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Better**

Tips from a savant

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Say So

Science often offers a corrective counterpoint to well-intentioned (but sometimes mistaken) folk wisdom and sayings. As we prepared this issue for you, several such aphorisms came to mind. I thought I'd set the record straight on a few of them.

Laughter is the best medicine. That phrase is far from empirically proved, but it contains more than a germ of truth. As you will learn in “Laughing Matters,” by Steve Ayan, starting on page 24, a good guffaw has powerful physiological and mental benefits. Listening to jokes relieves anxiety. Mirth eases stress and even, as studies have revealed, chronic pain. It bolsters the psyche, making you more resilient. Just forcing a smile can lift your spirits. If that were not enough to show that being jolly improves your satisfaction with life, a sense of humor is sexy, too.

You can't teach an old dog new tricks. Not so. Since the 1970s research has shown that the brains of older adults are much more plastic than once believed. And as you get older, you not only can learn new tricks, you also *should* tackle mental challenges to help yourself stay sharp. You might, for instance, do Sudoku, crossword puzzles—or one of the growing number of brain-training software games. Our intrepid reporter Kaspar Mossman pitted his gray matter against a battery of eight games over eight weeks. See page 32 for his review, “Brain Trainers.”

There are three kinds of lies: lies, damned lies and statistics. Actually the statistics aren't lying: we simply misunderstand them—or others misuse them by preying on our fears and ignorance. We are beset by headlines about disease risks and what certain medications can do. How to make sense of it all? Although most *Scientific American Mind* articles provide insights into the workings of the brain and behavior, they also offer information about how to exercise better critical thinking. “Knowing Your Chances,” by Gerd Gigerenzer and his colleagues, explains what various kinds of risk mean and how to interpret statistics. And you thought your math classes were a total waste of time! Turn to page 44 to find out how to take control of those numbers.

Mariette DiChristina
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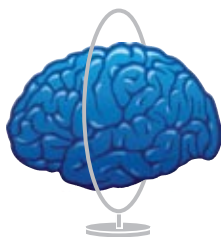
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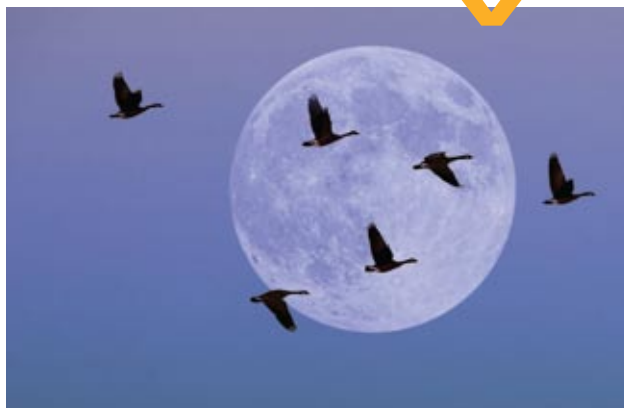
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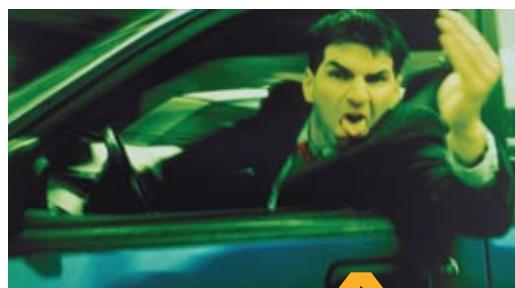
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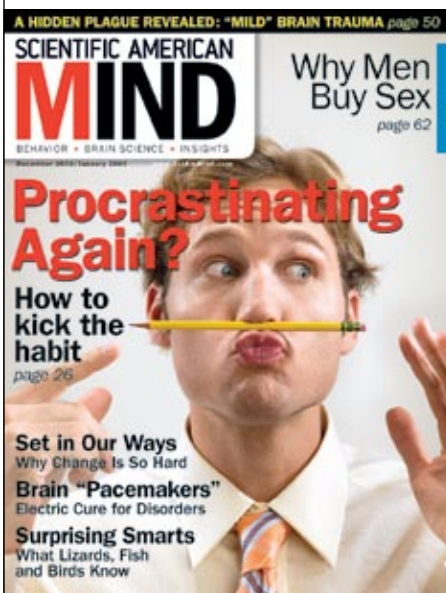
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GO AHEAD, PUT IT OFF

I disagree with Trisha Gura in "I'll Do It Tomorrow." I don't see procrastination as a problem to be fixed. In my corporate job, I found that the longer I procrastinated, the more likely the "need" for that activity would evaporate. Now, in my software development and musical activities, I find that in the time between procrastinating and actually getting down to it, I very often come up with a more efficient or creative idea than the way I would originally have approached the task. Procrastination is a method for letting ideas cook longer.

"elpifco99"

adapted from a comment
at www.SciAmMind.com

WEIGHING HYPOCRISY

"The Truth about Hypocrisy," by Scott F. Aikin and Robert B. Talisse, was full of fascinating, quotable material, but it had some logical inconsistencies. The authors gave abundant reason not to engage in ad hominem attacks. That's all well and good. They ultimately allowed that some hypocritical behavior indirectly supports the hypocrite's position, such as in the case of a father who might say, "Don't smoke, son; look how addicted I am." That's good, too. We shouldn't renounce our ideals simply because we fall short of them. But couldn't the same argument be applied to former New York governor Eliot Spitzer, who could have said, "Make prostitution illegal and strictly punished. Strong deterrents are necessary. Look at me, I need them!" This case is actually more consistent with the authors' argument than the example they gave of Al Gore's personal jet. It raises the question as to why moral (in a religious sense) hypocrites are apparently less redeemable than others.

Jennifer Schwirzer
via e-mail

HOW TO CHANGE

Although "Set in Our Ways," by Nikolas Westerhoff, correctly depicts change as difficult to make, the article does not stress the most fundamental reason that people fail to make changes in their lives: competing commitments. For example, I'm committed to losing





weight, but at an underlying level I may be more committed to appearing jolly and cuddly so that I'll be loved. We all have thousands of these competing commitments, developed over a lifetime—and even when we recognize them, like slippery little worms they wriggle away from our awareness. Tacking on these competing commitments one at a time, recognizing that they do not serve us and replacing them with commitments that help us move our lives forward present a daunting challenge—and are most worthwhile. In this way, it is possible to make large changes in our lives in a short period of time, regardless of our age.

“Chris210”
adapted from a comment
at www.SciAmMind.com

PRO-PROSTITUTION

I think the title of your article should be “Why Do Men Rent Sex?” rather than “Why Do Men Buy Sex?” Buying sex is called marriage; the marriage contract, distilled, has been as follows: the man gets sexual access and fidelity from the woman, and the woman, in exchange, gets lifelong financial support for herself and her offspring. Not consummating the marriage contract and “alienation of affection” (withholding sexual access) are still valid grounds for having a marriage annulled and for divorce.

A more interesting article might be entitled “Why Men, Crazy as This May

Seem, Actually Get Married Rather Than Use Prostitutes”!

What prostitutes really offer men is on-demand, cost-effective, emotionally painless sex and temporary intimacy, with very few strings attached. Considering a date and movie for two will run a guy \$60, and the average prostitute

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about \$120 to \$200, the choice, if you are just looking for sex, is simple. I have been on many dates where, after spending \$60 and listening to stories about crazy ex-husbands or boyfriends and other turn-offs, I thought, “Gee, I could have spent the evening reading *Scientific American Mind* and saved a lot of money!” And I haven’t even included the time it takes to find a date in the first place—going out to bars, church, and so on.

I have, in my younger years, pretended to be very interested in or even in love with a woman just to have sex with her. Obviously, using a prostitute’s services to satisfy my sexual needs would have been more ethical, as it would have been decidedly less painful for my date. As a buddy of mine once said, “The relationship between a prostitute and her client is the most honest relationship a man and woman will ever have.”

Name withheld
via e-mail

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The Psyche as Interaction is a philosophical composition which required over twenty years of scientific and mathematical data arrangement, in order to concretely prove the existence of the soul as a linear succession of projected images in three-dimensional time.

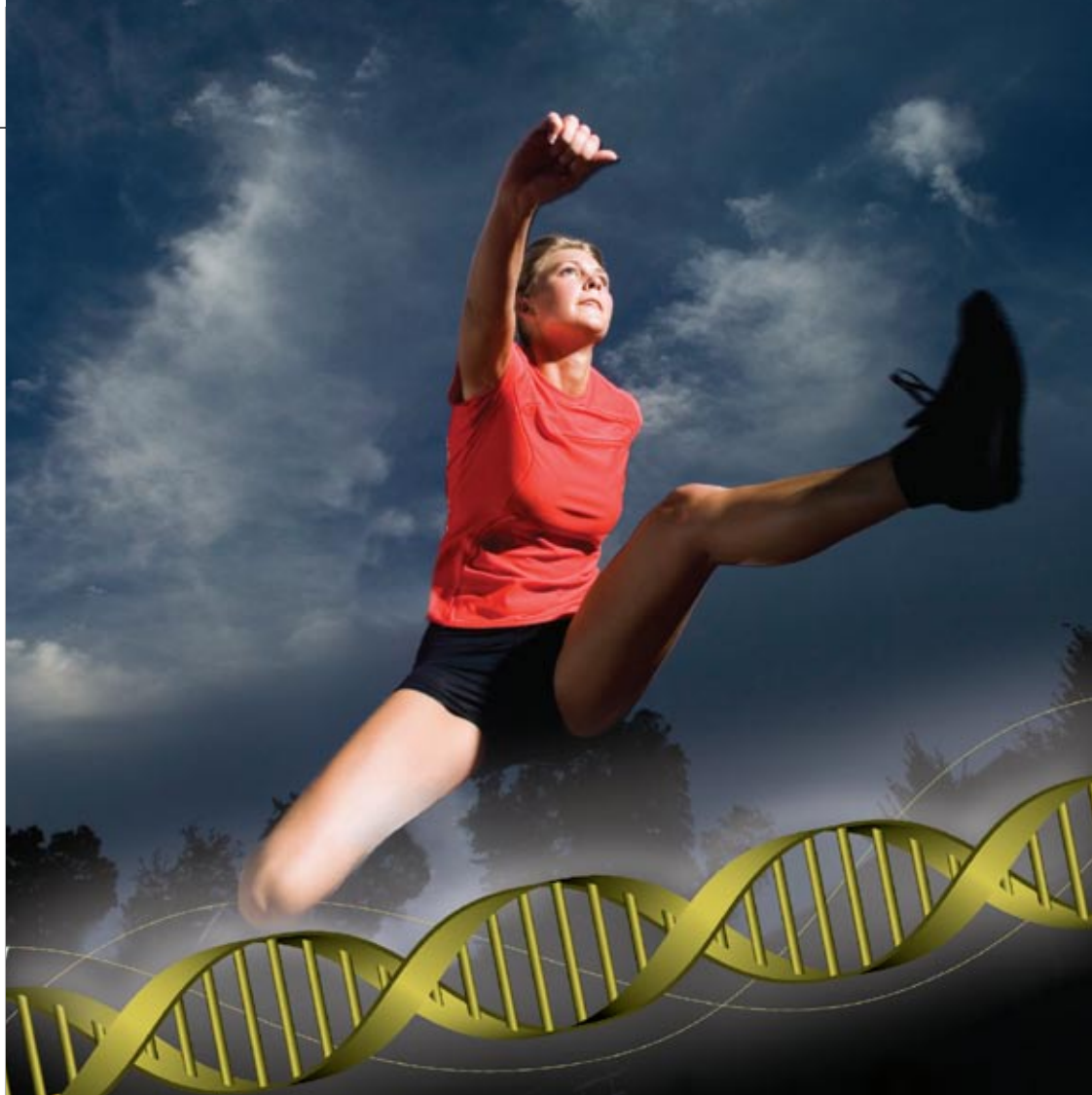
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>> GENETICS

A Gene for Athleticism?

The ability to learn new motor skills is affected by variation in a single gene

Scientists know that small variations in certain genes can predispose people to cancers or heart disease. Now researchers are starting to show a direct, quantifiable effect on learning traceable to these types of genetic influences: single-nucleotide polymorphisms. A difference in just one amino acid in a protein might explain why some people learn new motor skills faster and reach higher levels of performance.

The protein, called brain-derived neurotrophic factor (BDNF), is a key driver of synaptic plasticity, the ability of the connections between brain cells to change in strength. This plasticity is an important factor in learning, explains neurologist Janine Reis, who led the study at the National Institutes of Health. According to Reis, this finding offers the first evidence that slight variations in BDNF's structure affect learning ability.

Volunteers with one type of BDNF learned

faster and performed better at a task in which they had to grip a handle more or less tightly to move a computer cursor through a sequence of targets. Those with a different variant never reached the skill level acquired by the faster learners. (The researchers excluded people who play video games.)

Other groups have found that the BDNF version that Reis linked with poorer acquisition of skills is associated with reduced function of the hippocampus, a brain region involved in motor learning.

This difference in BDNF may be a clue as to why certain people excel at athletic performance, Reis says, or it may help predict how well patients will recover motor skills after a stroke. Her team and others are gearing up to look at gene variants in stroke patients, hoping to find new targets for drug therapy.

—Roberta Friedman

JENS NIETH zefa/Corbis (hurdler); ISTOCKPHOTO (DNA)

>> PSYCHOLOGY

More Tit Than Tat

People punish one another for stinginess more than they reward for generosity



“You scratch my back, I’ll scratch yours,” we say, and “An eye for an eye, a tooth for a tooth.” Conventional wisdom and decades of research point to the universal human tendency to reciprocate, responding to good or bad acts in kind. But if people only give as good as they get, how do conflicts escalate?

