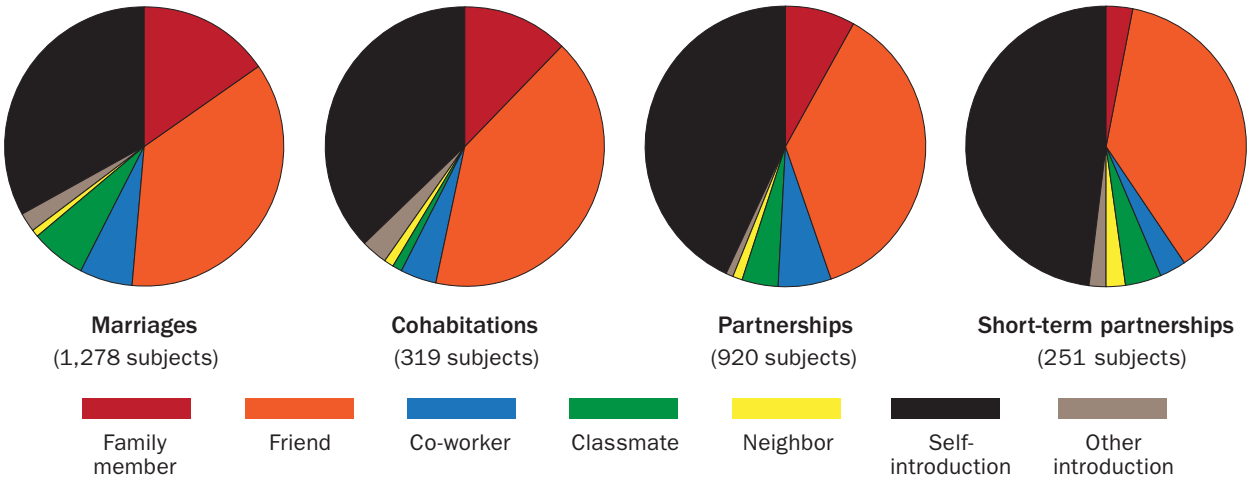
In many stories on the Internet, the future partners started out with two or three degrees of separation between them before the gap was inexorably closed.

Who Introduced the Couple?

A survey of more than 3,400 adults revealed how people met their currrent partners. In most cases, the couples connected through an intermediary. The graphs below show who introduced couples in various types of relationships: marriages, cohabitations, partnerships and short-term partnerships. Family members were more likely to have brokered marriages than briefer couplings. But friendships along with more tenuous ties together bridged the most pairings of any type.



SOURCE: NATIONAL HEALTH AND SOCIAL LIFE SURVEY. NUMBERS DO NOT ADD TO 100 PERCENT BECAUSE OF ROUNDING. ADAPTED FROM *THE SOCIAL ORGANIZATION OF SEXUALITY: SEXUAL PRACTICES IN THE UNITED STATES*, BY E. O. LAUMANN ET AL., UNIVERSITY OF CHICAGO PRESS, 1994

ship, charting an entirely new course, no matter how choppy the seas. It's surprising, and maybe even disappointing, to discover that we are in fact sailing through well-traveled shipping lanes using familiar navigational tools.

Because we are so sure of our individual power to make choices, we lose sight of the extraordinary degree to which our partner choice is in fact determined by our surroundings and in particular by our social network. The assumption that we make our own destiny also explains in part the romantic appeal of stories involving putatively chance encounters, because they seem to suggest that forces larger than ourselves are at work and that romance with a particular, unknown person is also predestined and magical. Now, we are not suggesting there isn't something amazing about meeting the love of your life after washing your hair in a bucket in Bangladesh. It's just that such magical moments are not as random as we might think.

Consider some systematic data about how people meet their partners. The National Health and Social Life Survey, also quaintly known as the Chicago Sex Survey, studied a national sample of 3,432 people aged 18 to 59 in 1992 and provides one of the most complete and accurate descriptions of romantic and sexual behavior in the U.S. It contains detailed information about partner choice, sexual practices, psychological traits, health measures, and so on. It also includes a type of data that is surprisingly very rare, namely, how and where people actually meet their current sexual partners. In most cases, couples in various relationships were introduced by a third party [*see box above*].

The introducers here did not necessarily intend for the two individuals they introduced to become partners, but the introduction nonetheless had this effect. About 68 percent of the people in the study met their spouses after being introduced by someone they knew, whereas only 32 percent met via "self-introduction." Even for short-term sexual partners such as one-night stands, 53 percent were introduced by someone else. So whereas chance encounters between strangers do happen, and people sometimes find their partners without assistance, most find spouses and partners by meeting friends of friends and others to whom they are loosely connected.

Family Ties

Although friends were a source of introduction for all kinds of sexual partnerships at roughly the

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When people meet on their own, say, at a private party, a social preselection process tends to bring together individuals with similar interests, preferences and background.

SABINE LUBENOW *age fotostock*

same rate (35 to 40 percent), family members were much more likely to introduce people to their future spouses than to future one-night stands. And how people meet is also relevant to how quickly they have sex. In the Chicago study, those who met their partners through their friends were slightly more likely to have sex within a month of meeting than those who met through family members. A similar study conducted in France found that couples who met at a nightclub were much more likely to have sex within a month (45 percent) than those who met at, say, a family gathering (24 percent), which is not surprising because typically one does not have sex in mind at family events.

What these data suggest is that people might use different strategies to find partners for different kinds of relationships. Maybe they ask family members for introduction to possible marriage partners and rely on their own resources to meet short-term partners. This idea makes intuitive sense: most drunken college students are not texting their mothers to see if they should invite that cute stranger at the bar home for the night. So what you get when searching your network depends in part on where you are looking and what you are looking for.

It is clear, however, that people rely heavily on friends and family for all kinds of relationships. When you meet a new person on your own, you have information only about yourself. In contrast, when others introduce you, they have information about *both* you and your potential partner, and sometimes they will play the role of matchmaker (consciously or not) by encouraging meetings between people they think will get along. Not only are friends and family very likely to know your personalities, social backgrounds and job histories, but they also know hidden details such as your tendency to leave clothes on the floor or to send roses. The socially brokered introduction is not only less risky but also more informative than going it alone, and it is one reason people have relied on introductions for thousands of years.

Yet in most modern societies, we generally have a negative view of arranged marriages, and we cannot possibly imagine what it would be like to marry a stranger. Well-meaning friends and relatives who nosily interfere in our lives to "help" us find partners are seen as comic figures, such as Yente in *Fiddler on the Roof*. In fact, our friends, relatives and co-workers typically take on a matchmaking role only when they think we are having trouble finding a partner on our own. The reality is, however, that our social network functions quite efficiently as matchmaker, even though we insist we are acting out our own private destiny.

And the structure of real social networks is perfectly suited to generate lots of leads. If you are single and you know 20 people reasonably well (enough that they would invite you to a party), and if each of them knows 20 other people, and each of *them* knows 20 more, then you are connected to 8,000 people who are three degrees away. And one

The reality is that our social network functions quite efficiently as matchmaker, even though we insist we are acting out our own private destiny.

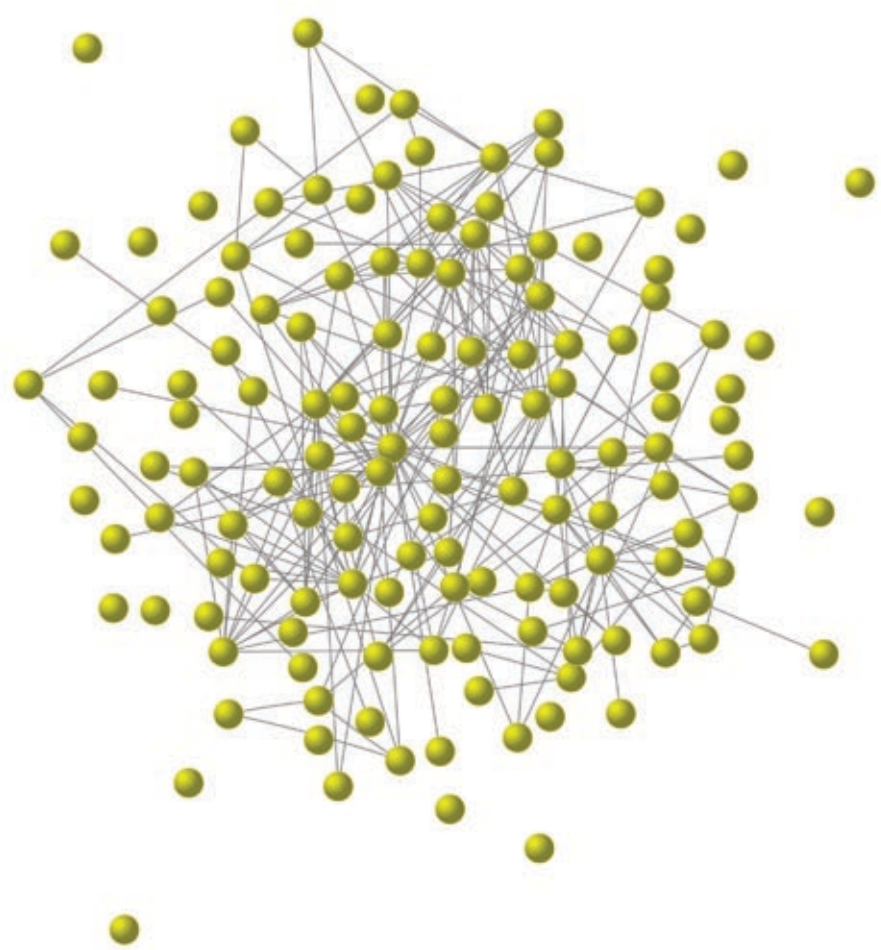
of these men or women is in all likelihood your future spouse.

Of course, random encounters can sometimes bring strangers together, especially when some incidental physical contact is involved. These happy accidents are frequently used as plot devices in romantic stories, whether it's two people grabbing the same pair of gloves in *Serendipity*, an umbrella taken by mistake after a concert in *Howards End* or dogs getting their leashes entangled in *101 Dalmations*. Incidents such as these provide the basis for further social interaction and possibly sex or marriage because they require what sociologist Erving Goffman, formerly at the University of Pennsylvania, called "corrective" rituals to be applied: people have to undo the "damage," and this action in turn means they have to get to know each other. Good flirts are able to turn such happenstances into real opportunities. And the best flirts may even be able to contrive an "accident" to meet someone: they make their own luck. But these chance events are the exception rather than the rule. And it is noteworthy that even these meetings of strangers involve some degree of shared interests, whether in clothing, music or pets, for instance.