The answer, according to recent University of Chicago research, is that positive and negative reciprocity are not symmetrical: we retaliate against selfishness more than we reward generosity—even when the slights are only illusory.

Researchers led by psychologist Boaz Keysar asked participants to play a “dictator game,” in which one player acts as a dictator and decides how to split a sum of money with a second player. One group of dictators started with \$100 and gave a portion to the second player; the other group of dictators started with no money but

took part of \$100 from their partner. Later, when participants rated the dictators’ generosity, they judged the taking group inordinately more harshly than the giving group. “We found if I give you \$50, you think I’m more generous than if I take just \$30 from you, which is mind-boggling,” Keysar says. Furthermore, takers do not realize how greedy they appear to those on the receiving end.

These skewed judgments led to increasing selfishness with each interaction: when participants switched roles, the new dictators responded to seemingly greedy splits with less generosity themselves, the pattern continuing with each subsequent role reversal.

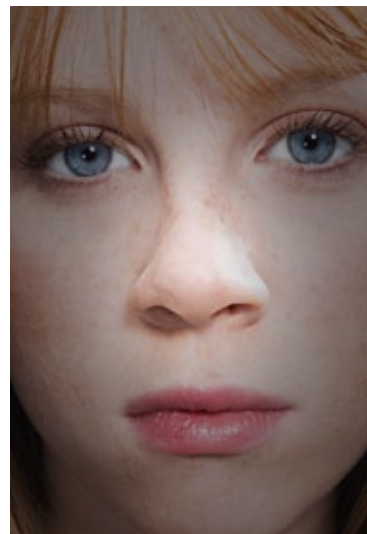
To stop such downward spirals, the research suggests, it is not enough to give back what you took. “To undo a negative action,” Keysar observes, “you have to go beyond reciprocating in kind.” —Marina Krakovsky

>> RECOGNITION

I Know That Nose

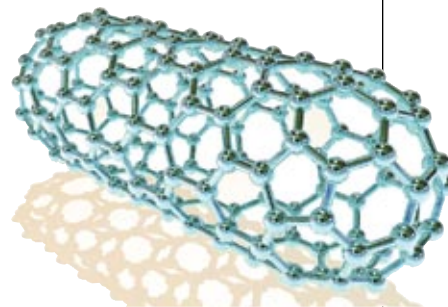
Look to the center of a face for familiarity

When you’re trying to recognize a face, the first thing you look at is the nose—whether you know it or not. Researchers at the University of California, San Diego, showed subjects faces on a computer screen and tracked their eye movements. They found that most people look first just to the left of the nose, then to the center of the nose, then to the eyes. The first look was enough for people to recognize a face more than half the time, the second look increased accuracy, but the third did not—those two glances at the nose were enough. The researchers speculate that glancing at the center of the face makes it easiest to take in enough information about the whole face to enable recognition. —Kurt Kleiner



Nanotech Meets Neuroscience

Carbon nanotubes, those smaller-than-microscopic cylinders made of superthin sheets of graphite, could be the go-to material of the future for correcting disrupted nerve wiring caused by traumatic brain or spinal cord injury. A *Nature Nanotechnology* study shows that the highly conductive nanotubes form tight connections with the cell membranes of neurons, increasing their electrical activity and speeding information flow—potentially useful for everything from improving deep-brain stimulation to developing neuroprosthetics. —Nikhil Swaminathan



(head lines)

>> LANGUAGE

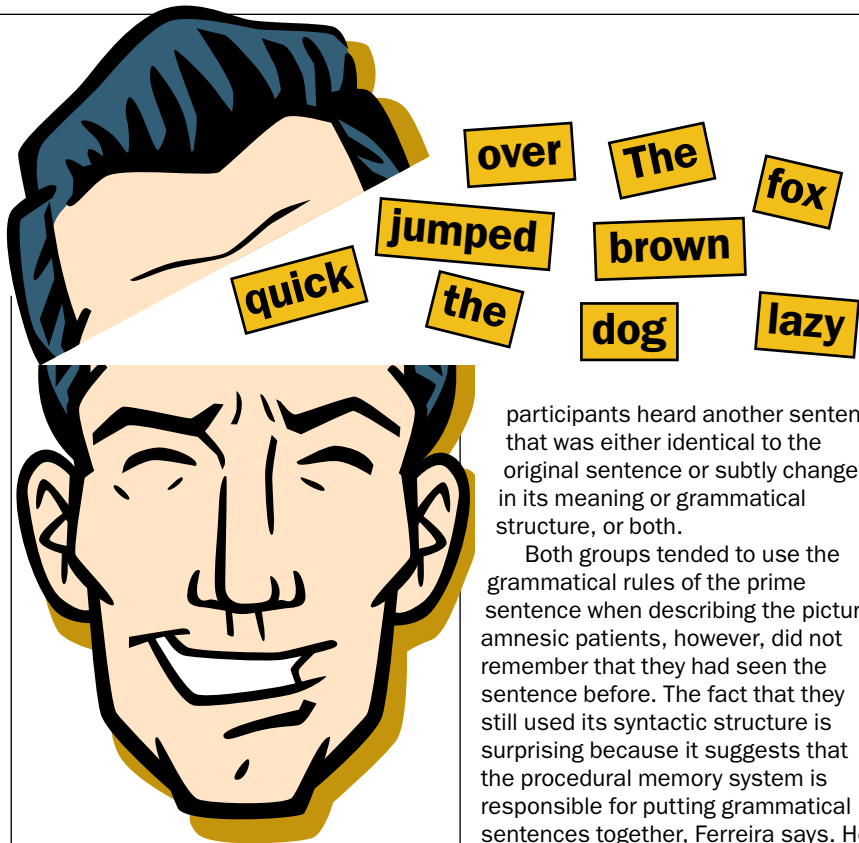
Memory for Grammar

Complex sentence construction may depend on a surprisingly simple system

Forming a grammatically correct sentence may seem to require advanced cognitive skills, but it turns out that our creative language capacity might rely on a less sophisticated system than is commonly thought. A recent study suggests that our ability to construct sentences may arise from procedural memory—the same simple memory system that lets our dogs learn to sit on command.

Scientists distinguish between procedural memory, which is relevant for learning skills such as how to swim, and declarative memory, which stores knowledge, including facts and memories of events, such as one's birthday, says Victor S. Ferreira of the University of California, San Diego. To find out which system is at work when we form sentences, Ferreira and his team exploited a phenomenon called syntactic persistence—speakers tend to use the same grammatical pattern they have used or heard in previous sentences.

The researchers tested four healthy individuals and four amnesic patients. The amnesiacs' procedural memory



was intact, meaning that they could learn skills with repetitive practice, but their declarative memory abilities were damaged, leaving them unable to memorize new facts. First, all participants heard and repeated a sentence. Then they saw an unrelated picture and had to describe it. Finally,

participants heard another sentence that was either identical to the original sentence or subtly changed in its meaning or grammatical structure, or both.

Both groups tended to use the grammatical rules of the prime sentence when describing the picture; amnesic patients, however, did not remember that they had seen the sentence before. The fact that they still used its syntactic structure is surprising because it suggests that the procedural memory system is responsible for putting grammatical sentences together, Ferreira says. He adds that the findings also shed light on our understanding of procedural memory itself, which was thought to be restricted to specific experiences and motor skills. This study shows it is also able to support abstract knowledge, making it “more powerful than previously thought,” he explains.

—Nicole Branar



Car Character

Which of these cars is friendlier? A car can't really be friendly, of course, but most people would choose the Nissan (*right*). In a recent study at the University of Vienna, participants perceived cars as more dominant, adult and hostile if the automobiles had a wider stance and slitlike headlights, such as the BMW has (*left*). They judged cars that had prominent windshields and rounder headlights to be more submissive, childlike and friendly. These traits may remind us of a baby's larger forehead and eyes, says co-author Dennis Slice, a computational biologist at Florida State University.

—Rachel Mahan

>> SLEEP

Napping Is for the Birds

During migratory season, nighttime fliers may rest half their brain at a time

We humans have trouble functioning when we are sleep-deprived, but some birds accomplish great migratory feats with little nighttime sleep. They may make up for the sleep they lose flying at night by snoozing—sometimes resting only half their brain for seconds at a time—while perched during the day. Studying these “micro-naps” may yield clues about how to combat human ailments related to sleep deprivation.

By examining EEG recordings, scientists recently confirmed that captive Swainson’s thrushes fall asleep almost immediately and nap for five to 10 seconds during periods of drowsiness. In some instances, the birds keep one eye open in a semialert state, possibly to watch for predators, while the other eye rests and the corresponding half of their brain sleeps. Other birds and a few aquatic mammals

(which must periodically swim to the surface to breathe) also experience “unihemispheric” sleep.

It is hard to imagine humans taking one-eyed naps, says one of the study’s authors, Verner Bingman, a behavioral neuroscientist at Bowling Green State University. Our brains are much more interconnected than those of a bird, which has hemispheres that can work more independently, he explains. Nevertheless, birds might teach us about how humans could compensate for sleep deprivation. It is not yet clear if the birds make up for all their sleep lost during the migratory season, according to Ruth Benca, a psychiatrist who studies animal sleep at the University of Wisconsin–Madison. If, instead, their need for sleep changes throughout the year, studies such as this one could help us to better understand insomnia and other human disorders, she says.

—Rachel Mahan



BURAZIN/GETTY IMAGES (migrating birds); D. ENDERS Plainpicture/jupiterimages (woman eating cake)

>> AGING

An End to Senior Moments

Lowering blood sugar levels may thwart forgetfulness

Senior moments, those pesky instances of not so total recall—forgetting where we left our keys or what we did last weekend—are a subtle but significant part of the aging process. Another effect of growing old: rising blood sugar levels, which typically take off in our late 30s or early 40s as our bodies become less adept at metabolizing glucose in the bloodstream. Now a study has linked these rising levels with momentary forgetfulness, pinpointing exactly where in the brain the aging process acts—a finding that could help the elderly ward off memory lapses.

The nature of senior moments led scientists to believe they stem from disruptions in the hippocampus—an area that, among other roles, acts as the brain’s “save” button, allowing us to retain new information. Using functional MRI, researchers looked at the effects of increased blood glucose

in the hippocampus of 181 subjects aged 65 or older with no history of dementia. They found that elevated levels impaired function of a section of the hippocampus called the dentate gyrus, which is a “hotspot” of age-related impairment, according to study author Scott Small, a neurologist at Columbia University.

Blood glucose is not alone in selectively affecting dentate gyrus performance. A 2007 study co-authored by Small shows that exercise improves its function in both mice and humans. The newer research, he points out, suggests that these positive effects may actually result from the influence of regular exercise on the body’s ability to break down glucose.



Psychiatrist Mony de Leon of New York University explains that the new study “may be showing a very fundamental aging process that might have some reversibility built into it.” If you correct the glucose intolerance, he says, you may be able to forget about forgetfulness.

—Nikhil Swaminathan

(head lines)

>> NEUROSCIENCE

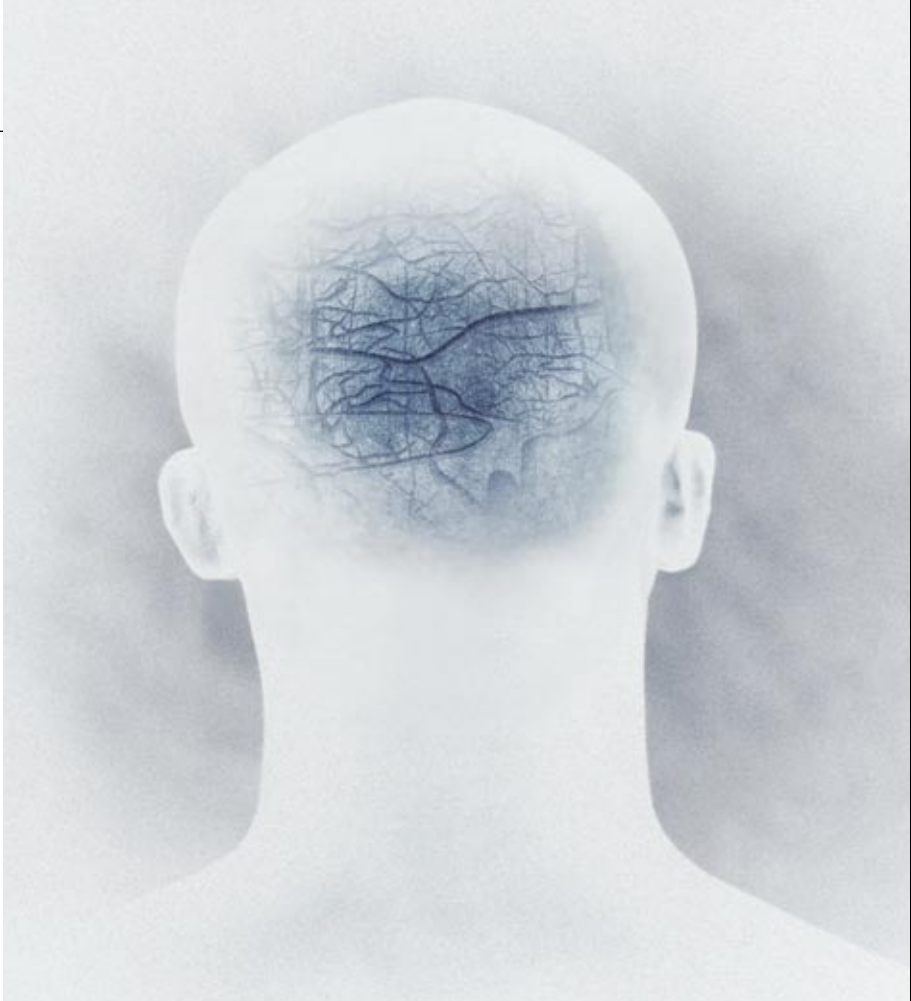
Brain Freeze

Cooling down parts of bird brains reveals clues about motor behaviors

Some of us sing, and some of us just mouth the lyrics, but we all rely on our brain to coordinate even the simplest motor behaviors. Scientists interested in the brain activity behind motion often use birdsong as a model because certain songs are sung the same way every time, providing a naturally controlled setting for investigation. Now researchers have solved a long-standing mystery about the hierarchy of brain regions essential for birdsong using a chilly technique that could tease out the interconnected processes behind many complex actions.

Birdsong experts have debated whether the HVC (for “high vocal center”) controls both the duration and onset, or timing, of a melody’s notes—or whether duration or onset is controlled elsewhere, such as in the robust nucleus of the arcopellum (RA). But they were stymied because surgically removing either region prevented the birds from singing at all.

Because brain cell activity is known to slow at low temperatures, Michael Long and Michale Fee of the Massachusetts Institute of Technology inserted tiny wires that transmitted heat into and out of the HVC and RA in zebra finches. Cooling the HVC reduced the speed of the song by up to 40 percent. Cooling the RA had



almost no effect, implying that the HVC plays a more central role in song generation, controlling both when notes begin and how long they last. The birds recover fully from this “localized cooling,” making it a powerful tool to investigate the many complex behaviors that rely on a combination of brain regions.

Studies using localized cooling could “probably explain processes beyond a song-control system, even

beyond a speech system,” predicts Erich Jarvis of Duke University, who was not involved in the study. The neural networks that control the timing and sequence of motor behaviors are relatively poorly understood, Jarvis explains; cooling could illuminate how the brain orchestrates everything from wing flapping in birds to, perhaps, sign language and dancing in humans.

—Lucas Laursen

>> EMOTIONS

Put on a Happy Face

Forcing a smile for social reasons is hardwired in the brain

Are the facial expressions we use to signify social emotions learned by observing others, or are they hardwired genetically? The latter, according to a study in the *Journal of Personality and Social Psychology* that examined the reactions of athletes participating in judo competitions at the 2004 Olympic and Paralympic Games. The fighters, some of whom were blind and could not have picked up expressions through observation, all wore the same forced “social smile” when at the podium after having just lost a gold medal match.

—Nikhil Swaminathan



RALPH MERCER Getty Images (brain-freeze illustration); ENS BUETTNER epa/Corbis (Olympians)

>> NEUROECONOMICS

Value Vision

Items of higher worth trigger greater activity in the visual cortex

Our brain knows a valuable thing when we see it—even if we may not be consciously registering its worth, a recent *Neuron* study says. While having their brain scanned, volunteers repeatedly chose between two targets, winning money if they happened to pick the right one. As the experiment progressed, visual areas responded more strongly to the option that paid off more frequently; in fact, brain activity was a better indicator of which target was more profitable than a subject's personal assessments were. The scientists say their results indicate that we may see valuable things more clearly than we see worthless objects.

—Nikhil Swaminathan



>> BEHAVIOR

Hierarchies among Equals

A clever rat study explores the roots of pecking orders

Drop two adult rats of the same sex into a cage, and it's a near certainty that the bigger rat, even if only slightly bigger, will dominate from the first minutes. But what happens if you take several freshly weaned rats, all of equal size and from good homes, and put them together? A hierarchy nonetheless emerges, according to a new experiment, but the determining factors remain a mystery. These factors—in good news for humans at the low end of the social ladder—may be mutable.

Darlene Francis, a psychologist at the University of California, Berkeley, placed 80 newly weaned rats in cages of four, with cage mates matched for size, activity level and early life environment. To Francis's amazement, it took weeks—until the rats were well past puberty—for a social hierarchy to evolve (as indicated by which mouse got first dibs at food and water, among other measures). Perhaps more surprising was that the hierarchies were not determined by the differences in weight, activity or size that had developed among the maturing quartets—or by anything else Francis could identify.

This mystery was unexpected and intriguing. "Social rank is a huge deal, because in both rats and people, how you do in life depends more on social place than almost any other individual difference you can measure. This study suggests that social status is determined by something quite subtle."

For Francis, who studies the effects of early experience on animals' physical and cognitive fitness, this experiment was a way to see what differences might arise among rats from similar upbringings. She took particular care to match the foursomes not only for size, weight and activity level but also for level of maternal

care. Work by Francis and others over the past decade has shown that rat mothers tend to be either highly nurturing or barely nurturing—an 8 or a 2, as it were—and that more highly nurtured rats go through life more confidently and competently. These factors raise their social standing, which breeds more confidence and better performance, and so on, in a happy loop. Rats from low-nurturing mothers, meanwhile, tend to be tentative, which lowers their social rank, which makes them more tentative.

For rats as for people, social rank and the individual's response to it have tremendous consequences. The top rats in Francis's study, for instance, performed far better than the second-, third- and fourth-ranked rats at cognitive tests such as finding hidden treats. They also acted more confidently and were less stressed (as indicated by stress hormone levels in their blood) when exposed to unfamiliar environments and other challenges. The lower-ranking rats solved puzzles more slowly. And even in their home cages, Francis says, they "looked like animals being tested in a novel environment. Not even home felt safe to them."

A dispiriting development, perhaps, after the weeks of early equality. Yet Francis sees in this study the outlines of levers by which such decrements might be reversed. The social hierarchy's slow development, along with its independence from size and activity level, suggests to her that whatever factors dictated the social gradient involved subtle and highly malleable gene-environment loops: traits that emerge in reaction to experience and then, in turn, help to shape further experience.

"Whatever these determining factors are," Francis says, "they're very plastic. If we can find where that plasticity lies, then perhaps we can help those animals improve their lot, even if they're near the bottom. You think about people, the same possibilities exist there. If you can identify what drives movements in social hierarchies and find ways to tweak those factors, you can reduce the huge penalty people pay for low social standing."

—David Dobbs

JIM FRAZIER Getty Images (value illustration); ELENA BUTINOVA iStockphoto (second and third mice from left); iSTOCKPHOTO (other mice)



Insights into the Brain's Circuitry

A novel brain-imaging technique called diffusion tensor imaging uncovers the structural connections underlying personality, behavior and diseases

>> MOOD DISORDERS

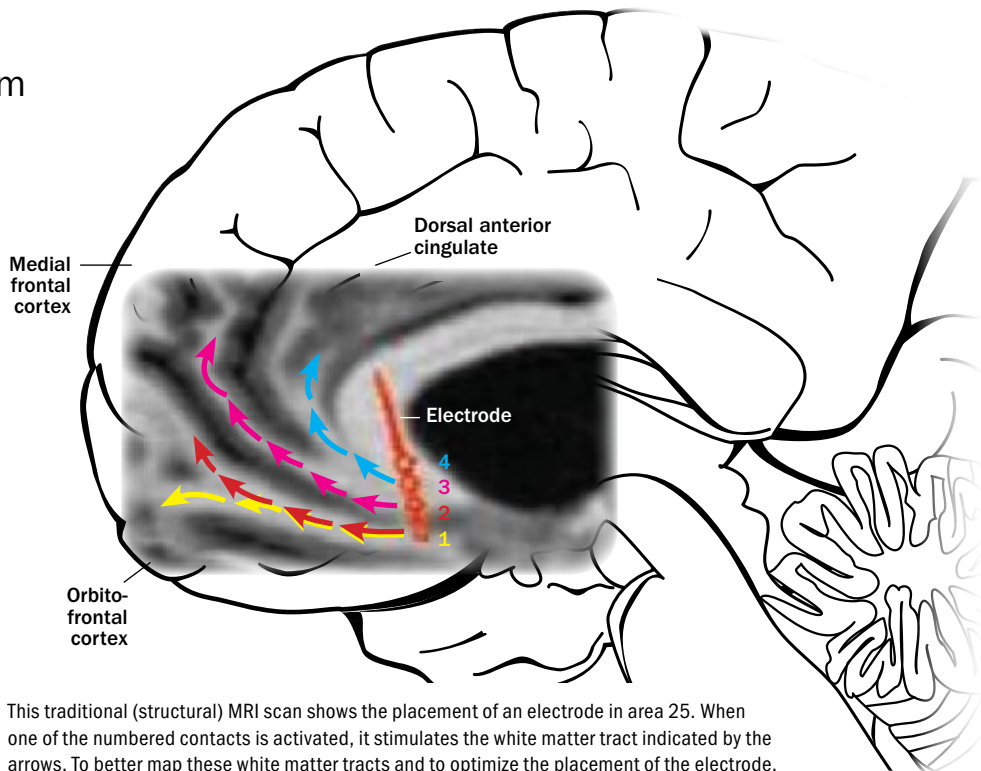
Depression's Wiring Diagram

When Helen Mayberg started curing depression by stimulating a previously unknown neural junction box in a brain area called Brodmann's area 25—discovered through 20 years of dogged research—people asked her where she was going to look next. Her reaction was, “What do you mean, Where am I going to look next? I'm going to look more closely here!”

Her closer look is now paying off. In a series of papers last year, Mayberg and several of her colleagues used diffusion tensor imaging (DTI) to reveal the neural circuitry of depression at new levels of precision. This MRI technique illuminates the connective tracts in the brain. For depression, the resulting map may allow a better understanding of what drives the disorder—and much better targeting and patient selection for treatments such as deep-brain stimulation (DBS) that seek to tweak this circuitry.

In the early 2000s Mayberg and Wayne C. Drevets, then at Washington University Medical School, separately established that area 25 (*above right*), which appeared to connect several brain regions involved in mood, thought and emotion, is hyperactive in depressed patients. The area's significance was confirmed when Mayberg and her colleagues at the University of Toronto—neurosurgeon Andres Lazano and psychiatrist Sidney Kennedy—used DBS devices to bring relief to 12 out of 20 intractably depressed patients [see “Turning Off Depression,” by David Dobbs; *SCIENTIFIC AMERICAN MIND*, August/September 2006]. “That confirmed my hypothesis that area 25 is an important crossroads,” Mayberg says. “But exactly what circuits were we affecting?”

The recent papers take her much closer to answering this question. Working with fellow imaging experts



This traditional (structural) MRI scan shows the placement of an electrode in area 25. When one of the numbered contacts is activated, it stimulates the white matter tract indicated by the arrows. To better map these white matter tracts and to optimize the placement of the electrode, researchers use a newer MRI technique called diffusion tensor imaging (*image below right*).

>> PERSONALITY

Finding Connections

Neuroscience has long focused on the brain in terms of components: the visual cortex processes what we see, Broca's area is the center for language, and so on. As our understanding of the brain has improved, however, it has become clear that a more accurate model depends on how these modules are wired together in circuits. A technique called diffusion tensor imaging (DTI) gives us a tool to probe the nature of those connections. A recent study suggests, for instance, that the more a person seeks out new experiences and relies on social approval, the stronger his or her wiring is among brain areas involved in reward, emotion and decision making.

Cognitive neuroscientist Michael Cohen and his colleagues at the University of Bonn in Germany asked 20

adults how often they sought out new experiences and relied on social approval. Then they used DTI to look at the subjects' white matter, which connects disparate regions of the brain. Cognition and high-level processing happen in gray matter, found mostly in the outer layer of the brain and made up of the main cell bodies of neurons. White matter, on the other hand, is made up of the long, spindly “arms” of neurons, called axons, along which electrical signals travel. (This interior part of the brain looks white because the axons are sheathed in myelin, a white insulating protein that helps signals travel more quickly.)

Cohen's team found that the more the subjects sought new experiences, the stronger their connections were

SOURCE: “CONNECTIVITY-BASED SEGREGATION OF THE HUMAN STRIATUM PREDICTS PERSONALITY CHARACTERISTICS,” BY M. X. COHEN ET AL., IN *NATURE NEUROSCIENCE*, VOL. 12, NO. 1; 2009 (DTI image at right)

Heidi Johansen-Berg and Tim Behrens of the University of Oxford and others, Mayberg used DTI to produce detailed images of area 25's "tractography," the layout of the white matter tracts that connect disparate brain regions. They identified five connective tracts that run through this pea-size region, carrying neural traffic among five vital areas: the amygdala, a deep-brain area that moderates fear and other emotions; the orbitofrontal and medial frontal cortices, two poorly understood areas that appear to be significant in expectation, reward processing, error assessment, learning and decision making; the hippocampus, vital to memory; and the hypothalamus, which helps to regulate stress and arousal.