Even when individuals meet on their own, without help from mutual contacts, there is a social "preselection process" that affects the kind of people they are likely to run into in the first place. For example, the Chicago Sex Survey also collected data on *where* Americans met their partners. Sixty percent of the people in the study met their spouses

Making Friends

Real-life interpersonal connections form a complex web in which particular people tend to occupy dedicated slots. The illustration at the right shows the close friendships (*gray lines*) among 140 university students (*green circles*). Those closer to the center of the network have friends who also have lots of friends. More peripheral individuals may also have plenty of chums, but those friends have few or no other pals. The more central you are in the network, the fewer hops you'll need to reach anyone else in it—and the more susceptible you are to whatever is flowing in the network, be it gossip or germs.



at places such as school, work, a private party, church or a social club that tend to involve men and women who closely resemble one another in their interests, preferences and background. Ten percent met their spouses at a bar, through a personal ad or at a vacation spot, where there is more diversity but still a limited range of the types of people who might be available to become future spouses.

The location and circumstances under which individuals meet partners have been changing over the past century. Our best data on this trend come from a study conducted in France. Looking across a broad range of venues where people meet spouses, including nightclubs, parties, schools, workplaces, holiday destinations, family gatherings or simply "in the neighborhood," the investigators traced out the change across time. For example, from 1914 to 1960, 15 to 20 percent of people reported meeting their future spouses in the neighborhood, but by 1984 this amount was down to 3 percent, reflecting the decline of geographically based social ties resulting from modernity and urbanization.

The Marriage Benefit

Modern research confirms that marriage is good for you, but the benefits for men and women are different. If we could randomly select 10,000 men to be married to 10,000 women, and if we could then follow these couples over the decades to see who died when, statistical analysis suggests that what we would find is this: being married adds seven years to a man's life and two years to a woman's life.

Recent innovative work by demographer Lee Lillard, formerly at the University of Michigan at Ann Arbor, and his colleagues sociologist Linda Waite of the University of Chicago and economist Constantijn Panis of Deloitte Financial Advisory Services has focused on untangling how and why being married lengthens life. Their research has analyzed what happened to more than 11,000 men and women as they entered and left marital relationships during the period 1968 to 1988. They carefully tracked people from before their marriages until after they ended (either because of death or divorce) and even on to any remarriages. And they closely examined how marriage might confer health and survival benefits and how these mechanisms might differ for men and women.

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The emotional support that spouses provide has numerous biological and psychological benefits. Being near a familiar person can have effects as diverse as lowering heart rate, improving immune function and reducing depression. In terms of gender roles, Lillard and Waite found that the main way marriage is helpful to the health of men is by providing them with social support and connection, via their wives, to the broader social world. Equally important, married men abandon what have been called "stupid bachelor tricks." When they get married, men assume adult roles: they get rid of the motorcycle in the garage, stop using illegal drugs, eat regular meals, get a job, come home at a reasonable hour and start taking their responsibilities more seriously—all of which helps to prolong their life. This process of social control, with wives modifying their husbands' health behaviors, appears to be crucial to how men's health improves with marriage. Conversely, the main way that marriage improves the health and longevity of women is much simpler: married women are richer.

This cartoonish summary of a large body of demographic research may seem quite sexist and out-of-date. It is important to note that these studies involved people who were married in the decades when women had much less economic power than men. Nevertheless, these results point to something more profound and less contentious, namely, that pairs of individuals exchange all kinds of things that affect their health, and such exchanges—as with any transaction—need not be symmetric, either in the type or amount exchanged.

—N.A.C. and J.H.F.

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Random encounters can bring people together, especially when some incidental physical contact is involved. These happy accidents are often used as plot devices in stories.

Geography is even less important with the rise of the Internet. In 2006 one in nine American Internet-using adults—about 16 million—reported using an online dating Web site or other site (such as match.com, eharmony.com or the wonderfully named plentyoffish.com, as well as countless others) to meet others. Of these "online daters," 43 percent—or nearly seven million adults—have gone on actual, real-life dates with men or women they met online, and 17 percent of them—nearly three million adults—have entered long-term relationships or married their online dating partners, according to a systematic national survey. Conversely, 3 percent of the Internet users who are married or in committed relationships reported meeting their partners online, a number that is likely to rise. Gone are the days of the girl next door. We increasingly meet our partners through social networks that are much less constrained by geography than they have been in the past.

Social Space

With the decline in importance of meetings in the neighborhood in the past few decades, people no longer search geographic space for partners. Nevertheless, they still search *social* space. Rather than going from house to house or town to town, we jump from person to person in search of the perfect mate. We see if anyone near us in our network (for instance, our friends, co-workers) is suitable as a partner, and if not, we look further away in the network (our friend's friends, our co-worker's siblings). And we often seek out circumstances, such as parties, that are very likely to result in meeting friends of friends and people still further removed in our network.

We have "weak ties" to friends of friends and other categories of people we do not know very well. But these kinds of ties can be incredibly valuable for connecting us to individuals we do not know at all, giving us a much greater pool from which to choose. The best way to search your network is to look beyond your direct connections, but not so far away that you no longer have anything in common with your contacts. A friend's friend or a friend's friend's friend may be just the right person to introduce you to your future spouse. M

Decoding Dementia

New technologies for spotting Alzheimer's disease are poised to unravel its cause and speed progress toward effective treatments

By Joel N. Shurkin

Kassie Rose, 30 years old, faces a frightening prospect: if a genetic coin toss fails to go her way, she could lose her mind within a decade or two. A mutation that causes Alzheimer's disease runs in her family, the DeMoes of North Dakota. The odds of any DeMoe harboring the mutation are 50–50, and if the mutation is present, the chances of developing early-onset Alzheimer's—the type that erodes memory before age 65—are 100 percent.

Five of the six DeMoe siblings—Rose's father and her aunts and uncles—have the mutation. One man is in a nursing home in his mid-50s; a second, younger, is on his way. A sister in her late 40s is already noticing her first symptoms. The next generation is tortured with the decision of whether to get tested. Rose, for now, chooses not to know. After all, she is unlikely to benefit much from the information: Alzheimer's remains incurable and, largely, unpreventable as well.

But the ability to predict the devastating disease—a disorder that robs about five million people in the U.S. of their memory, identity and ability to function—is of great benefit to science and the quest to find a cure for the ailment. For example, a long-range disease forecast offers scientists the opportunity to watch as the disease progresses from its earliest stages and to link changes in the brain (using imaging techniques) to cognitive problems as a way of tracing the most important biological underpinnings of Alzheimer's.

Only 1 percent of all cases are caused by inherited mutations such as the one that pervades the DeMoe family tree. But on the horizon are novel tests for the much more common late-onset form of Alzheimer's, which is thought to result from multiple interacting genetic and environmental factors, many of which are unknown. Beyond issuing a mere yes-no forecast, the new tests help to paint a picture of the pathology that is otherwise only visible at autopsy, yielding a wealth of biological information that could be used to develop and test antidementia drugs.

And although the new technologies are still experimental, researchers hope they will be able to definitively diagnose Alzheimer's in the living and perhaps even predict when the confusion and loss of memory will begin so that patients and their families can prepare for the ordeal of living with Alz-

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Of the six siblings in the DeMoe family, only Karla (*in red, at left*) is free of the family plague: a mutation that causes early-onset Alzheimer's disease. Clockwise from the back left, Dean, Jamie, Doug, Lori, Brian (Kassie Rose's father) and Karla surround their mother, Gail.

COURTESY OF KARLA DEMOE HORNSTEIN

heimer's. In addition, when—or if—an effective remedy is available, neurologists could begin treatment before the symptoms appear, maybe halting the advance of the disease so its victims can lead long, normal lives and turning the disorder into a mild chronic affliction. Doctors might also target drugs to particular pathologies as they pop up in the brain. Indeed, a large number of potential treatments are in the research pipeline, and investigators believe some of them are likely to be on the market within 10 years.

FAST FACTS

Forecasting Decline

1» New techniques for diagnosing Alzheimer's disease paint a picture of the pathology in the living, yielding biological insights that could be used to develop antidementia drugs.

2» Early diagnosis may enable treatment before symptoms appear—intervention that could halt the advance of the disease. Scientists also hope to target drugs to particular pathologies as they pop up in the brain.

3» A large number of potential treatments are in the research pipeline, and investigators believe some of them are likely to be on the market within 10 years or even sooner.

Scars in the Brain

Near the start of the 20th century in Germany, a homemaker named Auguste Deter showed symptoms of severe dementia at age 51, long before senile dementia commonly occurs. When she died, Alois Alzheimer, a neuropathologist, and his colleague Emil Kraepelin, a psychiatrist, discovered that her brain was riddled with lumpy, oval-shaped clumps outside of neurons—plaques of the protein beta-amyloid—and tangles inside the cells made of a protein that scientists now call tau. In 1906 Alzheimer and Kraepelin agreed to name this combination of memory loss and neuronal scarring Alzheimer's disease.

This landmark case was a form of the disease that runs in families similar to the one that torments the DeMoes. In such cases, mutations in the genes for any of three different proteins—amyloid precursor protein, presenilin 1 or presenilin 2—spawn abnormal amounts of these proteins. (The DeMoe family harbors a mutation in the *presenilin 1* gene on chromosome 14.) How these mutations lead to the buildup of

beta-amyloid is not clear. The abundance of the protein is thought to produce plaques, and the plaques spawn tangles, but the pathway is unknown.

The fact that these genetic alterations create both plaques and tangles and inexorably lead to the disease lends credence to the widely accepted hypothesis that these pathological hallmarks cause the dementia, although some uncertainty remains. For example, scientists are confounded by the fact that as many as 40 percent of older people who are autopsied have plaques and tangles in their brains but showed no sign of dementia when they were alive. Thus, some other pathology, still unknown, might be the cause of Alzheimer's, and the plaques might be either coincidental or a side effect.

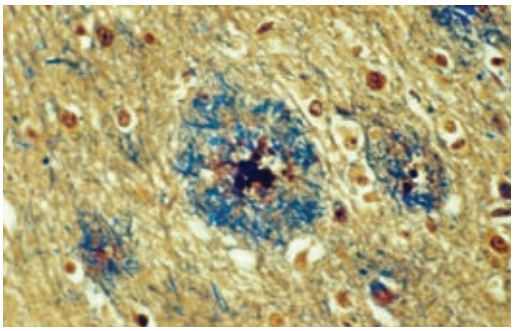
Regardless of the causal role of these lesions, their presence after death remains the most definitive diagnosis of the disorder. In the living, doctors typically spot Alzheimer's from its symptoms along with a physical exam to rule out other causes [*see box on next page*]. Predicting the disease in individuals who have no symptoms has so far been largely limited to people with a family history of the genetic form of the ailment. In these cases, a blood test can reveal whether a patient harbors any of the unfortunate variations of the three culprit genes. If so, he or she will get early-onset Alzheimer's.