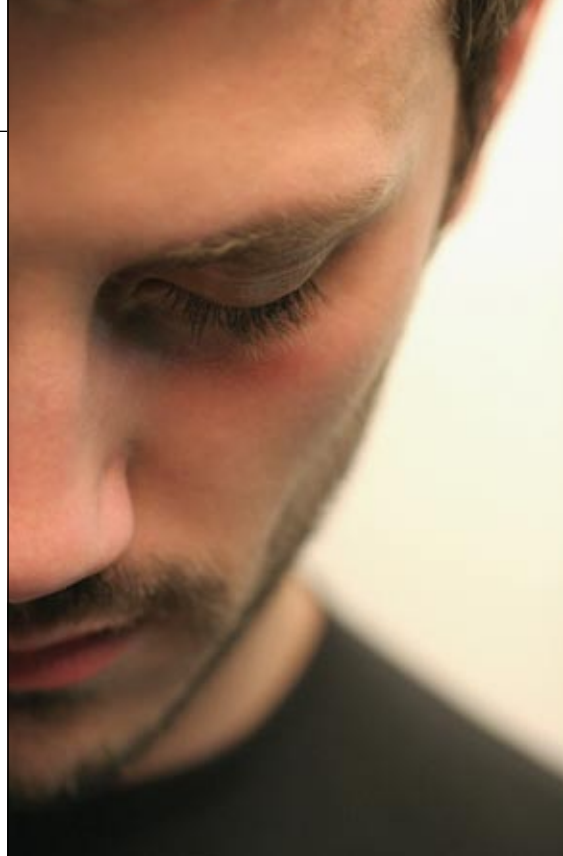
The refined imaging of these tracts does more than just confirm Mayberg's previous work identifying area 25 as a junction box. It also gives her a map that provides diagnostic and targeting information for DBS treatments of the area. As she expected, the locations of those tracts varies among individuals. "And this variation," Mayberg says, "along with variations in the nature of different patients' depression, probably explains why some patients respond better than others. Because the location varies, we're not hitting all five tracts the same way in every patient."

In a new study of 20 more patients

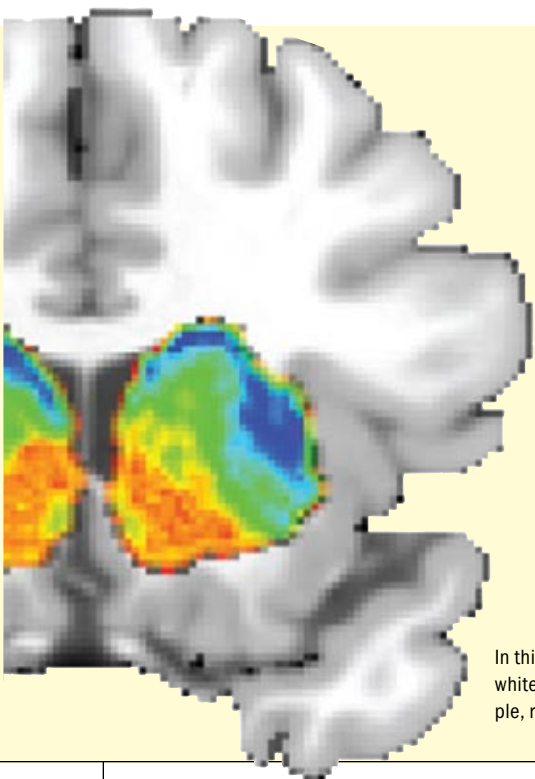
she began at Emory University, Mayberg plans to analyze the tractography and electrode placement to see which of the tracts seems to be most essential to the treatment's success. That investigation may reveal yet more about the nature of depression—and it might help Mayberg identify which patients will benefit from surgery so she can spare those it will not help.

Meanwhile a kind of DBS gold rush has developed as other scientists slide neuromodulators into different brain areas to try to treat depression, obsessive-compulsive disorder, eating disorders, Tourette's syndrome, headaches and chronic pain [see "Sparking Recovery with Brain 'Pacemakers,'" by Morton L. Kringelbach and Tipu Z. Aziz; SCIENTIFIC AMERICAN MIND, December 2008/January 2009].

Although DBS treatment for depression might receive FDA approval in as soon as four or five years, Mayberg does not think it will become common. She is following closely the work of researchers who are seeking ways to modulate tightly defined brain areas such as area 25 with tools less intrusive than electrodes. Stanford University bioengineer Karl Deisseroth, for instance, is having luck stimulating targeted brain areas in mice with proteins called opsins (cousins of retinal cells used in night vision) that can be placed



noninvasively and then stimulated with light via a very thin fiber-optic cable rather than electricity from a bulky electrode. He and others hope to develop these or similar tools to create less invasive "switches" that modulate brain areas more cleanly than electrodes do. "There may come a time," Mayberg says, "when we can work these circuits some other way." —David Dobbs



from the hippocampus and amygdala, brain regions involved in decision making and emotion, to the ventral and mesial striatum, areas that process information related to emotion and reward. The scientists also found that the subjects who were most dependent on social approval had stronger than normal connections between the striatum and the prefrontal cortex, a brain area involved in higher-order decision making.

But what exactly do these connections of varying strengths mean? DTI, which maps white matter tracts by measuring water flow along them, is not yet easy to interpret: no one knows how exactly the strength or abundance of white matter connections correlates to the quality of neuronal communication.

In this DTI image, the color indicates where in the brain the white matter at that point is heading. Blue areas, for example, run to the prefrontal cortex; red, to the amygdala.

But studies using the technique have already uncovered white matter's important role in health. Malfunctioning or damaged white matter can lead to multiple sclerosis, Alzheimer's disease and epilepsy, and a study published last year suggested that pedophiles have less white matter connecting the brain regions involved in sexual arousal.

"Never before has it been possible to link cognition and behavior to the brain's intrinsic wiring," says Cohen, who now splits his time between the University of Amsterdam and the University of Arizona. "A better understanding of the brain's communication network will lead to a better understanding of how the brain supports cognitive, emotional and social functions and, perhaps more important, why disconnections between parts of the brain might contribute to pathologies such as schizophrenia, autism and drug abuse." —Melinda Wenner

Explaining Fiscal Foolishness

A behavioral scientist discusses the irrational human impulses that led to the economic downturn

BY JONAH LEHRER



*Peter A. Ubel is professor of medicine and psychology at the University of Michigan at Ann Arbor, where he explores the quirks in human nature that influence our health, happiness and society. He is author of the book *Free Market Madness* (Harvard Business School Press, 2009), which investigates the irrational tics that lead people to overbid on eBay, eat too much ice cream and take out mortgages they cannot afford. In an interview with Jonah Lehrer, Ubel explains how innate optimism, greed and ignorance can depress financial and physical well-being—and how individuals can commit to change.*

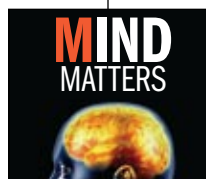
SCIENTIFIC AMERICAN MIND: Your new book, *Free Market Madness*, argues that conventional economics, which assumes

that humans are rational agents acting in their own self-interest, is deeply naive and scientifically unrealistic. Instead you describe a brain brimming with biases and flaws. Do you think these flaws are responsible for the latest economic turmoil? If so, how?

PETER UBEL: Irrationality is responsible for the economic mess we find ourselves in right now—irrationality plus greed, of course, and a substantial dose of ignorance. Let us start with ignorance. I am sad to say that many Americans have a difficult time with even simple math—around a third of American adults cannot calculate 10 percent of

1,000. People who struggle with concepts such as percents have an extremely difficult time with more complicated ideas, such as compounding of savings and, very relevant to our current crisis, adjustable-rate mortgages.

To make matters worse, most of us are hardwired for optimism. Ask us how we rate as drivers, and the vast majority of us are convinced we are above average—even those of us who have gotten into multiple car accidents. As a result of our unrealistic optimism, we are convinced that our incomes will rise fast enough to keep up with our outsized mortgage, or that



Each week in **Mind Matters**, www.SciAm.com/mind-and-brain, researchers explain and discuss their disciplines' most notable recent findings. **Mind Matters** is edited by Jonah Lehrer, the science writer behind the blog **The Frontal Cortex**, <http://scienceblogs.com/cortex>

COURTESY OF PETER A. UBEL

our adjustable rate will not rise, or that our house's value will indefinitely outpace inflation. We are social beings, too, and frequently judge our own decisions by seeing what other people are doing. If my neighbor added on a new kitchen with a home equity loan, I might assume that is a good idea for me, even if a more rational weighing of my finances would suggest otherwise. Even savvy financiers can get caught up in irrational impulses. If a competitor's firm makes huge profits on risky loans, it is easy for me to push aside my fears about such risks: if he took those risks and was rewarded, maybe I overestimated the risks!

MIND: What can eBay teach us about human irrationality?

UBEL: eBay auctions help to reveal the rational and irrational forces driving consumer behavior. People are often quite rational, after all. Raise the price of a T-shirt, and generally, fewer people will buy it. Reduce the quality of a good, and you better reduce its price, too! But behavioral economists have analyzed eBay data to help identify some ways that consumers act irrationally. [For more on eBay and irrationality, see "Is Greed Good?" by Christoph Uhlhaas; *SCIENTIFIC AMERICAN MIND*, August/September 2007.] Offer a really low price for opening bids, a price everyone knows will not be the final selling price, and you nonetheless lure some consumers into making an initial bid. That increases the number of people bidding on the product, which makes it look more attractive, thereby generating even more bids. And then bidders, who knew the price would rise from their initial bids, get emotionally attached to the product and keep raising their offers. Now you know why it makes sense to tell people that bids for that Picasso hanging in your living room can start at \$5!

MIND: You also argue that by taking our own irrationality into account, we can improve our health and well-being. Can you provide an example of a way to achieve such improvement?

UBEL: Precommitment! One reason we humans do not always behave rationally is that we have limited willpower. We know that exercise is good for us. We understand that junk food is bad. But we cannot follow through on our rational desires. We plan to run for 30 minutes, but after 10 we get off the treadmill and convince ourselves we are a bit stiff today. We try to cut down on empty calories and then grab a handful of M&Ms from a candy bowl, almost unaware of our action. No single M&M caused anyone to have diabetes. No one experi-



enced a heart attack because he was 20 minutes short of his exercise goal. And yet our lives, our waistlines even, are the result of thousands of such decisions and behaviors.

To improve ourselves, we have to act as if each M&M matters, as if each decision has important consequences. To do this, it helps to make rules and follow them. Commit yourselves to no candy, no desserts, and you will become more mindful of M&M bowls. Run outside, rather than inside on a treadmill, and you will be forced to finish your running loop. Tell a friend you will walk with her for 30 minutes this afternoon, and you will be forced to show up. Do you want to save more money? Have some money

automatically deposited into a savings account that you cannot access easily through ATMs, debit cards or checkbooks. Sometimes the best way to behave better when you are weak is to impose martial law on yourself when you feel strong.

MIND: Has your awareness of these innate flaws changed your daily routine?

UBEL: It has made me almost impossible to live with! Imagine spending time with someone who is obsessed with rationality, who constantly tries to find ways to "better himself." My poor wife!

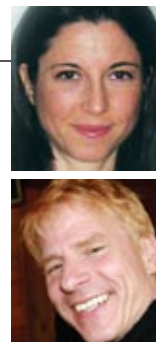
MIND: If you could give one piece of advice for avoiding a few of the mental mistakes outlined in your book, what would it be?

UBEL: None of us is perfect. We will all make a boatload of mistakes before our lives are done. So try to think about the areas in your life where you can least afford to make mistakes or where you must, simply must, remain steadfast in the face of temptation, and concentrate your energy and attention on these few areas. Is saving money your Achilles' heel? Do not worry, then, that you might not always make great decisions on the tennis court. Is food your downfall? Try to minimize the food-related mistakes you make, and do not get bogged down trying to fix everything else in your life. Once you have mastered food (is that possible?), you can move on to the next challenge. **M**

JONAH LEHRER is a contributing editor for *Scientific American Mind* and author of *Proust Was a Neuroscientist* (Houghton Mifflin, 2007) and *How We Decide* (Houghton Mifflin, 2009).

(Further Reading)

- ◆ **You're Stronger Than You Think: Tapping into the Secrets of Emotionally Resilient People.** Peter Ubel. McGraw-Hill, 2006.
- ◆ **Nudge: Improving Decisions about Health, Wealth, and Happiness.** Richard H. Thaler and Cass R. Sunstein. Yale University Press, 2008.
- ◆ **Predictably Irrational: The Hidden Forces That Shape Our Decisions.** Dan Ariely. HarperCollins, 2008.
- ◆ **Free Market Madness: Why Human Nature Is at Odds with Economics—and Why It Matters.** Peter A. Ubel. Harvard Business School Press, 2009.



Neuroscience Meets Psychoanalysis

Suppression and dissociation, two psychoanalytic defense mechanisms, are now studied by modern neuroscience **BY HEATHER A. BERLIN AND CHRISTOF KOCH**

Nothing is so difficult as not deceiving oneself.

—Ludwig Wittgenstein

How much of what you consciously experience in your daily life is influenced by hidden unconscious processes? This mystery is one of the many that continue to confound our understanding of ourselves. We do not know how conscious impulses, desires or motives become unconscious or, conversely, how unconscious impulses, desires or motives suddenly become conscious.

Advances in technologies such as functional magnetic resonance imaging permit scientists to directly measure

brain activity. This ability has led to a revival and reconceptualization of key psychoanalytic concepts, based on the idea of inner forces outside our awareness that influence our behavior. According to psychodynamic theory, unconscious dynamic processes defensively remove anxiety-provoking thoughts and impulses from consciousness in response to our conflicting attitudes. The processes that keep unwanted thoughts from entering consciousness are known as defense mechanisms and include repression, suppression and dissociation.

Suppression is the voluntary form of repression proposed by Sigmund Freud in 1892. It is the conscious process of

pushing unwanted, anxiety-provoking thoughts, memories, emotions, fantasies and desires out of awareness. Suppression is more amenable to controlled experiments than is repression, the unconscious process of excluding painful memories, thoughts and impulses from consciousness.