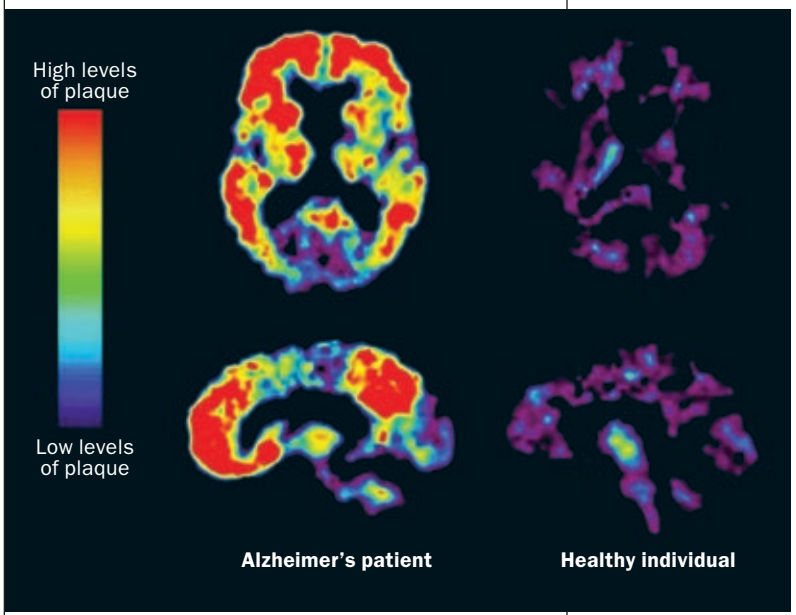
Modern brain scanning has revealed other anomalies—such as shrinkage of certain parts of the brain—associated with the development of Alzheimer's. But the two most promising methods for diagnosing the disease in the general population, especially in its earliest stages when symptoms are mild or absent, pick up the proteins that lead to the tangles and plaque. Both are now being used in some academic medical clinics and large hospitals.

Pictures of Plaque

One of the most promising experimental techniques for early detection, amyloid imaging, was developed five years ago by psychiatrist William Klunk and radiochemist Chester Mathis of the University of Pittsburgh Medical Center. The technique is relatively noninvasive. A doctor injects a radioactive tracer—a substance called Pittsburgh compound B (PiB)—into a vein in a patient's arm. The tracer chemically binds to the amyloid, if it is present, in the patient's brain. Then the person is slid into a positron-emission tomographic (PET) scanner. The tracer bound to the plaques lights up in the scanner image. The result is a picture of the inside of the head that shows how much plaque is present; a little is okay, but too much means trouble. When the process debuted at a meeting of the International Conference on Alzheimer's Disease in Stockholm in 2004, the audience gasped. The difference between a brain with Alzheimer's and a normal, healthy brain was obvious: a few scattered plaques dotted the brain of the normal elderly brain, whereas the Alzheimer's brain was clogged with the lesions [*see illustration above*].

"When a PET scan is positive, we are very certain there is amyloid in the brain," says Klunk, who makes a judgment based on the amount of plaque he sees in the brain, although different scientists set the





At 500-fold magnification, plaques (*blue, at left*) become visible in brain tissue taken from a patient with Alzheimer's disease. In a new diagnostic technique, an injected chemical binds to beta-amyloid in the brain, making plaques (*red, below*) light up in a PET scan.

CECIL H. FOX *Photo Researchers, Inc. (top)*; UNIVERSITY OF PITTSBURGH, PET AMYLOID IMAGING GROUP *(bottom)*

A large number of potential treatments are in the research pipeline, and investigators believe some of them are likely to be on the market within 10 years.

Seven Signs of Decline

Neurologists now determine if a patient has Alzheimer's disease by giving the patient a memory test and then taking an extensive medical history, talking to the family and performing tests to eliminate other possible causes for the cognitive lapses. In this way, doctors accurately diagnose Alzheimer's 90 percent of the time, especially with older patients, according to Nechama Bernhardt, a neurologist in Baltimore specializing in Alzheimer's. Here are some of signs of the memory loss and confusion that characterize the disorder:

- Asking the same questions repeatedly.
- Repeating the same story word for word multiple times.
- Forgetting how to do basic tasks that the person once performed easily, such as cooking, making repairs and playing cards.
- Problems paying bills or balancing a checkbook (assuming these tasks were not previously difficult).
- Getting lost in familiar places.
- Neglecting personal hygiene habits such as bathing or dressing in clean clothes while insisting on having taken a bath or put on a new outfit.
- Relying on someone else to make decisions—such as what to buy at a supermarket or where to go next—that were easily handled in the past.

None of the symptoms above—alone or even in combination—is a sure sign of the disease. But anyone who displays several of these abnormal behaviors should see a specialist for a more thorough examination. —*J.N.S.*

MACDUFF EVERTON *Getty Images*

bar at different levels. In March 2007 scientists at Massachusetts General Hospital reported performing an autopsy on a dementia patient who, when he was alive, had undergone amyloid imaging that revealed abundant plaque in his brain. The autopsy uncovered plaques exactly where the images said they were. In a study published in 2008 Klunk, along with Pittsburgh neurologist Milos D. Ikonomovic and their colleagues, replicated the finding, showing the same match in the placement and amount of plaque in an autopsy of another patient who had undergone scanning before he died.

PiB is expensive, costing thousands of dollars for a test, and requires equipment most hospitals do not have, adding to the potential expense. A change in the source of radioactivity would lessen the cost—and new sources, substances with longer half-lives, are in the pipeline, which should allow wider use.

Chemical Clues

Researchers are also testing a competing technique, involving the use of spinal taps. This method is more invasive, requiring a needle inserted in the lower back to collect cerebrospinal fluid (CSF), the liquid that bathes the brain and spinal cord, which is then analyzed for the quantity of beta-amyloid and tau proteins. The less amyloid in the CSF, the more of it is likely to be in the brain and the greater the likelihood of Alzheimer's. In contrast, having more tau in the CSF raises a person's risk. Scientists make the call based on certain threshold levels of these proteins, although the exact concentration cutoffs for diagnosing Alzheimer's vary among medical centers.

The method holds particular promise for predicting dementia in people with ambiguous signs of cognitive decline. In a study of 750 patients with mild symptoms of dementia published this year, neuroscientist Niklas Mattsson of Sahlgrenska University Hospital in Sweden and his colleagues showed that the technique is sensitive enough to accurately predict, at least 80 percent of the time, which patients would progress to full-blown Alzheimer's in a year or two. In another study published this year psychiatrist Volker Welge and his colleagues at the University of Duisburg-Essen in Germany examined the CSF of 156 individuals for two forms of beta-amyloid and tau. In 94 percent of the cases, a peek at these proteins enabled the researchers to differentiate Alzheimer's from other forms of dementia, such as those caused by other disorders, as assessed by symptoms or pathology

after death. The test proved superior to the current method of physical exams and medical histories.

Although spinal taps can be painful and risky, research indicates that the CSF test may be more accurate than the tracer technique for predicting Alzheimer's, says neurologist Randy Bateman of Washington University in St. Louis who is actively studying the technique. The spinal tap technique is also cheaper than a PET scan.

Working out which method is best is one goal of the ongoing Alzheimer's Disease Neuroimaging Initiative, which began in 2004. The initiative represents the most comprehensive effort to date to determine the best diagnostic techniques and to identify the biological signs of the behavioral changes associated with mild cognitive impairment and Alzheimer's. At 59 U.S. research centers, doctors examine cognitively impaired patients and healthy volunteers—819 in all—using both the tracer technique and the spinal fluid method.

BSIP/PHOTOTAKE

An invasive method involving a spinal tap is sensitive enough to accurately predict, at least 80 percent of the time, which patients will progress to full-blown Alzheimer's disease in a year or two.

The results of these studies flow into a central computer at the University of California, Los Angeles, neuroimaging lab, where they are accessible to scientists everywhere on the Internet. The research database is enormous: the U.C.L.A. computer holds more than 32,000 magnetic resonance and PET scans. So far the study has confirmed that the new techniques are indeed better than the present method of diagnosing Alzheimer's but has not ruled on their efficacy otherwise.

In the future, scientists hope the data will tie changes in a brain image or spinal fluid test with worsening cognition. If the connection is clear, it might be possible to design drugs that target specific pathologies as the disease progresses. (Most drugs now try to aim at the plaques; none seem to work against the tangles.) What is more, if a medication's efficacy can be assessed early on using a PET scan or spinal tap, then such a technique could cut the cost and length of drug trials dramatically. Doctors might also use such a method to more rapidly assess whether a particular medication is working in an individual patient.

Drugs for Thought

Although there is no cure for Alzheimer's, a few medications seem to slow its progression in some patients. So-called cholinesterase inhibitors such as Aricept slow the metabolic breakdown of acetylcholine, a chemical involved in nerve cell communication. Alzheimer's patients typically have low levels of acetylcholine. Slowing the breakdown of the chemical enhances communication between nerve cells and can, in some patients, retard cognitive decline.

Another drug, Namenda, approved for moderate to severe Alzheimer's, protects healthy nerve cells from the excitatory neurotransmitter glutamate. Damaged neurons, such as those affected by Alzheimer's, release glutamate in massive quantities that essentially stimulate other cells to death.

Nevertheless, many neurologists say that the current drugs' effects on a patient's symptoms are modest at best. "If you put a patient on a drug and took the same patient in a parallel universe without the drug, you might see a difference, but not much," says Baltimore neurologist Nechama Bernhardt.

Several therapeutic vaccines that target Alzheimer's plaques and tangles are now in clinical trials. Unlike traditional vaccines, which prevent

(The Author)

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disease, these substances are designed to combat it after it appears by stimulating the immune system to destroy the disease-causing proteins. In 2002 Wyeth, working with Elan Pharmaceuticals, had to discontinue testing of a vaccine consisting of beta-amyloid itself, because a few of the subjects developed inflammation in the brain. Nevertheless, the vaccine did slow accretion of the plaques and retard progression of the disease. Wyeth redesigned the vaccine, and testing has resumed.

One controversial drug now in late-stage clinical trials is Dimebon (dimebolin), which improves mitochondrial function and seems to inhibit brain cell death. The drug, an antihistamine, was developed in Russia, and not all Western investigators think that promising preliminary data on the drug meet Western standards. Pfizer and a small San Francisco company, Medivation, are sponsoring the trial. And many more drug candidates are in the offing: the Web site clinicaltrials.gov lists 675 clinical trials of various Alzheimer's treatments and diagnostic aids.

Although scientists hope that early detection of Alzheimer's will help them target preventive measures to the right people, no lifestyle remedy has yet been proven to slow the cognitive decline characterizing the ailment. Some widely publicized studies hint at the "use it or lose it" theory, which says that individuals who use their brains—by doing everything from solving crossword puzzles to writing novels—can slow the progression of the disease. In its early stages Alzheimer's has not prevented creative people from working. Norman Rockwell kept painting, Iris Murdoch kept writing, and Terry Pratchett, the English fantasy writer, is still writing and raising money for Alzheimer's research. But the idea that engaging in intellectual tasks can significantly forestall dementia remains undocumented.

Being physically fit may keep the mind sharp. Exercising promotes cardiovascular health and thus good blood flow to the brain. A steady supply of oxygenated blood is likely to bolster the function of healthy brain cells.

VICKY KASALA *Getty Images*

Linking Hearts and Minds

Nevertheless, maintaining cardiovascular health—and therefore good blood flow to the brain—may improve the function of the healthy neurons that remain. Both cardiovascular disease and Alzheimer's also share risk factors, including high cholesterol. Thus, being physically fit might be beneficial generally for maintaining a sound mind. "If you can maintain heart health, it's going to help," Klunk says. "It won't stop the amyloid, but you might live with it for a longer time." [See "Fit Body, Fit Mind?" by Christopher Hertzog, Arthur F. Kramer, Robert S. Wilson and Ulman Lindenberger; Scientific American Mind, July/August 2009.]