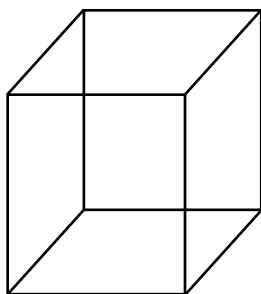
If you are grieving over the death of a loved one or the breakup of a relationship, you may consciously decide to suppress thinking about the situation to get on with your life. Or, in another example, you may have an impulse to tell your boss what you really think about him and his abysmal behavior, but you suppress this thought because you need the



Just a couch? Psychoanalysis concepts explored by Freud on this couch, now at the Sigmund Freud Museum in London, are being linked to brain mechanisms.

COURTESY OF HEATHER A. BERLIN (Berlin); FATMA KONUSKAN (Koch); AP PHOTO (Freud's couch)

People suppressing unwanted memories can be tracked in ways **only dreamed of** by Freud.



Do similar neural mechanisms underlie both visual perceptual suppression and psychoanalytic suppression? In these bistable figures, perception switches between the two perspectives of the Necker cube (far left), the silhouette of the vase and faces (middle), and the duck and rabbit (right).

job. In both cases, the desire is conscious but is thwarted by the exercise of willpower resulting from a rational decision to avoid the action. The impulse or drive may display itself in other ways, however: you may develop a nervous cough around your boss even though you are not sick. Or a suppressed sexual desire may resurface in a careless phrase or slip of the tongue. In general, “forgotten” thoughts, memories and urges can influence behaviors, conscious thoughts and feelings and can express themselves as symptoms or even as mental illness.

Although some claim that suppression is a psychoanalytical myth with no scientific support, fMRI data suggest otherwise. Psychologist Michael C. Anderson, now at St. Andrews University in Scotland, and his colleagues carried out what they call a “think/no-think” experiment to explore the brain basis of memory suppression. Two dozen volunteers had to memorize 48 word pairs (for example, ordeal-roach or steam-train). Subsequently, while lying in a scanner, subjects were shown the first cue word and had to either recall the second, associated word (called the respond condition) or prevent it from entering consciousness (suppress condition). Actively suppressing the matched word while lying in the scanner had the effect of reducing recall of the word afterward (as compared with the respond condition); this result is not just simple forgetting that occurs with the passage of time.

The imaging data that Anderson and

his colleagues collected showed that the volunteers suppressed the words by recruiting parts of the brain involved in “executive control,” namely, areas in the prefrontal cortex, to disengage processing in sectors of the brain important for memory formation and retrieval, in particular the hippocampus. This finding is noteworthy because earlier experiments showed that the amplitude of activity in the hippocampus is proportional to memory recall—the stronger the activity, the higher the likelihood of remembering. A second intriguing observation is that the brain is more active when avoiding recalling a memory than during recall itself. People suppress unwanted memories by exerting willful effort that can be tracked in the nervous system in ways only dreamed of by Freud—who was, after all, a neuroscientist by training.

Evidence of Suppression

Linking suppression to widely accepted brain mechanisms involved in behavioral control moves this concept from the domain of the psychoanalyst’s couch [see illustration on opposite page] to the physical realm of the brain.

A different form of suppression, known as visual perceptual suppression, occurs when an object—or part of one—is not consciously seen even though the image is always clearly visible. A common example is the bistable figure, such as the drawing of the cube, the vase-face or the duck-rabbit in the triptych illus-

tration above. The eyes see the same lines and shapes on the page, but what you consciously see in your head changes from the duck to the rabbit and back again. When the image of the duck is being consciously seen in your mind’s eye, the image of the rabbit is “suppressed,” and vice versa.

Another example of visual suppression is binocular rivalry. Here two different images are simultaneously present, one in each eye. Say a photograph of a smiling girl is projected into your left eye and an image of a car is projected into your right eye. Rather than appearing as the girl superimposed on the car, the two pictures rival for conscious access, and one will suppress the other briefly. For a few seconds you will see the girl’s face; suddenly, patches of the car begin to shine through until the face is entirely gone, and you’ll see only the car. Subsequently, the smiling eyes will break through the automobile, and it will disappear to be replaced by the girl’s face, and so on in a never-ending pas de deux.

So although the physical input to the eyes always remains the same, your conscious perception of it changes from one moment to the next and back again. Bistable percepts are ideal for tracking the footprints of consciousness in the human brain using functional brain imaging [see “Rendering the Visible Invisible,” by Christof Koch; SCIENTIFIC AMERICAN MIND, October/November 2008].

(consciousness redux)

Provided the eyes don't move or blink, this ceaseless dance is under only very limited voluntary control. Thus, from the point of view of psychoanalysis, it would be more proper to call this perceptual *repression* rather than perceptual *suppression*. Whether the neural mechanisms underlying visual perceptual suppression and repression are related to those underlying psychodynamic suppression or repression remains to be determined.

Emotions Apart

Dissociation is another controversial psychological state in which thoughts,

identity states. These states are characterized by different emotional responses, thoughts, moods and perceived self-images that recurrently and alternately take control of a patient's behavior and consciousness. DID is considered to be a result of identity fragmentation rather than proliferation of separate personalities. So patients do not have more than one personality (a proliferation of selves), but rather they have less than one (a fragmented self).

Dissociative identity disorder is often associated with severe and prolonged childhood trauma (such as neglect or emotional or sexual abuse) and develops

tion prevails long after the traumatic experiences have ended.

Neurobiological studies of DID support the validity of the clinical diagnosis and suggest that one brain can generate two or more distinct states of self-awareness, each with its own unique pattern of seeing, thinking, behaving and remembering. Physiological markers such as changes in electrical skin conductance (related to sweating), heartbeat, response to medication, allergic reactions and endocrine function behave differently depending on which state the patient is in. For example, Simone Reinders and her colleagues at the University

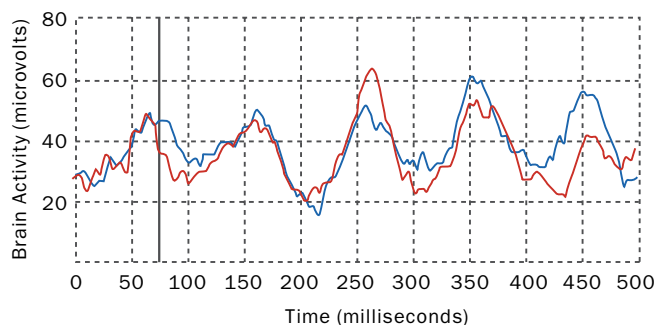
(Empirical tests of dynamic unconscious processes will inevitably revise the original "talking cure.")

emotions, sensations or memories are separated from the rest of the psyche. Originally championed by French psychiatrist Pierre Janet, dissociation can occur in healthy individuals such as when you blank out for a mile or two while driving along a freeway, become completely absorbed by a book or movie, or find yourself walking into a room in your house only to forget why you ventured there in the first place.

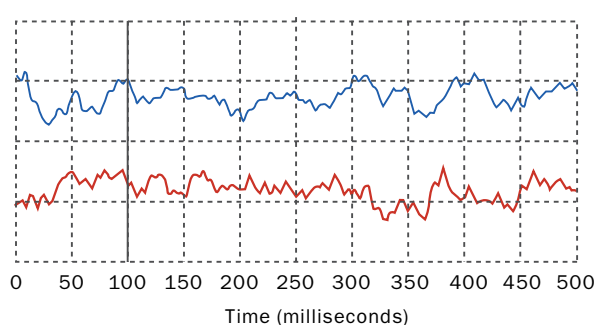
More extreme forms of dissociation manifest themselves in mental diseases such as dissociative identity disorder (DID)—formerly known as multiple personality disorder—which involves the presence of two or more distinct

as a way to cope with an overwhelming situation that is too painful or violent to assimilate into one's conscious self. The person literally "goes away" in his or her head to flee from the anxiety-producing experience from which there is no physical escape. This dissociative process allows traumatic feelings and memories to be psychologically separated off so that the person can function as if the trauma had not occurred. While in one mental state, the patient has access to traumatic autobiographical memories, say of a rape, and intense emotional responses to them. But when in her other state, she claims not to recall anything related to her rape. This defensive use of dissocia-

of Groningen in the Netherlands recorded subjective reactions (emotional, such as fear, and sensorimotor, such as restlessness), cardiovascular responses (heart rate, blood pressure and heart rate variability) and cerebral activation patterns in 11 DID patients. While the patients were first in one mental state and then the other, they were read a story from their life that pertained either to their trauma or to a nontraumatic autobiographical event. When in their neutral mental state, patients reacted to the story of their traumatic experience as if it were a neutral memory and claimed not to recall it; when in their traumatic personality state, they had a significant

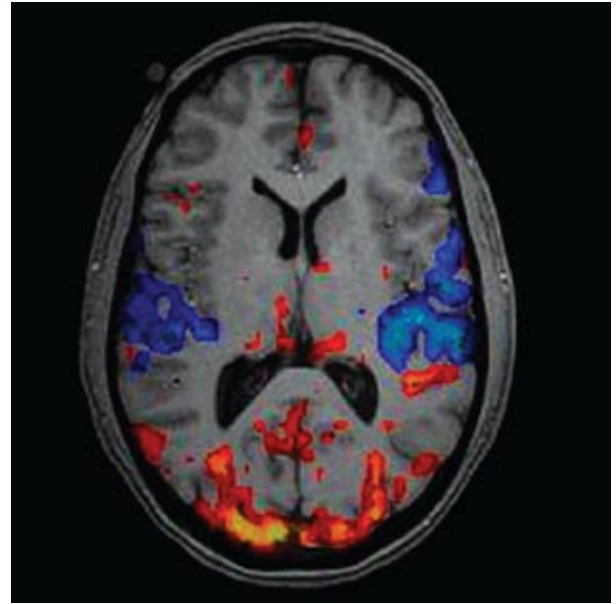
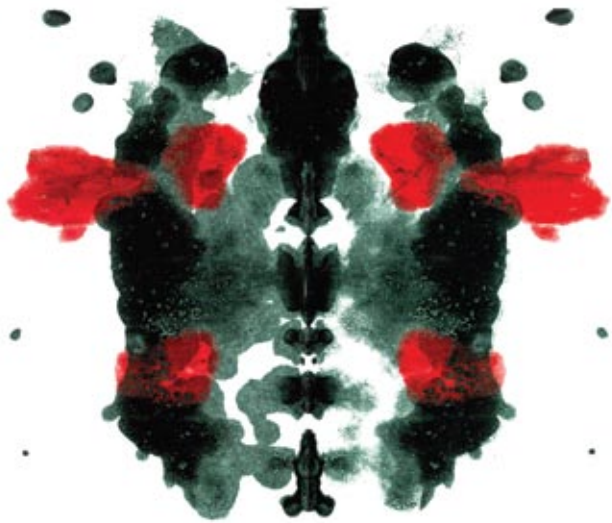


Electroencephalographic recording from a woman with dissociative identity (formerly multiple personality) disorder. She had normal brain activity when looking at a checkerboard pattern that alternated



its squares 10 times a second in her sighted state (left). But when in her blind state (right), activity was almost absent, suggesting that two different identities can indeed exist in the same skull.

SOURCE: "BLIND UND SEHEND IN EINER PERSON. SCHLUSSFOLGERUNGEN ZUR PSYCHONEUROBIOLOGIE DES SEHENS" BY B. WALDVOGEL, A. ULLRICH AND H. STRASBURGER IN NERVENARZT, VOL. 78, NO. 11; 2007



Could more than a superficial resemblance link these icons of psychoanalysis (*inkblot*, left) and modern neuroscience (*fMRI scan*, right)?

subjective and cardiovascular reaction to the traumatic memory and a different cerebral activation pattern, and they remembered the event. It appears that different identities can truly live inside the same skull.

To See or Not to See

Sometimes the difference between the personalities can be as stark as night and day. Psychoanalysts Bruno Waldvogel and Axel Ullrich and psychologist Hans Strasburger, all in Munich, Germany, reported a dissociated patient who gradually regained sight during psychotherapy—after 15 years of diagnosed blindness. There was nothing wrong with the patient’s eyes per se, but she claimed she couldn’t see, and testing at the ophthalmologist bore this out. During the experiment reported here, one personality state had essentially normal eyesight, whereas a younger, male personality—which could be summoned momentarily by calling out his name—was blind. This phenomenon could be construed as hysterical ranting were it not for the electrical activity recorded by electroencephalographic scalp electrodes. When in her sighted personality, the EEG showed normal brain waves in response to a checkerboard pattern that alternated its squares 10 times each sec-

ond—from white to black and back again. But visually evoked activity was much reduced in her blind personality state [see illustration on opposite page]. There is no known mechanism that allows someone to consciously block vision with open eyes. This remarkable finding implies that the brain can rapidly intervene at a very early stage of the visual system, preventing visual information from reaching the patient’s cortex. How it does so remains a mystery.

What may be altered in dissociative disorders is not so much the degree of activity of a particular brain area but the degree of interactivity between areas. Functional integration of cortical and subcortical regions is necessary for cohesive conscious experience. The way the brain is connected and the way different parts of the brain communicate with one another are important. Dissociation may be the result of a disruption of certain connections among brain regions. Hence, dissociative disorders may result from the failure of coordination or

integration of the distributed neural circuitry that represents subjective self-awareness.

New advances in neuroscience and technology are revealing the neurobiology of the dynamic unconscious that Freud, Janet and others envisioned. In the process, inevitably, much of what was originally put forth based solely on the “talking cure” will be revised, refined and enhanced. Devising novel ways to empirically test dynamic unconscious processes such as repression, suppression and dissociation will reveal their neural bases. This effort will ultimately lead to more effective treatment options for psychiatric patients and help us to better understand our own consciousness. **M**

HEATHER A. BERLIN is assistant professor of psychiatry at Mount Sinai School of Medicine. CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology.

(Further Reading)

- ◆ **Neural Systems Underlying the Suppression of Unwanted Memories.** Michael C. Anderson et al. in *Science*, Vol. 303, pages 232–235; January 9, 2004.
- ◆ **Psychobiological Characteristics of Dissociative Identity Disorder: A Symptom Provocation Study.** A.A.T. Simone Reinders et al. in *Biological Psychiatry*, Vol. 60, No. 7, pages 730–740; October 1, 2006.

STEFAN KLEIN / iStockphoto (inkblot); OXFORD CENTER FOR FUNCTIONAL MAGNETIC RESONANCE IMAGING OF THE BRAIN (brain scan)

The Power of Symmetry

Our brain's preference for symmetry influences how we perceive motion

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

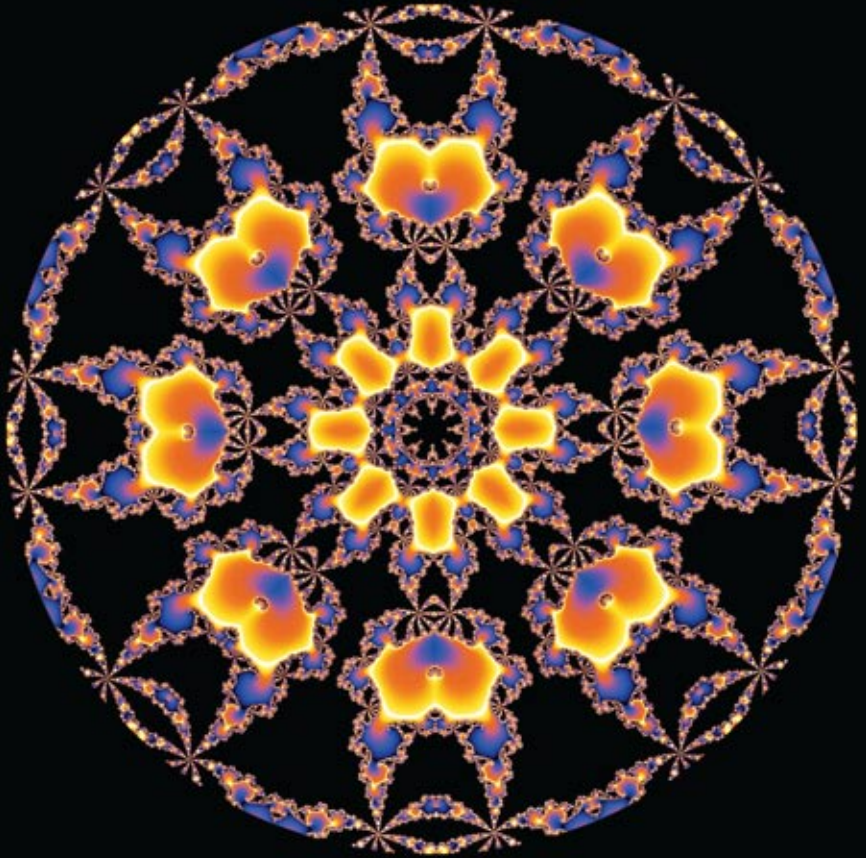
THE AESTHETIC APPEAL of symmetry is obvious whether you are a child playing with a kaleidoscope or a Great Mogul emperor building the Taj Mahal as a monument to eternal love. That preference, as it turns out, greatly shapes how we see the world when items are in motion. More on that shortly.

In the natural, as opposed to man-made, world, symmetry—whether we see it in prey, predator, mate or mother—serves as an early-alert system, drawing your attention. Even an infant, who has blurry views of his or her surroundings because of not yet developed acuity, has an innate preference for symmetry. Babies stare longer at faces that have two eyes in the normal position than they do at those that have a cyclopean or a stacked-eyes configuration.

Symmetrical faces tend to be judged as more attractive than asymmetrical ones. Some researchers have postulated that this partiality may be because infestation with parasites can cause visible asymmetry in victims. As a parasite species evolves, it continuously

tries to match its surface antigens to those of its host to evade immunological rejection. At the same time, there is a strong selection pressure on the host to be able to detect parasitic infestation and other abnormalities that might potentially reduce fitness and reproductive success. If parasitic infestation occurs sufficiently early in development, it can produce minor deviations from symmetry—hence the adaptive advantage of using asymmetry as a marker to avoid potential mates with poor health, weak genes or a challenged immune system.

a



Balance on the Whole

Early in the 20th century Gestalt psychologists started exploring the perceptual importance of symmetry. They rejected and attacked the prevailing atomistic, or reductionist, approaches to perception. The Gestaltists, beginning with Max Wertheimer, identified “laws” of perceptual organization and emphasized how the relation of all the elements in a scene, rather than the individual elements by themselves, will influence the final perception. For example, three collinear

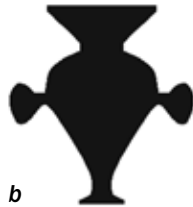
dots suggest a line, but three dots when misaligned will evoke an unmistakable perception of triangleness—even though the display lacks the shape’s hallmark of three lines and three vertices (*a*).

The illustration in *b* demonstrates one of the most basic Gestalt principles—organization of a scene into “figure” and “ground.” Even in novel, abstract images, a perceptual division exists between an object, or thing, and the background. Contours are seen to belong to the figure, which is seen to be

(In the **natural world**, symmetry serves as an early-alert system, drawing your attention.)

lying in front of the shapeless ground. Here you see a black vase, but with some time and effort, you should be able to perceive an alternative percept of two white faces in profile in front of a dark ground.

Gestaltists identified many “laws” for determining what is seen as figure or ground in a display. In general, if contours are near each other, they will be perceived as belonging together, as being part of the same figure, a tendency termed the Law of Proximity. If contours are mirror-symmetric, they also will group together and define a figure, known as the Law of Symmetry.

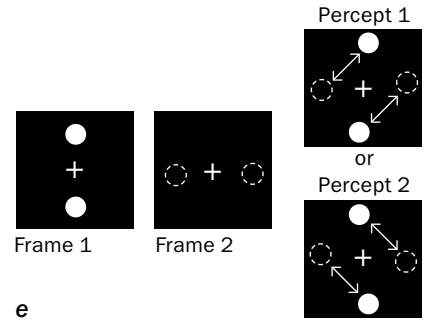
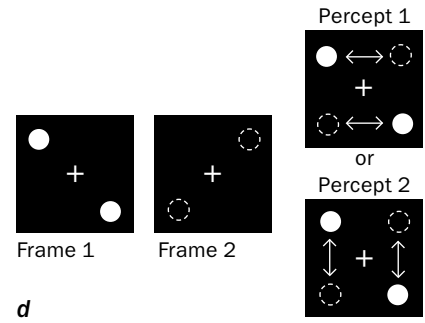


bulbs themselves do not budge, your perception of motion between them is vivid. Because the same brain mechanisms appear to process real motion (your cat walking across the room) and apparent motion (holiday lights), apparent-motion displays provide a convenient tool for the study of motion perception.

Apparent Motion

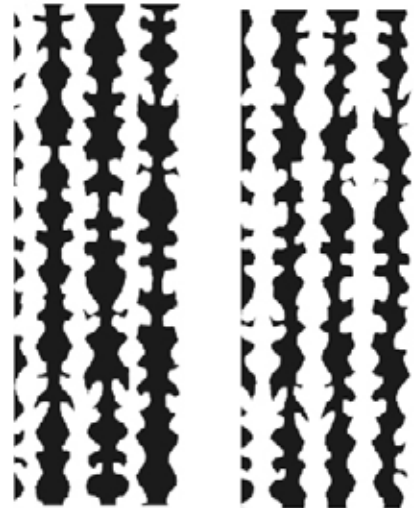
In the 1980s one of us (Ramachandran) and our colleague Stuart M. Anstis developed an apparent-motion display called the Bistable Quartet (*d*). In this illusion, two dots are flashed simultaneously (frame 1 in *d*) on two corners of an imaginary square and then switched off and replaced by two identical dots on the remaining two corners (frame 2 in *d*). When frames 1 and 2 are alternated rapidly, you can see apparent motion: the dots appear to move either left-right, left-right or up-down, up-down. The perceived direction of motion is ambiguous, or bistable. You can see one or the other, but you cannot see both simultaneously. It is similar to the experience with the face-vase illusion shown in *b*.

If this display is rotated 45 degrees so that the dots define an imaginary diamond instead of a square, you perceive the path of motion rotated 45 degrees as well. That is, the dots appear to move back and forth along parallel diagonals. Again, there are two equally possible, mutually exclusive perceptions of motion: either along the diagonal with a positive slope or along the diagonal with a negative slope. And again, you should be able to alternate between the two.



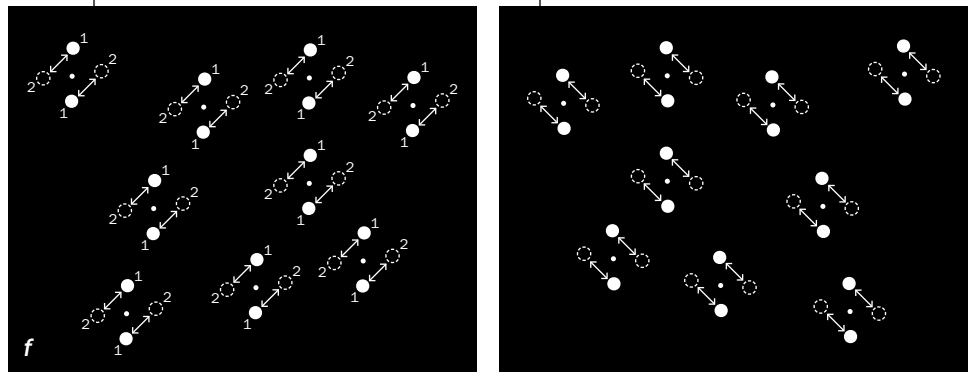
nal with a negative slope. And again, you should be able to alternate between the two.

Consider what happens when we scatter multiple Bistable Quartets randomly on a computer display screen (*f*). Because each one has a 50 percent probability of being seen with movement along the positive versus the negative axis, you might expect a 50–50 split. Amazingly, they all get coupled together by the brain. They end up doing exactly the same type of oscillation throughout the visual field. You can cause some brief moments of uncoupling the quartets if you expend intense mental effort, but their natural state in your perception is to remain synchronized. This experiment shows that the perception of apparent motion is not a piecemeal affair happening separately in



So what happens when symmetry is pitted against proximity? Symmetry tends to dominate; that is, we usually see the shapes defined by mirror-symmetric contours as figure rather than as ground (*c*). Our brain is choosing symmetry to perceive objects.

Now we return to the idea of considering how symmetry can influence the processing of motion. Let us begin with apparent motion, the illusion of movement that you get when, for instance, two spatially separated spots are presented in rapid temporal succession (as in a string of Christmas bulbs that appear to jump back and forth). Even though the spots/



SCIENTIFIC AMERICAN MIND (a-f)

(The need for symmetry **overrides the need** for seeing synchronized motion throughout the field.)

different parts of the visual field. There is a global imposition of coherence.

Now we introduce symmetry by rearranging the field of Bistable Quartets to form a “butterfly” pattern, which is bilaterally symmetric across the vertical axis. An extraordinary thing happens: people see the quartets within each half of the display synchronized, as expected, but across the axis of symmetry, in the mirror half of the display, all the quartets are synchronized to the opposite direction of motion (g). It is as though the overall global symmetry of the *form* of the butterfly imposes its symmetry on the perceived motion, which necessarily means opposite directions for the two halves of the display. (We are currently exploring this phenomenon with our student Elizabeth Seckel of the University of California, San Diego.)

silhouette—but your brain makes sense of it instantly to see a young woman in full 3-D spinning on her vertical axis. If asked, you could confidently answer which direction she is spinning, clockwise or counterclockwise (as seen from above). But keep looking because, again, the direction of motion is ambiguous. With effort (or by first covering all but a small part of the moving display), you should be able to flip the direction you see her spinning.

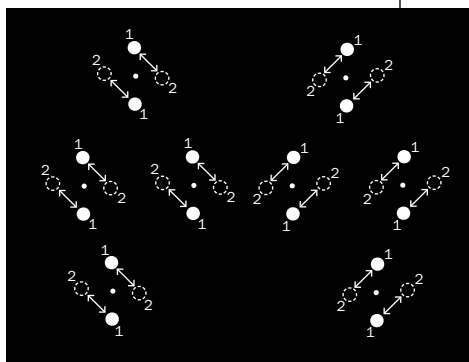
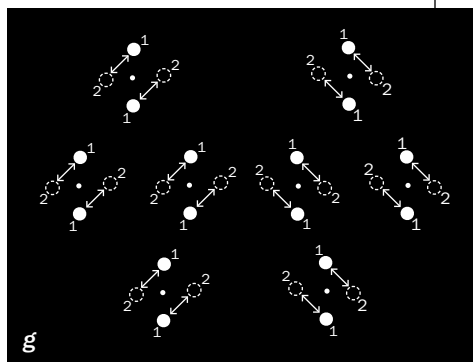


ballerinas, and again, most subjects instantly saw the ballerinas within one half of the axis of symmetry synchronized—but the populations on the two halves spun in opposite directions from each other. In other words, the two fields appeared to spin either toward or

away from each other. The need for symmetry overrides the need for seeing synchronized motion throughout the field. (Sometimes, with mental effort, they can all be made to do the same thing, but the spontaneous preference is toward seeing opposite directions.) You can verify this result by simply putting a mirror at right angles to the computer screen next to the ballerina.