A 2005 population study by researchers in Finland and Sweden called out obesity in mid-life, high blood pressure and high cholesterol as key risk factors for developing dementia within two decades—another piece of data suggesting that heart health and brain health are linked. In addition, at least one genetic quirk connects brain health to heart health: people who have a variant called *ApoE4* of the gene for apolipoprotein E, a protein involved in lipid metabolism, appear to be more susceptible to both atherosclerosis and Alzheimer's.

Cardiovascular conditioning might help on another front if, as some believe, Alzheimer's is linked to diabetes. In diabetes, the body fails to make, or

A 2005 study called out obesity, high blood pressure and high cholesterol as key risk factors for developing dementia within two decades—a hint that heart health and brain health are linked.

STEPHEN CROWLEY *New York Times*/Redux Pictures

Ronald Reagan, who served as president of the U.S. from 1981 to 1989, was diagnosed with Alzheimer's disease after he left office.

becomes resistant to, the hormone insulin, which converts sugars, starches and other food into energy. Neurobiologist William L. Klein and his colleagues at Northwestern University showed in 2008 that beta-amyloid severely disrupts insulin signaling, which is important for memory functioning, in neuronal cell cultures, suggesting that a brain-specific form of diabetes may play a role in Alzheimer's. Consistent with this idea, those with diabetes stand a higher than average chance of the disease developing. Thus, habits such as exercise and healthy eating that can cut a person's risk of diabetes may also lower his or her chances of developing Alzheimer's.

For the DeMoes, proven preventive measures cannot come too soon. Rose's aunt, Lori McIntyre, 49, is already experiencing worrisome difficulties. "It is frustrating," McIntyre says. "One day you know something, the next day, poof, you just don't. Sometimes it just gets to you." As with many Alzheimer's patients, she is taking medication for depression. There are personality changes, she adds: "You lose interest in certain things like golfing or doing fancy work. You aren't as good at things as you used to be and tend to steer away from them. You repeat things a lot. There is confusion. It takes twice as long to get the day in order."

The unlucky ones in the family who test positive before their memory wanes just wait and worry. Did I forget my keys because of normal aging, or is my lapse the first sign of the slide into what Ronald Reagan, himself a victim, described as the "sunset?" Why did her name slip my mind? Why did I miss that turnoff? Rose, who recently married, knew that if she tested positive she would not allow herself to become a mother. "I wanted a normal life," she says. And amid this uncertainty, she gave birth to a child, now a toddler, named Briana. M

(Further Reading)

- **Decreased Beta-Amyloid 1-42 and Increased Tau Levels in Cerebrospinal Fluid of Patients with Alzheimer Disease.** T. Sunderland et al. in *Journal of the American Medical Association,* Vol. 289, No. 16, pages 2094–2103; April 23, 2003.
- **Imaging Brain Amyloid in Alzheimer's Disease with Pittsburgh Compound-B.** W. E. Klunk et al. in *Annals of Neurology,* Vol. 55, No. 3, pages 306–319; March 2004.
- **Cardiovascular Disease and Alzheimer's Disease: Common Links.** M. J. Stampfer in *Journal of Internal Medicine,* Vol. 260, No. 3, pages 211–223; September 2006.
- **Post-mortem Correlates of *in Vivo* PiB-PET Amyloid Imaging in a Typical Case of Alzheimer's Disease.** Milos D. Ikonomovic et al. in *Brain,* Vol. 131, No. 6, pages 1630–1645; June 2008.
- The central hub for all news and research about Alzheimer's disease is at **www.alzforum.org**

Meditation on Demand

New research reveals the cell mechanisms underlying a meditative state

By Peter B. Reiner

In the fall of 2005 the Dalai Lama delivered a lecture at the annual meeting of the Society for Neuroscience in Washington, D.C., highlighting the areas of convergence between neuroscience and Buddhist thought about the mind. He took the opportunity to remind the audience that not only is he a Buddhist monk but that he is also an enthusiastic proponent of modern technology. [For more on the Dalai Lama's lecture, see "Meditations on the Brain," by R. Douglas Fields; Scientific American Mind, February/March 2006.]

Elaborating, the spiritual leader of Tibet explained to the audience of scientists that although he meditates for four hours every morning, it is hard work. He divulged that if neuroscientists could find a way to put electrodes in his brain and create the same outcome he gets from meditating, he would be an eager volunteer. Now a set of experiments from researchers at the Massachusetts Institute of Technology and Stanford University moves us a step closer to making his wish a reality. The neuroscientists managed to induce in mice a brain-wave pattern associated with meditation—answering a long-standing question about how this pattern is generated and theoretically laying the groundwork for a cognitive-enhancement technology that could mimic meditation's effects.

To better understand how the new work relates to meditation, it helps to review some earlier studies. The Dalai Lama's keen interest in neuroscience has been reciprocated by at least some members of the neuroscience community, who reason that studying people who meditate might lead to novel

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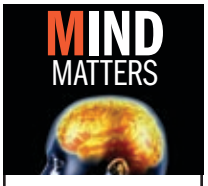

This article was adapted from Mind Matters, www.ScientificAmerican.com/MindMatters, a column edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, and Jonah Lehrer, the science writer behind the blog The Frontal Cortex, http://scienceblogs.com/cortex

FAST FACTS

Rhythm of Serenity

1» **Regular deep meditation changes the brain in positive ways. This type of meditation seems to be associated with gamma waves, the electromagnetic rhythm of neurons firing very rapidly in harmony.**

2» **Neuroscientists have pinpointed the cells responsible for producing these gamma rhythms and demonstrated a technology that can induce the brain-wave pattern in mice.**

3» **In the future it might be possible to use this technology to reproduce some of the beneficial effects of meditation.**

insights about the workings of the human brain.

From the perspective of neuroscience, meditation can be characterized as a series of mental exercises by which a person strengthens control over the workings of his or her own brain. The simplest of these practices is focused attention, during which one concentrates on a single object or experience—say, one's breathing. Many studies have described how the ability of long-term meditators to focus and attend to tasks differs from people who are new to the practice. For instance, expert meditators perform better on rapid-fire visual tests because they avoid the common pitfall known as attentional blink, which causes most people to miss a second target because they focus too long on the first. [For more about the neuroscience of meditation, see "Searching for God in the Brain," by David Biello; SCIENTIFIC AMERICAN MIND, October/November 2007.]

Thinking about Thinking

But focused-attention meditation is fairly basic compared with the kind of contemplation conducted by experienced Buddhists. Called open-monitoring meditation, this advanced method is, in many ways, a form of metacognition—the objective is not to focus one's attention but rather to use one's brain to monitor the universe of mental experience without directing attention to any one task. Psychologist Richard Davidson led a seminal study of open-monitoring meditation at his laboratory at the University of Wisconsin–Madison.

Using electroencephalographic (EEG) recordings, Davidson and his colleagues compared long-term Buddhist practitioners with students who had been introduced to the principles of meditation a week before the study and were instructed to practice an hour a day. The findings, reported in *Proceedings of the National Academy of Sciences USA* in 2004, were unexpected: the long-term meditators' brain waves (the electrical oscillations indicative of neural activity) were in sync at unusually high speed. Brain waves, which signify groups of neurons firing in relative harmony, occur at different speeds—slow delta waves happen only in dreamless sleep, for example, and rapid beta waves occur during concentration and cognition. Gamma waves are the fastest of the bunch, and in normal people they happen only in very short bursts during REM sleep and, rarely, waking cognition. The Davidson study was remarkable in that it showed that long-term meditators are able to produce sustained gamma activity in a manner that had never been previously observed in a human being. As such, sustained gamma activity emerged as a proxy for at least some aspects of the meditative state.

If sustained gamma rhythm is a hallmark of meditation, could we achieve "meditation on demand" for the Dalai Lama by inducing gamma waves in the brain? Perhaps—but first researchers must tease out how exactly gamma rhythm is produced in the brain. This mechanism is precisely what the new studies defined and replicated.

In two new studies published in *Nature* in June, the laboratories of Christopher I. Moore and Li-Huei Tsai at M.I.T. and Karl Deisseroth at Stanford tested and confirmed the hypothesis that gamma rhythm results from the activation of fast-spiking interneurons, so named because they fire at a higher than normal rate and have short, local connections within the cerebral cortex, the outer layer of gray matter responsible for higher cognition. The experimenters utilized optogenetics—combining optical (light-based) and genetic techniques to investigate the brains of living animals. They developed viruses that infected only the fast-spiking interneurons of either the prefrontal cortex or the barrel cortex (the area that processes sensory input from a rodent's whiskers) in mice.

The virus delivered an engineered gene that made the target cells sensitive to light. Then the researchers inserted fine optical fibers into the relevant region of the mouse cortex, allowing light to be delivered to the infected neurons and thereby activating only the fast-spiking interneurons. In essence, this procedure allowed them to switch particular brain cells on and off with exquisite temporal and spatial control. In both experiments, selectively

> The long-term meditators' brain waves were in sync at **unusually high speed**.

(The Author)

PETER B. REINER is professor of neuroethics at the National Core for Neuroethics at the University of British Columbia. He specializes in the field of cognitive enhancement.

The Dalai Lama urged neuroscientists to find a way to use technology to induce in the brain the benefits of arduous meditation. A new study in mice may point the way to such technology.

AMIT SHAH *laif/Redux Pictures*

stimulating the fast-spiking interneurons evoked gamma oscillations, thereby confirming the hypothesis that these neurons drive the gamma rhythm.

Riding the Waves

The sustained gamma activity evoked in these mice is, of course, highly reminiscent of the type of electrical activity recorded from the long-time meditators practicing the elusive phenomenon of open-monitoring meditation. That being said, sustained gamma activity is not identical to meditation—so this experiment alone (despite the elegant methods used) clearly does not satisfy the Dalai Lama's challenge to the neuroscience community to develop a technological replacement for the many hours spent immersed in contemplative thought.

Given the growing body of evidence that suggests that even short-term meditation improves measures of attention, however, these new experiments provide an interesting twist to the growing field of cognitive enhancement. If gamma-wave synchrony is indeed responsible for some of meditation's beneficial effects on the brain, inducing such rhythms artificially might result in similarly desirable outcomes. In addition, abnormal gamma synchronization is a hallmark of disorders such as autism and schizophrenia, and it may contribute to altered cognition in these and other mental illnesses. Thus, developing a technology that could correct the gamma rhythm could be invaluable for clinical treatment.

How long will it be before a new version of this technology is available for human consumption? It is hard to imagine anyone but the most ardently progressive technophile signing up to have genetically engineered viruses and optical probes inserted into his or her brain. But it is worth remembering that both deep-brain stimulation, whereby implanted electrodes act as a kind of pacemaker in the brain, and transcranial magnetic stimulation, in which powerful magnetic fields are transmitted through the skull to affect brain activity, are rapidly moving from the lab to the clinic. Both these techniques represent relatively crude forms of brain stimulation.

Still, the emerging field of optogenetics is advancing very quickly. One recent paper in *Neuron* demonstrated that neurons can be infected and optical fibers implanted safely in nonhuman primates. At the very least, it is safe to say that the prospect of using advanced technology to mimic at least some of the brain activity present during meditation states has moved from the realm of science fiction to that of scientific possibility. **M**

(Further Reading)

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Foreign Afflictions

Do psychological disorders differ across cultures?

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

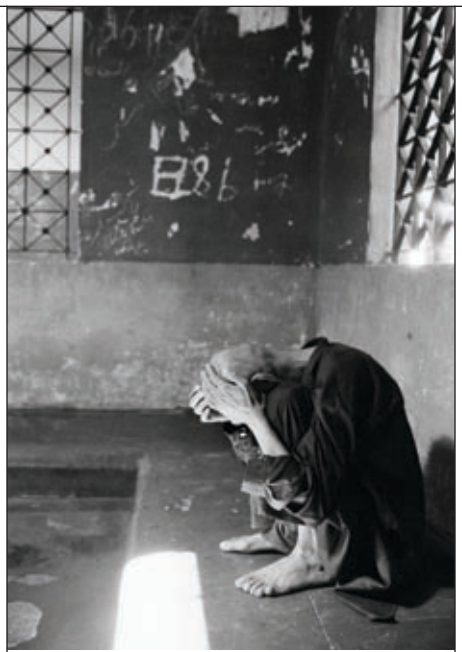
LET US START with a little quiz. How many of these conditions have you heard of?

Taijin kyofusho, hikikomori, hwa-byung, or *qi-gong* psychotic reaction.

If your score was 0 out of 4, do not feel bad: your culture may be to blame. The first two conditions are mental illnesses largely endemic to Japan; the second two are endemic to China. Psychological disorders, or at least our labels for them, differ across cultures. But are these and other non-Western conditions truly distinct from those in the U.S. and Europe? Or does every mental malady, no matter how foreign-sounding in name, vary only in minor ways from a problem that is more familiar to us, such as depression or schizophrenia?

The evidence to date strongly suggests that culture can influence the expression of mental illnesses. Whether radically different cultures can give rise to entirely new psychiatric disorders, however, is a matter of fierce debate.

This issue is of more than academic importance. Psychotherapists often consider cultural differences in their treatment, to be sure, but they typically assume that depression, for example, looks pretty much the same everywhere with minor exceptions. If so-called culture-bound syndromes—mental illnesses that are specific to a particular society—are merely variations of Western disorders, then mental health professionals in Western countries can safely continue to draw on existing knowledge about familiar disorders to treat them. In contrast, if some psychiatric ailments are entirely distinct from those in Western countries, psychologists and psychiatrists may need to start from scratch in figuring out how best to treat them.



Similar Syndromes

In the past century the presumed role of culture in mental illness has swung from one extreme to the other. For decades many cultural anthropologists, sociologists and psychologists assumed such enormous diversity in psychiatric disorders across the globe that they were skeptical of any attempts to classify them. But that viewpoint came under serious scrutiny in 1976, when Harvard University anthropologist Jane Murphy reported powerful evidence that some syndromes did, in fact, seem to cross cultural lines.

Murphy examined two very different societies—a group of Yorubas in Nigeria and a group of Inuit Eskimos near the Bering Strait—that had experienced essentially no contact with modern culture. Yet these populations had names for disorders that appeared strikingly similar to schizophrenia, alcoholism and psychopathy. For example, the Inuit used the term "*kunlangeta*" to describe someone (usually a man) who lies, cheats and steals, is unfaithful to women and does not obey elders—a sketch very much like that of a Western psychopath. When Murphy asked one of the Inuit how the group typically dealt with such an individual, he replied that "somebody would have pushed him off the ice when no one was looking." Apparently the Inuit are no fonder of psychopaths than we are.

Later research bolstered Murphy's conclusion. But the idea that some mental illnesses are present in both Western and non-Western cultures does not preclude the possibility that some disorders might exist only in certain societies. Indeed, in 1994 the American Psychiatric Association introduced an appendix of 25 culture-bound syndromes into the fourth edition of its *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-IV*).

But just as soon as this appendix appeared, many scientists contested the notion that culture-bound syndromes are unique conditions, arguing that some or perhaps even all might be variants of disorders already known in Western culture by different labels. For example, some seal hunters in Greenland experience a condition called kayak angst, character-

(Psychotherapists ought to give further consideration to learning more about **cultural influences** on mental illness.)

COURTESY OF SCOTT O. LILIENFELD (*top*); COURTESY OF HAL ARKOWITZ (*bottom*); CHRIS STEELE-PERKINS *Magnum Photos (mental patient)*

ized by feelings of panic out in the ocean, along with an intense need to seek security back on land. Although kayak angst appears on some lists of culture-bound syndromes, it strongly resembles the Western condition of panic disorder with agoraphobia, which is marked by extreme fear of situations in which escape would be difficult in the event of a sudden surge of overwhelming fear.

Another possible Western illness in disguise is *taijin kyofusho,* which appeared in our quiz and is also listed in the *DSM-IV* appendix of culture-bound syndromes. *Taijin kyofusho* is an anxiety disorder, common in Japan, marked by a fear of offending other people, typically by appearance or body odor. *Taijin kyofusho* may be an Asian form of social phobia (also called social anxiety disorder), in which people dread behaving in a fashion that is potentially embarrassing—say, making a gaffe when speaking or performing in public. Because Japanese tend to be more concerned with group harmony and cohesiveness than are Westerners, *taijin kyofusho* may be a form of social phobia in a culture that is especially sensitive to the feelings of others.

Distinct Disorders?

Nevertheless, some culture-bound syndromes may be sufficiently different from Western disorders to merit separate diagnostic criteria [*see box on this page*]. In the bizarre condition of *koro,* found primarily in Southeast Asia and Africa, people fear that their sexual organs are disappearing or shrinking. *Koro* sometimes spreads in waves of mass panic and is triggered by marked anxiety. In the Malaysian condition of *amok,* which has given rise to the expression "running amok," afflicted individuals, almost all of whom are males, often respond to a perceived slight by withdrawal and brooding, followed by frenzied and uncontrolled violence.

And in the disorder of "2-D love," recently reported in Japan and some other countries, men develop what appear to be amorous relationships with animated female characters; they may carry around pillows or other tangible reminders of these characters wherever they go. Whether these mysterious maladies bear any underlying commonalities to well-documented Western psychiatric illnesses is unknown. *Koro,* for example, could be a type of hypochondriasis (hypochondria), but this possibility has received little systematic research.

Scientific disagreements aside, experts concur that culture can shape the overt expression of mental illness in significant ways. As a consequence, psychotherapists ought to give further consideration to learning more about cultural influences on mental illness and incorporating them into their treatment plans. Meanwhile scientists should use personality and laboratory tests to investigate the causes and manifestations of culture-bound syndromes to determine which of these disorders, if any, are distinct from those in Western culture. If some of these syndromes turn out to be unique, mental health professionals may need to construct and implement psychological interventions that differ in significant ways from those we recognize. M

Cultivated Madness?

Some mental illnesses, such as those listed below, have no direct counterpart in our society. Scientists debate whether such ailments are distinct from problems that plague Westerners or whether they include hidden facets that will eventually tie them to illnesses we know all too well.

Name of Condition	Principal Region(s) in Which It Has Been Reported	Clinical Features
Hikikomori	Japan	Extreme social withdrawal
Dhat	India, Pakistan	Anxiety, fatigue, worries about loss of semen
Hwa-byung	Korea	Insomnia, fatigue, indigestion, aches and pains, other physical symptoms, all attributed to suppressed anger
Latah	Malaysia, Southeast Asia	Sudden and extreme startle reactions, followed by loss of control, profanity and mimicking of others
Windigo	Central and Northeast Canada, Native American populations	Extreme anxiety, along with fears of cannibalizing others
Qi-gong psychotic reaction	China	Sudden loss of sense of reality following certain meditative practices
Ataque de nervios	Latin America	Shouting, trembling, cursing, feelings of loss of control and fear, sometimes accompanied by violent or suicidal behavior

SCOTT O. LILIENFELD and HAL ARKOWITZ serve on the board of advisers for *Scientific American Mind.* Lilienfeld is a psychology professor at Emory University, and Arkowitz is a psychology professor at the University of Arizona.

Send suggestions for column topics to editors@SciAmMind.com.

(Further Reading)

- **The Culture-Bound Syndromes: Folk Illnesses of Psychiatric and Anthropological Interest.** Edited by Ronald C. Simons and Charles C. Hughes. D. Reidel/Kluwer Academic Publishers, 1985.
- **Research on Culture-Bound Syndromes: New Directions.** Peter J. Guarnaccia and Lloyd H. Rogler in *American Journal of Psychiatry,* Vol. 156, No. 9, pages 1322–1327; September 1999.

The Color of Sin

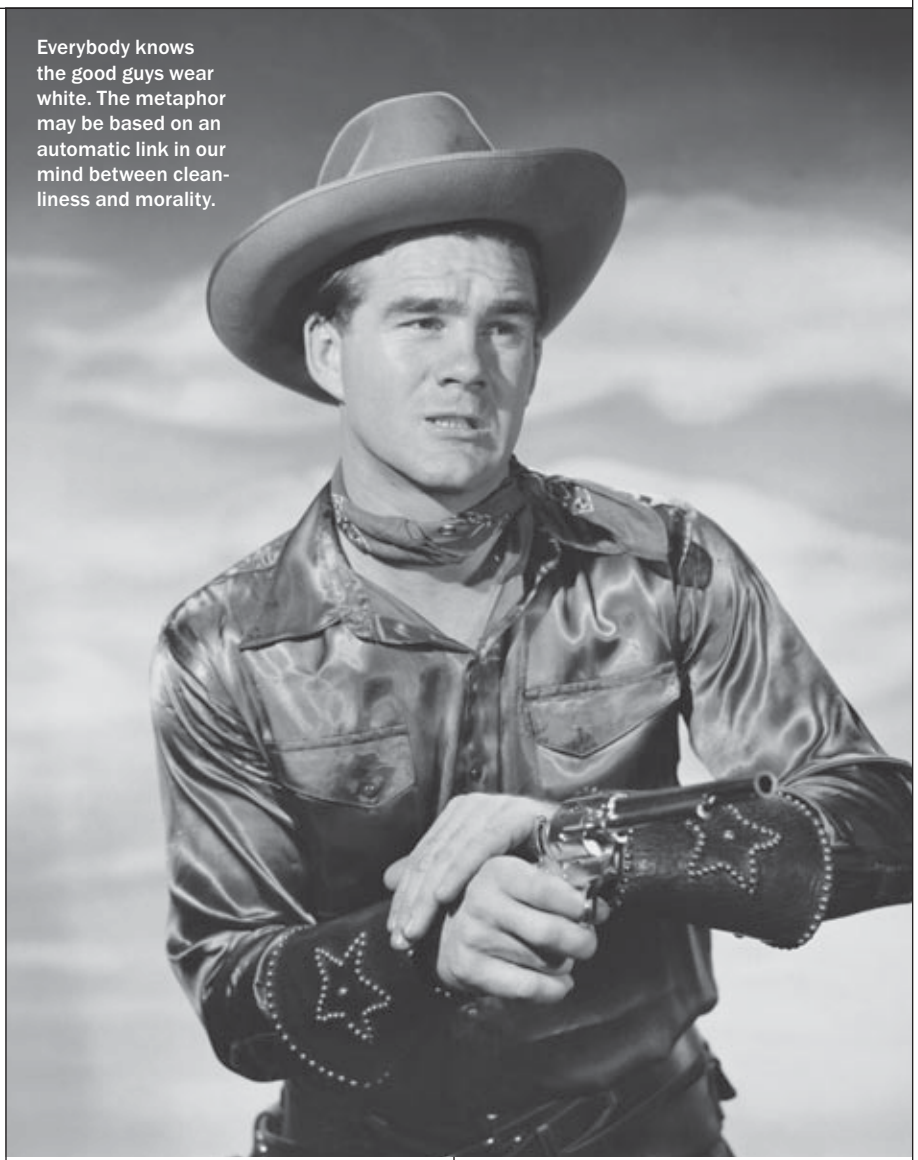
Ancient fears of filth and contagion may explain why we think of morality in black and white