It is fun to see a group of these figures spinning; if you have some programming skills, you can try creating it. Otherwise, you may generate a reasonable display by opening multiple new pages, each with the same image, and scattering them

The coupling of motion and direction is based partially on the objects’ synchronicity in time (and speed). Physiologists have proposed that such perceptual groupings may arise when there is synchronization of nerve impulses that are evoked in multiple brain regions by the individual quartets or ballerinas. If so, what happens if ballerinas in different parts of the visual field spin at speeds slightly different from one another? Would they still get synchronized? What if ballerinas were of nonuniform sizes? Could you uncouple large and small ones then? Have fun! **M**



Ambiguous Pirouette

Thus, the need for symmetry overrides the global tendency to see identical motion throughout the visual field. All of perception depends on a hierarchy of precedence rules that determines how different “laws” interact, rules that reflect the statistical properties of the world and the organism’s need for survival.

A different experiment on the interaction between motion and symmetry, one that you can perform yourself, involves the spinning ballet dancer illusion (b; you can Google that phrase to bring up the moving display). What is on the retina is a deforming shadow—a black

across your screen. Or you could employ a multilens (insect eye) fresnel lens sheet (available in novelty or science museum stores) that will optically multiply the ballerina. As with the earlier, simpler bistable motion quartets, you will perceive all the ballerinas synchronized, spinning together either rightward or leftward. (We conducted this experiment with Shai Azoulai, then a U.C.S.D. graduate student.) Again we created a symmetrical butterflylike display with multiple

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(Further Reading)

- ◆ **The Perception of Apparent Motion.** Vilayanur S. Ramachandran and Stuart M. Anstis in *Scientific American*, Vol. 254, No. 6, pages 102–109; June 1986.

NOBUYUKI KAYAHARA (spinning dancer); SCIENTIFIC AMERICAN MIND (g)

(calendar)

April



Ongoing

Were you secretly solving differential equations while your friends were hanging out at the mall? Do you credit your luck in Vegas to a keen grasp of probability and statistics? Celebrate your knack (or lack) for numbers during **Mathematics Awareness Month**. This year's theme is "Mathematics and Climate"; lectures and events will focus on how math is applied to modeling the global climate, from figuring out if hurricanes are getting stronger to predicting changes in the polar ice caps. [For a math-related article on health statistics in this issue, turn to "Knowing Your Chances," on page 44.]

www.mathaware.org

1-4 More than 8,000 psychiatrists and other mental health professionals will convene at the **World Psychiatric Association's International Congress** in Florence to discuss the state of the art in evidence-based treatments for mental illness. Workshop and symposium topics will include treatments for pregnant women with chronic psychiatric disorders and the mental health effects of living in big cities.

Florence, Italy
www.wpa2009florence.org

2-4 As many as 20 percent of newly diagnosed patients with a movement disorder might suffer from an unidentified psychiatric problem instead of a flaw in the motor system. Members of the international Movement Disorder Society are neurologists, psychologists and other experts whose work is unraveling the mysteries behind these so-called psychogenic movement disorders. At the society's **Second International Conference on Psychogenic Movement Disorders**

and **Other Conversion Disorders**, researchers will discuss recent developments in diagnosis and patient therapies. Washington, D.C.
www.movementdisorders.org/education/pmd

3-4 Charles Darwin's ideas have forever changed the way people in Western cultures perceive themselves. As part of the bicentennial of Darwin's birth, Boston University's Colloquium for Philosophy of Science is hosting a series of lectures that includes a symposium on the **Reception of Darwinism: Transcultural Differences**. International speakers will discuss the ways in which different groups—including Estonians, Cuban naturalists and Brazilian intelligentia—have adopted the influential theory.

Boston
www.bu.edu/philo/centers/cphs/colloquium/colloquia/49th.htm

24 Genius and madness are a historic duo. In **The Soloist**, Nathaniel Ayres (Jamie Foxx)—a Juilliard-trained musician—suffers from schizophrenia and is living on the streets of Los Angeles when *L.A. Times* columnist Steve Lopez (Robert Downey, Jr.) discovers him on a corner playing a two-stringed violin. Based on a true story and Lopez's book of the same name, this film, in theaters starting April 24, explores the nightmare of mental illness and homelessness and the redemptive powers of music and friendship.

DreamWorks Pictures
www.soloistmovie.com



May

Ongoing

Test your problem-solving abilities at **Brain Teasers 2**, the sequel to the Oregon Museum of Science and Industry's popular Brain Teasers exhibition. Now residing at the World of Wonder Children's Museum through May 3, these 20 puzzles, from mazes to mathematical mysteries, will challenge visitors of all ages to think outside the box.

Lafayette, Colo.
www.wowmuseum.com/traveling.html

6&7 Why do groups form? **Sigmund Freud**, born on May 6, 1856, tackled this question in his essay "Group Psychology and the Analysis of the Ego" (1921) and concluded that the answer is love. His work borrowed from and critiqued the successful book *The Crowd: A Study of the Popular Mind* (published originally in French in 1895) by social scientist and philosopher **Gustave Le Bon**, who was born on May 7, 1841. Le Bon, even before Freud, was a great popularizer of theories of the unconscious. His influential writings on the collective mind and on propaganda techniques drew careful study by fascist dictators Adolf Hitler and Benito Mussolini.



28-30 Exciting advances in genetics and in cognitive and developmental sciences are constantly reshaping our views of how learning happens in the brain. The **International Mind, Brain, and Education Society (IMBES)** fosters mutual exchange between the neurosciences and the educational system. Insights into the brain's learning process can inform the way educators teach and evaluate their students. And results from the classroom can in turn help identify new testable hypotheses for researchers. The society's second biennial conference will bring together scientists, teachers and policy makers from around the globe.

Philadelphia
www.imbes.org/conference2009/conf09.html

● Compiled by Rachel Dvoskin and Katherine Harmon. Send items to editors@SciAmMind.com

Laughing Matters

Seeing the bright side of life may **strengthen the psyche, ease pain and tighten social bonds**

■ By Steve Ayan



Norman Cousins, the storied journalist, author and editor, found no pain reliever better than clips of the Marx Brothers. For years, Cousins suffered from inflammatory arthritis, and he swore that 10 minutes of uproarious laughing at the hilarious team bought him two hours of pain-free sleep.

In his book *Anatomy of an Illness as Perceived by the Patient* (W. W. Norton, 1979), Cousins described his self-prescribed laughing cure, which seemed to ameliorate his inflammation as well as his pain. He eventually was able to return to work, landing a job as an adjunct professor at the School of Medicine at the University of California, Los Angeles, where he investigated the effects of emotions on biological states and health.

The community of patients inspired by such miracle treatments believes not only that humor is psychologically beneficial but that it actually cures disease. In reality, only a smattering of scientific evidence exists to support the latter idea—but laughter and humor do seem to have significant effects on the psyche, even influencing our perception of pain. What is more, psychological well-being has an impact on overall wellness, including our risk of disease.

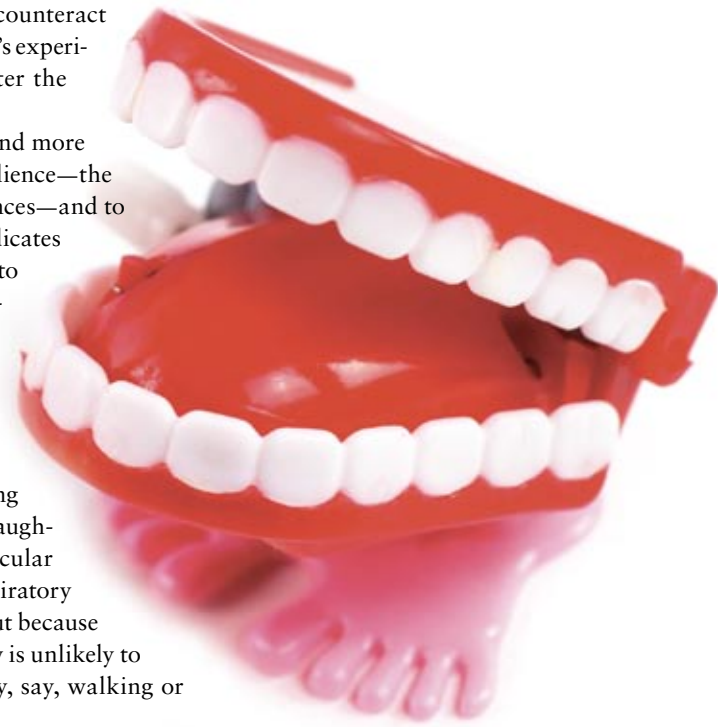
Laughter relaxes us and improves our mood, and hearing jokes may ease anxiety. Amusement's ability to counteract physical agony is well documented, and as Cousins's experience suggests, humor's analgesic effect lasts after the smile has faded.

Cheerfulness, a trait that makes people respond more readily to laugh lines, is linked to emotional resilience—the ability to keep a level head in difficult circumstances—and to close relationships, studies show. Science also indicates that a sense of humor is sexy; women are attracted to men who have one. Thus, in various ways, life satisfaction may increase with the ability to laugh.

Amusing Exercise

Ancient Greek philosopher Aristotle viewed laughter as “a bodily exercise precious to health.” But despite some claims to the contrary, chuckling probably has little influence on physical fitness. Laughter does produce short-term changes in cardiovascular function and respiration, boosting heart rate, respiratory rate and depth, as well as oxygen consumption. But because hard laughter is difficult to sustain, a good guffaw is unlikely to have measurable cardiovascular benefits the way, say, walking or jogging does.

In fact, instead of straining muscles to build them, as exercise does,





Watching the Marx Brothers comedy team (seated from left: Harpo, Groucho, Zeppo and Chico) provided pain relief for journalist and author Norman Cousins, who suffered from inflammatory arthritis.

laughter apparently accomplishes the opposite. Studies dating back to the 1930s indicate that laughter relaxes muscles, decreasing muscle tone for up to 45 minutes after the guffaw subsides.

Such physical relaxation might conceivably help moderate the effects of psychological stress. After all, the act of laughing probably does produce other types of physical feedback that improve an individual's emotional state. According to one classical theory of emotion, our feelings are partially rooted in physical reactions. American psychologist William James and Danish physiologist Carl Lange argued at the end of the 19th century that humans do not cry because they are sad but that they become sad when the tears begin to flow.

Although sadness also precedes tears, evidence

suggests that emotions can flow from muscular responses. In an experiment published in 1988, social psychologist Fritz Strack of the University of Würzburg in Germany and his colleagues asked volunteers to hold a pen either with their teeth—thereby creating an artificial smile—or with their lips, which would produce a disappointed expression. Those forced to exercise their smiling muscles reacted more exuberantly to funny cartoons than did those whose mouths were contracted in a frown, suggesting that expressions may influence emotions rather than just the other way around. Similarly, the physical act of laughter could improve mood.

Additional studies have shown that laughing at a funny film can cause a drop in the blood's concentration of the stress hormone cortisol (although other stress hormones appear to be unaffected). Because chronically elevated cortisol levels have been shown to weaken the immune system, this mechanism could conceivably help ward off disease. Indeed, experiments have indicated that laughter increases the activity of immune cells called natural killer cells in saliva in healthy subjects.

In some cases, though, laughter may dampen inappropriate immune responses. In a 2007 study allergy researcher Hajime Kimata of Moriguchi-Keijinkai Hospital in Japan measured levels of the hormone melatonin in the breast milk of nursing mothers before and after the subjects watched either a comic Charlie Chaplin video or an ordinary weather report. Melatonin regulates the sleep-wake cycle and is often disturbed in the allergic skin condition atopic eczema, which all of the 48 babies in the study had. Kimata found that laughing at the funny film, but not hearing the weather report, increased the amount of melatonin in the mothers' milk. In addition, the laughter-fortified breast milk reduced the allergic responses to latex and house dust mites in the infants. Thus, making a nursing mom laugh might sometimes serve as an allergy remedy for her baby.

The idea that laughter itself, independent of humor, provides physiological and psychological benefits motivates proponents of "laughter yoga," a group exercise in simulated laughter, which (like yawning) quickly becomes contagious. Many participants in such programs, which are growing in popularity, report feeling looser and happier after them. Some researchers are skeptical that feigned laughter has direct health benefits, however. Psychiatrist Barbara Wild of the University of Tübingen in Germany, for example, believes that the sense of well-being that people report after such sessions results from the social experience of giggling and

HULTON-DEUTSCH COLLECTION/CORBIS

FAST FACTS
Harnessing Humor

- 1>> The concept of laughter as a cure for disease lacks scientific support, but humor may indeed have significant effects on the psyche.
- 2>> Laughter relaxes us and improves our mood, and hearing jokes may ease anxiety. Amusement can also counteract pain.
- 3>> Cheerfulness, a trait that makes people respond more readily to humor, is linked to emotional resilience—the ability to keep a level head in difficult circumstances—and to close relationships. Life satisfaction may increase with the ability to laugh.

The **humorous perspective** can create cognitive distance between yourself and the circumstances in a way that can be **psychologically protective**.

interacting as a group and not from a direct physiological effect of laughter itself.

Shifting Perspective

Of course, humor elicits various thoughts and emotions in addition to a social response such as laughing, smiling, groaning or verbal banter. Indeed, most humor researchers believe that the psychology of humor, rather than laughter per se, is what most benefits mental and physical health.

Humor is an intellectual skill that requires an ability to view situations in a particular light. Humor and comedy are often based on a logical twist, paradox or displacement. In Lewis Carroll's *Alice in Wonderland*, the Mad Hatter announces to Alice: "If you knew Time as well as I do, you wouldn't talk about wasting it." And after Alice says she has to "beat time" when she learns music, the Hatter replies: "Ah! That accounts for it. He won't stand beating."