BY WRAY HERBERT

WHEN THE CHRYSLER car company released a new model of its Dodge Coronet in 1967, the theme of its advertising campaign was the "White Hat Special." Some of the ads featured cartoon cowboys riding around "keepin' the prices low," whereas others had the ubiquitous "Dodge Girl" in her signature white Stetson, chirping: "Only the good guys could put together a deal like this."

These ads did not need any elaboration. Madison Avenue knew that potential buyers had all been raised on film and TV Westerns and were familiar with the symbolism of white hats. Roy Rogers, Gene Autry, the Lone Ranger—these cinematic heroes wore white hats, and bad guys wore black. It was all very simple.

Simple, but maybe not all that original. The colors white and black have carried layers of moral meaning since long before Americans' infatuation with cowboys and automobiles. Indeed, some scientists believe that our conception of blackness and sin may be entangled with a fundamental and ancient fear of dirt and contagion that remains deeply wired in our neurons today.



Everybody knows the good guys wear white. The metaphor may be based on an automatic link in our mind between cleanliness and morality.

MATT MENDELSON (*Herbert*); SUPERSTOCK *Getty Images* (*cowboy*)

Mental Mismatch

Two University of Virginia psychologists recently decided to explore this provocative idea in the laboratory. Gary D. Sherman and Gerald L. Clore wanted to know if common metaphors may be more than mere rhetorical devices, if in fact they might be deep embodiments of moral thinking. They decided to test the link between white and virtue (and black and sin) as part of this larger question.

The psychologists adapted a reaction-time test from the 1930s called the Stroop test. You may know it from the Internet, where it circulates as a kind of parlor game. In the test the names of colors are printed in a mismatched color—say, the word "blue" may be yellow in hue—and you must very quickly indicate the color rather than the word's meaning. The task is hard because our mind wants to read the word, and slow reaction time is taken as a sign of cognitive disconnect or conflict.

In Sherman and Clore's version of the Stroop, volunteers read not the names of colors but words with strong moral overtones: greed and honesty, for example. Some of the words were printed in black and some in white, and they flashed rapidly on a screen. As with the original Stroop, a fast reaction time was taken as evidence that a connection was mentally automatic and natural; hesitation was taken as a sign that a connection did not ring true. The researchers wanted to see if the volunteers automatically linked immorality with blackness, as in black ink, and virtue with whiteness.

And they did, so quickly that the con-

Think of the metaphor "**new-fallen snow**." It is not only white, it is also virginal and unadulterated.

People who most strongly associate the color white with moral goodness also express the strongest desire for personal cleaning products such as soap and toothpaste.

NICHOLA EVANS *Getty Images*

nections could not possibly be deliberate. When moral words were printed in white and immoral words in black, reaction time was significantly faster than when words of virtue were black and sin were white. Just as we unthinkingly—almost unconsciously—"know" a lemon is yellow, we instantly know that sin and crime are black and that grace and virtue are white.

Dirt and Sin

Why would this intrinsic association exist? One possibility is that the metaphor is more complex, embodying not just right and wrong but purity and contagion, too. Think of the metaphor "new-fallen snow." It is not only white, it is also virginal and unadulterated, like a wedding dress. And blackness not only discolors it, it stains it, taints its purity. With this in mind, the psychologists ran another experiment, adding this dimension of contagion, of feeling morally "dirty." They deliberately primed some volunteers' immoral thoughts by having them read a story about a self-serving, immoral lawyer and then compared them with volunteers primed for ethical thinking.

The idea was that people who were feeling morally dirty would be quicker to make the connection between immorality and blackness on the moral Stroop test, which is exactly what the researchers found. And what's more, they found the link using much looser definitions of morality and immorality—including words such as dieting, gossip, duty, partying, helping, and so forth. In other words, those primed for misbehavior linked blackness not only with crime and cheating but with being irresponsible, unreliable, self-centered slackers.

This result offers pretty convincing evidence in itself that the connection between black and bad is not just a metaphor we all have learned over the years, but rather it is deeply associated with our ancient fear of filth and contagion. But Sherman and Clore wanted to look at the question yet another way. If the association between sin and blackness really does reflect a concern about dirt and impurity, then this association should be stronger for people who are preoccupied with purity and pollution. Such fastidiousness often manifests as personal cleanliness, and a proxy for personal cleansing might be the desire for cleaning products. The researchers tested this string of psychological connections in a final study, again ending with the Stroop test.

The results were unambiguous. As reported in the August issue of *Psychological Science*, those who expressed the strongest desire for an array of cleaning products were also those most likely to link morality with white and immorality with black. But here is the really interesting part: The only products to show such an association were Dove soap and Crest toothpaste, products for personal cleanliness. Items such as Lysol and Windex did not activate the sin-blackness connection. In short, concerns about filth and personal hygiene appear central to seeing the moral universe in black and white.

These findings have obvious implications for our understanding of racial prejudice. Although scientists have not yet investigated whether people of different races perform the same way on the moral Stroop test, research on other types of unconscious associations has shown racial differences [see "Buried Prejudice," by Siri Carpenter; Scientific American Mind, April/May 2008]. As Sherman and Clore note, this country once had a "one drop of blood" rule, which meant that even a trace of African lineage "tainted" an otherwise white lineage. These official practices may be gone, but this new study may help explain why black is linked to immorality and impurity on a fundamental level in many people's minds. M

For more insights into the quirks of human nature, visit the "We're Only Human . . ." blog and podcasts at www.psychologicalscience.org/onlyhuman

WRAY HERBERT is director of public affairs for the Association for Psychological Science.

(Further Reading)

◆ **The Color of Sin: White and Black Are Perceptual Symbols of Moral Purity and Pollution.** Gary D. Sherman and Gerald L. Clore in *Psychological Science,* Vol. 20, No. 8, pages 923–1048; August 2009. Published online July 8, 2009.

Brainy Gifts

From home sleep-cycle monitoring to a tap into the psychology of motivation, these clever products promise to get inside your head.

Catch Some Slow Waves

Zeo sleep monitor ($399)

www.myzeo.com

It takes about an hour to glue more than a dozen sensors to a research subject about to undergo polysomnography, the technology designed to monitor brain waves and other physiological variables used to characterize our time asleep. A Boston-based company called Zeo now lets you simply strap on a headband, similar to a runner's sweatband, that allows you to obtain information about your own sleep patterns that would otherwise only be available from a costly laboratory setup.

Three electrodes attached to the headband record hour by hour what happens after you close your eyes: REM (rapid eye movement), light and deep sleep (various non-REM measures, such as slow waves), nocturnal wakings and length of rest. The zigs and zags of z's then move wirelessly to a fancy alarm clock, which crunches the electrophysiological brain dump to yield an overall sleep quality score and a graph, below the digital hours and minutes display, of what transpired the night before—whether you were dreaming at 3 A.M. or in a light snooze an hour later. Last night's download can be moved via a memory card to a computer, where you may further analyze your sleep history and receive sleep hygiene recommendations (don't drink alcohol or exercise before bedtime).

I tried Zeo at a sleepover press event this past June, and the most surprising result was not the percentage of REM versus non-REM or any other sleep-cycle phenomenon but rather how little I actually slept. What I thought was six hours or so was actually five hours and 13 minutes, a seeming explanation for the half-daze that hangs over so many of my mornings.

So should you try Zeo? Even with the consumer-oriented streamlining, the whole process seems like a lot of work for the third of your life that is supposed to be the opposite of work. It depends if you're the kind of person who likes heart rate monitors for a workout and handheld calorie counters for restaurant sojourns. If you really, really want to know yourself better—and your partner doesn't mind that you look vaguely ridiculous at bedtime, Zeo may be just the thing for you. All it lacks is an uplink to Twitter. *—Gary Stix*

Feel Smarter Than a Computer

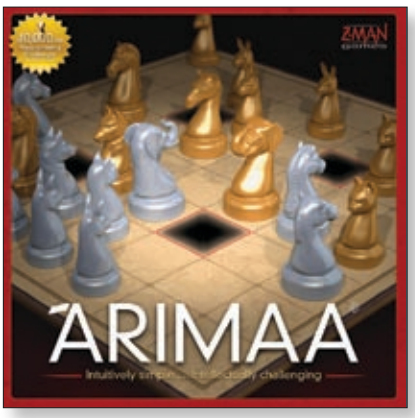
Arimaa board game ($29.99)

www.arimaa.com

When IBM computer Deep Blue defeated chess champion Garry Kasparov in 1997, it was by evaluating an immense number of moves in a very short time—a feat of brute-force calculation that hardly qualifies as intelligence. That mixed victory for the artificial-intelligence (AI) community got computer scientist Omar Syed of 4You Net Services thinking. If he could create a strategy game that was superficially similar to chess but had many more possible moves, maybe he could outmaneuver computers and reinvigorate the search for truly intelligent software.

Arimaa, the result of his efforts, was released as a box set earlier this year (although a small group of hard-core gamers have been playing it online for years). As an incentive for the AI community, Syed is offering a $10,000 prize for anyone who can write a program that will defeat the best human players. So far our species still has the upper hand.

But Arimaa isn't only for computer geniuses and gaming geeks. I, for one, am neither, and I have never been particularly apt at chess. But as soon as I started a game with a friend, the intimidation vanished. The rules are simple enough for kids to learn, and the game was creative and engaging. What's more, Arimaa levels the playing field between opponents because—in contrast to chess—both will be equally inexperienced. So in addition to flexing our unique human brains, we had fun, too. *—Frederik Joelving*



Boost Your Motivation

Nike+ ($59)

www.nikeplus.com

The hardest part about exercising is getting motivated to do it. Athletic company Nike is attempting to solve that age-old problem with its Nike+ system. A tiny accelerometer measures running distance and speed and reports the data back, in real time, via an Apple iPod, iTouch or, as of a few months ago, a small wristband. On good days the voice of marathoner Paula Radcliffe or bicyclist Lance Armstrong might tell you that you've just finished your longest run or your fastest mile—effortlessly feeding our natural psychological desire for positive feedback. Users can also upload exercise data onto an online site that shows trends over time, helps you set personal goals and shares details with friends. Nike+ turns you into your own biggest competitor and fiercest personal trainer.

As for boosting the desire to exercise, I can attest to the power of this product. Although I have used Nike+ for only about two weeks, I've run a whopping 40 miles in that time (a personal best), and I feel faster and more powerful than I ever have in my life. I attribute it all to the fact that I can see my progress each day and—gosh darn it—I know that whatever I did yesterday, I can do better today. Indeed, with Nike+, all you want to do is get out there and beat your last running time—suggesting that competition, even just against yourself, can be an extremely effective incentive. *—Melinda Wenner*

COURTESY OF ZEO (*sleep monitor*); COURTESY OF Z-MAN GAMES, INC. (*board game*); COURTESY OF NIKE, INC. (*wristbands*)

television

LIFE LESSONS

The Human Spark

PBS, November 9, 16 and 23 at 10 P.M. EST

www.pbs.org/humanspark

Watching Alan Alda host *The Human Spark,* you get the sense that he could teach basket weaving and make it entertaining and relevant. This program, however, aims for a much headier topic—the question of what makes human beings so unique. What is it about our brain that allowed us to take over the world? The three-part series investigates how our ancestors differed from Neandertals and from our closest relatives today, the chimpanzees.

We follow Alda as he meets with archaeologists unearthing stonework from caves in the Dordogne region in southern France and as he participates in behavioral studies on both chimps and children with primatologists at the Yerkes National Primate Research Center of Emory University in Atlanta. In Boston, neuroscientists scan and analyze Alda's brain. The whirlwind trip includes many brief lessons on big ideas. Some of these themes deserve an entire miniseries of their own—especially the light treatment of our ancient history, glossed over in the first episode. It's worth sticking by Alda's side to laugh with him, however, as he throws a primitive spear at a plastic deer and to share his glee when, in an experiment, a toddler learns to free a block from a container in one go by mimicking an adult.

This passion for teaching and learning may be one of the most unique and important qualities we humans have developed, according to the central theme of *The Human Spark.* As Alda points out, "we look into our students' eyes as if to say, 'Are you getting this? Are you following me?' Not quite like our nearest cousins whose behavior seems to be implying, 'Hey, you're on your own, bub.' " —*Corey Binns*

books

PEER INTO THE PAST

Asylum: Inside the Closed World of State Mental Hospitals

Photography by Christopher Payne. Essay by Oliver Sacks. MIT Press ($39.95)

Insane asylum. For many people the phrase conjures up images of desperate patients trapped in concrete fortresses. Although abuse no doubt has occurred in some mental hospitals, there is another, much less frequently explored side to the story.

In his surprisingly arresting photoessay book, *Asylum,* photographer and architect Christopher Payne reveals that mental institutions were quite often considered the pride of local communities across the U.S. in the 19th century, providing a safe haven and humane care for the mentally ill. Through his camera lens, Payne pays tribute to these now empty places, capturing abandoned palatial redbrick estates, grand theaters, long, deserted hallways with light streaming through arched windows, and peeled paint gathering on the floor.

Neuroscientist Oliver Sacks provides a stirring introduction. Payne's images, Sacks says, are testimony to the "heartbreak" of living with mental illness and to magnificent spaces where patients were paid respect and given "a vital sense of companionship and community." —*Victoria Stern*

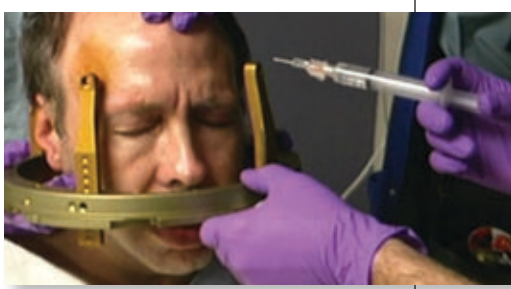
dvds

INSIGHT INTO PARKINSON'S

Shaken: Journey into the Mind of a Parkinson's Patient

Lila Films

www.lilafilms.com/shakendvd.htm



Most people know that Parkinson's disease is a crippling neurodegenerative disorder. But what do Parkinson's patients actually have to go through day after day? And what do such procedures as deep-brain stimulation (DBS)—currently the most effective surgical treatment for the disease—involve? *Shaken: Journey into the Mind of a Parkinson's Patient* answers these questions. The documentary follows Paul Schroder (*above*), who was diagnosed with the disease when he was in his 30s and who, after growing increasingly debilitated, decided to undergo DBS. The film is now airing nationally on public television stations and is available on DVD through the Lila Films Web site.

Shaken gives viewers a glimpse into Schroder's mind, both literally and figuratively. Writer, director and producer Deborah J. Fryer not only filmed the actual DBS surgery (not for weak stomachs) but also invites viewers into Schroder's life, his thoughts and emotions. This seamless blend of medical science and personal accounts of a patient's struggles make this documentary both highly educational and deeply moving.

One of *Shaken*'s highlights is its excellent explanation of DBS, which involves implanting electrodes into the brain and a generator underneath the collarbone to deliver electrical pulses that, through unknown mechanisms, lessen the symptoms of Parkinson's. As they perform the complicated surgery, the participating physicians explain it step by step. [For more on DBS, see "Sparking Recovery with Brain 'Pacemakers,'" by Morton Kringelbach and Tipu Aziz; SCIENTIFIC AMERICAN MIND, December 2008/January 2009.]

The film is an eye-opener for everyone who is not personally affected by Parkinson's. It puts a face on a cruel disease. —*Nicole Branan*

COURTESY OF WNET.ORG (*Alda with chimp and child*); CHRISTOPHER PAYNE (*straitjacket*); COURTESY OF LILA FILMS, INC. (*Parkinson's patient*)

askthe**Brains**

Is it true that when we drive, walk or reach for something our brain performs calculations? Is this ability learned or innate?

—Helena Larks, San Francisco

Computational neuroscientist **Terry Sejnowski** of the Howard Hughes Medical Institute at the Salk Institute and the University of California, San Diego, answers: OUR BRAIN IS WIRED to perform calculations that let us judge how far away an object is when we walk or jump around or reach for a container of milk. Although this task may seem easy, it turns out that calculating depth is surprisingly complex.

When we look at an object, our eyes project the three-dimensional structure onto a two-dimensional retina. To see the three dimensions, our brain must reconstruct the three-dimensional world from our two-dimensional retinal images. We have learned to judge depth using a variety of visual cues, some involving just one eye (monocular vision) and others involving both eyes (binocular vision).

Binocular vision provides more precise perception of depth, allowing us to judge small differences between the images on both retinas, whereas monocular vision gives us a larger field of view. Occlusion, a monocular cue whereby an object that is closer partly obstructs the faraway one, enables the brain to judge relative distances. When one object occludes another, the observer can rank the relative distances of these objects.

Another monocular cue is motion parallax, which occurs when an observer moves his or her body (or just the head) to provide hints about the relative distance between objects. By moving the head back and forth, the motion allows you to see the objects from slightly different angles. A nearby object will move more quickly along the retina (creating a larger parallax) than a distant object, allowing you to determine which object is closer. When you are driving a car, for instance, nearby things pass more quickly, and faraway objects appear stationary.

Although our brain circuits are genetically programmed to judge depth from such visual cues, it takes experience to calibrate them. Initially children are bad at judging distance, but over time they train their brain to calculate distance. By adulthood we have become experts at judging depth but only with regard to objects in familiar environments. In unfamiliar territory, such as a new mountainous trail, automatic depth judgment fails because our brain has not yet calibrated new clues in the environment. In these new scenarios, we have to retrain our brain to compute distance.

Why do most customers at my bookstore have trouble understanding my instructions to swipe their debit cards with the magnetic stripe "toward me?" Almost everyone positions their card the wrong way, then asks in confusion, "Stripe toward me?"—meaning themselves. What is causing everyone to make the same mistake?

—Michael Manchester, Aylmer, Ontario

Robert O. Duncan, a behavioral scientist at York College, the City University of New York, explains: THIS DEBIT-CARD mystery may seem insignificant (albeit intriguing), but it actually serves as an excellent illustration of how we store memories and why that system sometimes fails us.

In 1974 psychologists Alan Baddeley and Graham Hitch of the University of York in England proposed that we possess working memory, a space where new memories can be accessed and manipulated. According to Baddeley and Hitch's model, we store and alter memories through a phonological loop, which processes sound information, and through a visuospatial scratchpad, which maintains and manipulates spatial and visual information.

When trying to remember a telephone number, you probably rehearse it in your head by repeating the names of the numbers rather than picturing them.

In the case of the debit-card stripe, the phonological loop comes into play because the cashier gives the customer verbal instructions. We use this loop all the time. For example, when trying to remember a telephone number, you probably rehearse the number in your mind by repeating the names of the numbers rather than picturing them.

Your customers are likely rehearsing the words "stripe toward me" so they can remember the command and act on it. A problem occurs, however, when the customer interprets "stripe toward me" literally. This happens because the phonological loop only serves to keep a phrase fresh in your memory—it does not help you intelligently interpret its meaning. Rehearsing the pronoun "me" over and over can alter your interpretation of the instruction, believing the "me" refers to yourself instead of the cashier. M

Have a question? Send it to editors@SciAmMind.com

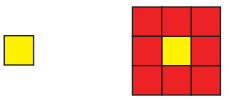
COURTESY OF TERRY SEJNOWSKI; COURTESY OF ROBERT O. DUNCAN

Head Games

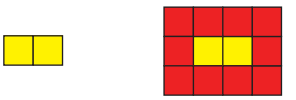
Match wits with the Mensa puzzlers

1 RED SQUARES

When a single yellow square is surrounded by red squares, the red squares have eight times the area.



When a one-by-two yellow area is surrounded by red squares, the red squares have five times the area.



What dimensions would the yellow area have to measure so that, when surrounded as above, the red squares will have exactly the same area as the yellow?

2 NUMBERS OF LETTERS OF NUMBERS

Answer the questions below using only whole numbers (no fractions).

a) The numbers ONE, TWO and SIX each have three letters. What is another three-letter number?

b) The numbers THREE, SEVEN and EIGHT each have five letters. What is another five-letter number?

c) The numbers FIFTEEN and SIXTEEN each have seven letters. What is another seven-letter number?

d) The numbers FOUR, FIVE and NINE each have four letters. What is another four-letter number?

3 ANAGRAM × 6

Fill in the blanks according to the clues. The first word is six letters long and serves as the base word. Each of the remaining answers removes a different letter from the base and makes an anagram of the five-letter remainder.

_ _ _ _ _ _	**An ancient region bordering the Black and Aegean seas, now part of Greece**
_ _ _ _ _	**To extend forth, as if to grab**
_ _ _ _ _	**A very small quantity, a whiff**
_ _ _ _ _	**To swindle**
_ _ _ _ _	**To strain, as if to throw up**
_ _ _ _ _	**The central part**
_ _ _ _ _	**A marine map**

4 RHYME TIME

Find three rhyming words, each preceded by "a," that describe the clue words.

a) AL	**TARGET**	**FRENCH**
b) SHAVED	**PANETTONE**	**BRASS**
c) MYLAR	**TREASURE**	**TERMITE**
d) QUEEN	**VEAL**	**BUCK**
e) CHEETOS	**DAYTONA**	**QUARTER**

5 LOST FRIENDS

Can you find six friends (or their synonyms) somewhere in the dialogue below?

"Hey, here's a guy with a laptop. Have you seen our friends around?"

"Hmm. Uh, can you describe them?"

"Yes, they are Irish—from Dublin."

"Oh, yeah. One of them came over, and he tampered with my computer."

"Really? Just what do you do with it, anyway?"

"Oh, I blog, I make puzzles and other stuff."

"So why did he do it?"

"Why? I cannot say why. Nor can I help you further."

Answers

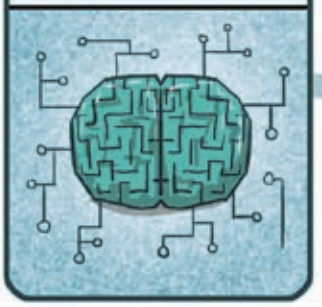
1. The yellow rectangle is six by four.
2. a) TEN b) FORTY c) SEVENTY d) ZERO
3. THRACE, REACH, TRACE, CHEAT, RETCH, HEART, CHART
4. a) A Gore, a store and a door
   b) A head, a bread and a bed
   c) A vest, a chest and a pest
   d) A sheet, a meat and a wheat
   e) A snack, a track and a back
5. Synonyms for friends are written backward:
   LAPtop (pal)
   hmM, UH, Can you (chum)
   from DUBlin (bud)
   hE TAMpered (mate)
   I bIOG I MAke (amigo)
   why. NOR Can (crony)

SCIENCE COMICS!

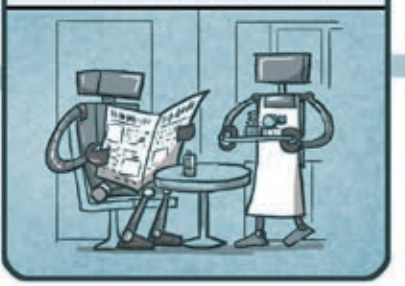
Artificial Intelligence?

BY DWAYNE GODWIN AND JORGE CHAM

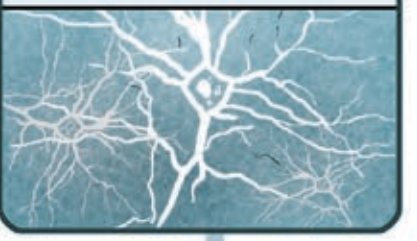
What would it take to create an artificial brain?



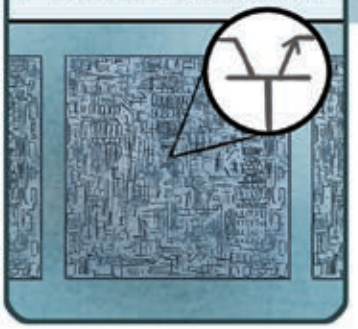
Will we be replaced one day by robots of our own creation?



To create an equivalent human brain, you would have to simulate the 100 billion neurons that exist in your head.



In comparison, the most current microprocessor chips have only about 2 billion transistors.



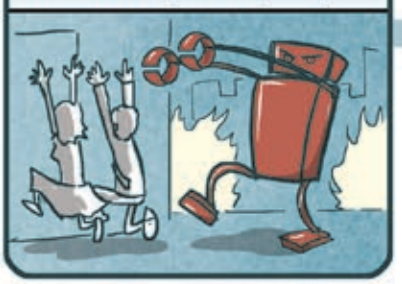
Moreover, each neuron in a real brain is connected to (on average) about 10,000 other neurons.

That's a circuit with over 1,000,000,000,000,000 connections!

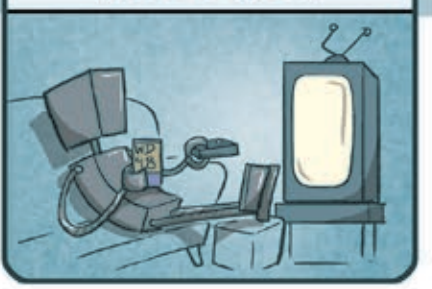
And we are only just starting to understand the complex rules that make these connections malleable and adaptive.

Synaptic transmission depends on time, frequency of activation, use and chemical cues.

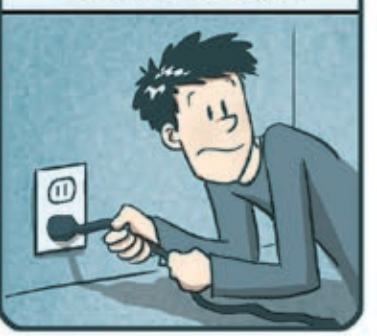
But even if technology eventually makes it possible to build such a circuit, there's no reason to panic just yet.



Our brain circuits are modularly arranged, so we could create machines that had high intelligence but lacked motivation or personal goals.



But just in case, maybe we should keep *some* connections simple enough.



Dwayne Godwin is a neuroscientist at the Wake Forest University School of Medicine. Jorge Cham draws the comic strip "Piled Higher and Deeper" at www.phdcomics.com

Bright Horizons™ 7

May 29 – June 5, 2010

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SCIENTIFIC AMERICAN TRAVEL

Partake of intellectual adventure in the company of experts and fellow citizens of science. Join Scientific American Travel on a cruise down the mighty St. Lawrence Seaway into the heart of contemporary cosmology, genetics, and astronautics. Black holes parallel universes, and the Big Bang itself are among the abstract ports of call Dr. Max Tegmark shows us. You'll have a new perspective on the significance of food choices after indulging in a discussion with Dr. Paul Rozin. Satisfy your curiosity about navigating space, from the science behind solar sails to mapping the Interplanetary Superhighway, with Dr. Kathleen Howell. Maneuver through the newly charted territory of the human genome, genetic medicine, genetic agriculture, and all their nuances and consequences with Dr. David Sadava. Set the scene for Summer on the Bright Horizons 7 conference on Holland America Line's m.s. Maasdam, sailing Montreal to Boston May 29-June 5, 2010.

Cap your Bright Horizons experience with an optional, incomparable, behind-the-scenes tour of the Massachusetts Institute of Technology with MIT insider Dr. Max Tegmark as your guide. Campus, research facilities, and lunch at the MIT Museum are on the itinerary. ▼

Discover the pleasures of dynamic and interactive science learning in Canada's historic and hospitable Atlantic provinces, and bring back your own True North story. Hike Springtime Quebec with a friend. Hear Celtic echoes in the Nova Scotia breeze. Visit www.insightcruises.com/SciAm-7 or call Neil or Theresa at (650) 787-5665 to get all the details, and then journey with Scientific American and a thinking community on Bright Horizons.

Psychological, Cultural, and Biological Perspectives on Spices, Meat, Chocolate & Water

Why do billions of people in the world add hot chili pepper, which irritates the inner surface of their mouth, on most of their savory foods? Would you drink pure water recycled directly from sewage water? How do you feel about T-bone steaks? Why is chocolate irresistible? Dr. Rozin will shed light on the answers to these questions. The biological and cultural history of these substances, and the reactions of contemporary people from Western-developed cultures to each of these foods are on the table in this session.

I've Got Questions: Black Holes Edition

Take a look at some of the most spectacular recent evidence that black holes really exist. Dr. Tegmark will cover what we know about them and what remains mysterious. Are black holes in fact crucial to enable galaxies to form? Can black holes form new universes in their interiors? Plus, using a fully general-relativistic flight simulator, you'll take a scenic orbit of the monster black hole at the center of our Galaxy and discuss how one could actually make this dizzying journey with only modest energy expenditure.

A Brief History of Our Universe

With a cosmic flight simulator, we'll take a scenic journey through space and time. After exploring our local Galactic neighborhood, we'll travel back 13.7 billion years to explore the Big Bang itself and how state-of-the-art measurements are transforming our understanding of our cosmic origin and ultimate fate.

Mission Design: Exploring the Solar System

Scientific mysteries and huge surprises await all of us space explorers, whether we're viewing Earth from the perspective of space or seeking out our neighbors, that is, the planets, dwarf planets, moons, asteroids, and comets that populate the solar system. But how do we get there? How do we get a spacecraft where we want it to go? What about power? How do we address the demands of the space environment? Dr. Howell will lay out the principles and process of designing a space mission. Get the scoop on the successful engineering techniques and some of the challenges in getting humans and robots to space destinations.

Obesity and Unhealthy Food Choices in Cultural Perspective: The French-American Contrast

Americans worry so much about their weight and try to eat low fat food, and French eat a higher fat diet than Americans and worry less. Doesn't that make you wonder why obesity is much lower in France than in the USA? Settle into a sedentary session with Dr. Rozin, and assess the determinants of food choice and food intake. You'll take a look at how the modern developed-world food environment is opposite to the environment to which we are adapted, and how this leads to obesity. We'll compare the ways the French and Americans have adapted to the major changes in the food world, and get the scoop on how the French have managed to be less afflicted by obesity and more engaged in the enjoyment of eating.

Call or email Neil Bauman: 650-787-5665 or neil@InSightCruises.com

Listed is a sampling of the 18 sessions you can participate in while we're at sea.

CST# 2065380-40

Genetic Medicine: Can knowledge of the genome transform medicine?

Your health is determined by both heredity and environment. Beginning in the 1800s, humankind has made great progress in modifying the environment to improve public health. This progress has led to the near-elimination of many infectious diseases in some parts of the world and treatments for other diseases. Dr. Sadava will show you that as we learn more about our heredity through studies of the genome, we can describe what goes wrong in the many diseases that have a genetic component, such as cancer and heart disease. Get a researcher's input on how these descriptions may lead to cures and how information about an individual's genome may lead to personalized treatments.

Cloning and Stem Cells

The biology behind cloning has been known for over a century. The first plant was cloned in the mid-1950s and the first animal several decades later. In this lecture, you will learn how and why these feats were accomplished. Human cloning is now a possibility. The promise of using stem cells to treat diseases and even improve athletic performance in healthy people is a related topic. Delve into the realm of cloning and stem cells with Dr. Sadava. You'll learn of the ethical issues surrounding the use of human embryos to get the cells used, and the ways biologists may circumvent these concerns.

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Insight Cruises
EDUCATION THAT TAKES YOU PLACES

Cruise prices vary from $999 for a Better Inside to $3599 for a Full Suite, per person. (Cruise pricing is subject to change. InSight Cruises will generally match the cruise pricing offered at the Holland America website at the time of booking.) For those attending the conference, there is a $1,275 fee. Taxes and gratuities are $182.

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