Understanding a reference to "time" as if it were a living thing with feelings requires the ability to shift perspective away from the conventional view of the concept. Clinical psychologist Michael Titze, founder of HumorCare, an association that promotes humor as therapy, believes the humorous per-

spective creates cognitive distance between yourself and the circumstances in a way that can be psychologically protective. As Sigmund Freud wrote in 1928, "No doubt, the essence of humor is that one spares oneself the affects to which the situation would naturally give rise and overrides with a jest the possibility of such an emotional display."

Such cognitive and emotional distancing may help keep anxiety at bay. In a 1990 study Nancy A. Yovetich, now a pharmaceutical researcher at Rho, Inc., along with psychologists J. Alexander Dale and Mary A. Hudak of Allegheny College, told 53 college students they would receive an electric shock in 12 minutes (although no shock was forthcoming). During the wait, some students listened to a funny tape, whereas others heard a humorless speech or nothing at all. Those exposed to the humor rated themselves as less anxious as the fictitious shock approached than did those in the other two groups. In addition, participants who in a prior personality test had scored higher on "sense of humor" showed the least tension of all, suggesting that humor is indeed calming.

For similar reasons, humor can take the sting out of defeat and disappointment, helping people weather difficulty. In the mid-1990s psychologist



TIM WIMBORNE Reuters/Landov

World Laughter Day

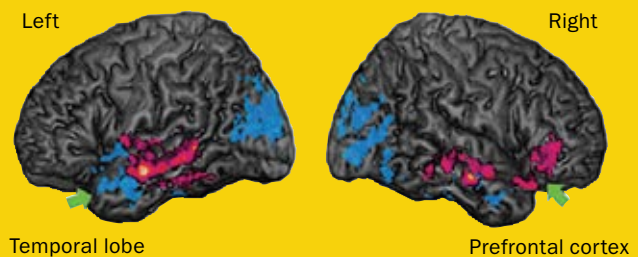
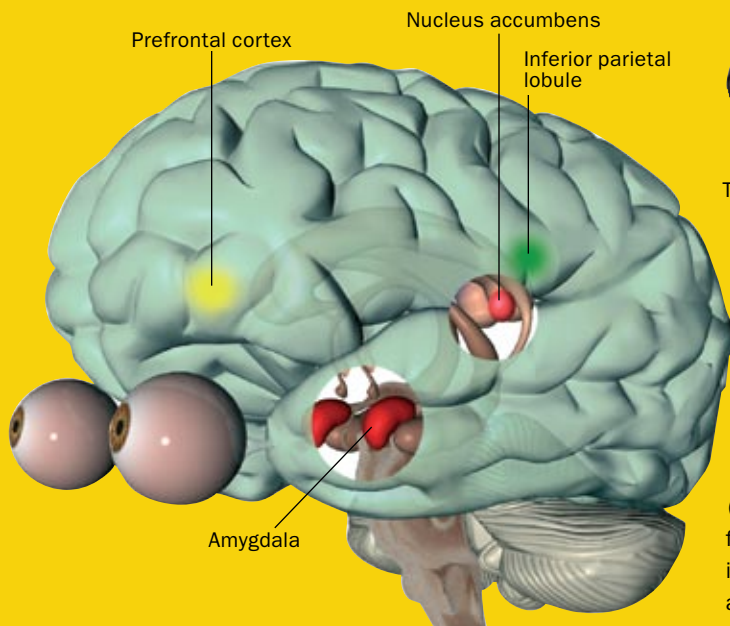
Inspired by physician Madan Kataria, who founded the laughter yoga movement, the first Laughter Day took place in Mumbai, India, on January 11, 1998. Since then, numerous events dedicated to promoting laughter and cheerfulness have been staged annually all over the world (shown here in Sydney, Australia).

Humor in the Brain

The brain contains a network of regions that underlie the appreciation of jokes. Several studies have pointed to the prefrontal cortex (yellow) as a major player. Damage to that region profoundly disrupts a person's ability to grasp and react emotionally to jokes. Some evidence even hints that the prefrontal cortex becomes more activated the funnier the joke is. Meanwhile other experiments point to the amygdala (a generator of emotions, including fear) and the nucleus accumbens (both in red), as well as other parts of the brain's reward system, as essential to humor appreciation.

A 2005 study by neuroscientist Allan L. Reiss and his colleagues at the Stanford University School of Medicine attempts to reconcile these findings by suggesting that the brain regions

activated in the response to a funny joke or cartoon depend on an individual's personality. Reiss and his co-workers showed that in extroverted people the prefrontal cortex and nearby orbitofrontal cortex light up preferentially when a person reacts to funny cartoons (pink splotches in brain). In introverts, on the other hand, the amygdala and the front part of the temporal lobe become more stimulated when an individual sees humor in a cartoon (blue). The researchers suggest that these structures mediate the rewarding feelings people experience when they respond to humor, with the pleasurable emotions originating from different brain sites in extroverts and introverts.



In a study published in 2008 neuroscientist Wolfgang Grodd of the University of Tübingen in Germany and his colleagues found that a cheerful personality, as assessed by the State-Trait Cheerfulness Inventory, was associated with activation of lateral cortical brain regions during the viewing of Gary Larson cartoons. (They did not link cheerfulness to activity in limbic brain areas such as the amygdala.) One cortical area that responded, the inferior parietal lobule (green), is involved in resolving incongruities, a skill essential for appreciating humor. The researchers believe commotion in this region may characterize a person who is easily amused and enjoys ambiguity. —Ingrid Wickelgren, staff editor

Willibald Ruch, now at the University of Zurich, and his co-workers at the University of Düsseldorf in Germany created a measure of cheerfulness and sense of humor called the State-Trait Cheerfulness Inventory (STCI). Its questions distinguish between a person's momentary mood (state)—triggered, say, by a joke—and a general disposition for enjoyment (trait). A high cheerfulness score means a person gets in a cheerful mood easily and laughs readily.

(The Author)

STEVE AYAN is a psychologist and editor at *Gehirn & Geist*.

One benefit of a cheerful character is resilience, a psychic robustness that emotionally buffers people against crises and enables them to see silver linings in major disappointments such as the dissolution of a marriage or the loss of a job. "Humor strengthens the psyche," Ruch says. In a study published in 1999, he and his colleagues assigned 72 students, all of whom took the STCI, to one of three rooms: a "cheerful" room with large windows, yellow walls, funny posters and colored drapes; a "depressing" room painted black and lit only by a small frosted bulb; and a small "serious" room filled with scientific equipment, books, manuals and presentation posters. The participants performed tasks such as drawing and filling out questionnaires in each of

GEHRN & GEIST/SIGANIM (brain illustration at left); SOURCE: "PERSONALITY PREDICTS ACTIVITY IN REWARD AND EMOTIONAL REGIONS ASSOCIATED WITH HUMOR," BY D. MOBBS ET AL., IN PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA, VOL. 102, NO. 48, 2005. COPYRIGHT 2005 NATIONAL ACADEMY OF SCIENCES, U.S.A. (brain activation illustrations at right)

the rooms, as an excuse for spending time in the separate environments. As expected, the ambience of the rooms had a much larger effect on the less cheerful individuals: the depressing and serious rooms put the more humorless students in a worse mood but did not alter the mind-set of the sunnier participants, as measured by a mood test.

In another test of the buffering power of cheerfulness published in 1996, Ruch, physician Claus-Udo Wancke and their colleagues in Düsseldorf measured this trait in 68 adults and then asked them to discuss emotionally laden proverbs. The researchers found that talking about the negative proverbs put people with more sober personalities into a bad mood, whereas the more upbeat folks stayed as jovial as before, again indicating that be-

exposure to the water to feel pain and could tolerate longer submersions before pulling their hand out. These changes in pain perception were lasting, persisting for 20 minutes after the film ended. Smiling, but not necessarily laughter, seemed to be most important for the pain-suppressing effect. The women who were asked to refrain from smiling in response to the film generally felt the most pain, and the members of that group who failed to suppress a grin showed more pain tolerance than the others did.

A lack of seriousness (the counterpart to cheerfulness, though not its opposite) also seemed to help, the researchers found. The individuals who ranked low in seriousness, as measured by the STCI, showed the most genuine smiling and laughter, which lessened their pain. The authors speculate

Humor can have **painkilling properties**: patients who watched **funny movies** needed less of their mild analgesics after orthopedic surgery.

ing a cheerful person with a sense of humor may help you endure negative events and situations.

Easing Agony

In addition to being less affected by negative events, individuals with a sense of humor may also be able to distance themselves from the threat of pain. As early as 1928, New York physician James J. Walsh noticed that laughter seemed to dampen pain after surgery. Since then, research has indicated that humor can have painkilling properties. One 1996 study demonstrated that patients who watched funny movies needed less of their mild painkillers after orthopedic surgery than did patients who viewed serious flicks or nothing at all.

Humor's analgesic effect requires enjoyment but not necessarily laughter, according to a 2004 study by Ruch, along with his then graduate students Karen Zweyer and Barbara Velker. The researchers asked 56 women to submerge a hand in ice-cold water before, immediately after and 20 minutes after a funny seven-minute film. In response to the film, some of the women were instructed to get into a cheerful mood without smiling or laughing; others were asked to smile and laugh a lot; the rest were told to create humorous verbal commentaries on the film while watching it.

As expected, seeing the funny film did boost pain tolerance in all the women: after exposure to the comedy, all the participants required a longer



Cheerful people have a lighthearted **interaction style** that facilitates bonding closely with others and builds **social support**.

that people who are less sober in general may also take pain less seriously. They propose that seriousness or its opposite, playfulness, might be a good indicator of whether an intervention involving humor would alleviate pain in an individual.

In addition to suppressing pain, being funny and cheerful can cultivate friendships. Cheerful people have a lighthearted interaction style that facilitates bonding closely with others and builds social support. They also may get more dates. In 2006 psychologists Eric R. Bressler of Westfield State

College and Sigal Balshine of McMaster University in Ontario reported that women are more likely to consider a man in a photograph a desirable relationship partner if the picture is accompanied by a funny quote attributed to the man. In fact, the women preferred the funny men despite rating them, on average, less intelligent and less trustworthy.

Although the men in Bressler and Balshine's study did not prefer witty women as partners, other research indicates that both men and women value a "sense of humor" when choosing a partner. Either way, males do seem to like ladies who laugh at *their* jokes. A 1990 study suggests that when women and men chat, the amount of laughing by the woman indicates both her interest in dating the man and her sexual appeal to the man. (The man's laughter did not relate to attraction in either direction.)

Healing with Humor

Because of humor's many psychological benefits, some psychologists and mental health experts are testing comedy as a remedy for stress, mild depression or just feeling down. Psychologist Paul McGhee, a former humor researcher who is now president of the Laughter Remedy in Wilmington, Del., has developed a widely used humor training program to help people manage stress [*see box on opposite page*]. In an unpublished study, Ruch, along with graduate students Heidi Stolz and Sandra Rusch, found that the McGhee program helped 96 mentally healthy individuals become more naturally cheerful and content with their lives, an improvement that lasted for at least two months.

In 2008 psychologists Ilona Papousek and Günter Schuler, both at the University of Graz in Austria, described a novel method of teaching people to make themselves cheerful that left participants in a better mood for at least two days after their three-week course ended. The subjects also felt calmer and showed reductions in blood pressure.

Wild and psychiatrist Irina Falkenberg, now at the University of Marburg in Germany, have adapted the McGhee program for patients with mild depression. Until recently, humor was taboo in psychotherapy. "Naturally, you can't just laugh away a serious mental illness," Wild says. And nobody is suggesting humor as a treatment for severe depression. But being funny could ease moderate distress.



LWA-STEPHEN WELSTEAD Corbis

Educating Comedians

Psychologist Paul McGhee, public speaker, author and president of the Laughter Remedy in Wilmington, Del., has developed a humor-training program designed to help healthy people to cope with ordinary stress. Humor training coaches people to emotionally distance themselves from bothersome issues and to relax and experience pleasure. McGhee's program consists of eight steps, each of which is supposed to take approximately two weeks to complete:

1. Characterize your own sense of humor.
2. Become less serious and more playful about life.
3. Work on your belly laugh.
4. Improve your ability to tell jokes.
5. Create your own spontaneous humor.
6. Find humor in daily life.
7. Learn to laugh at yourself.
8. Use all of the above to cope with stress.



In psychotherapy, patients often learn how to reinterpret or distance themselves from negative emotions such as stress and fear. Humor can help with these goals. “Having a sense for the comedic can be an important coping strategy,” Wild suggests.

Wild and Falkenberg coach patients to weave comedy into their daily lives. The researchers first determine what individuals find funny by asking each of them to recall a humorous experience and to provide pictures or cartoons that make him or her laugh. Later, the patients are encouraged to see the amusing side of situations—in some cases, brainstorming as a group—or to collect or create punch lines. No one is supposed to laugh *at* anyone else or turn a patient’s illness into an object of fun. Also against the rules are potentially mean-spirited forms of humor such as sarcasm or *schadenfreude* (delighting in others’ misfortune or misery).

So far Wild and Falkenberg have discovered that the humor therapy can temporarily improve patients’ mood; they are now probing its long-term effects. Meanwhile another study hints that humor might be able to lift the veil of depression. In 2007 psychiatrist Marc Walter of the University of Basel in Switzerland and his colleagues reported that 10 elderly depressed patients who received humor training in addition to medication were more satisfied with their lives than were patients in a group that received only medication. “The patients open up more easily and are more lively in their interactions” after the therapy, Walter says.

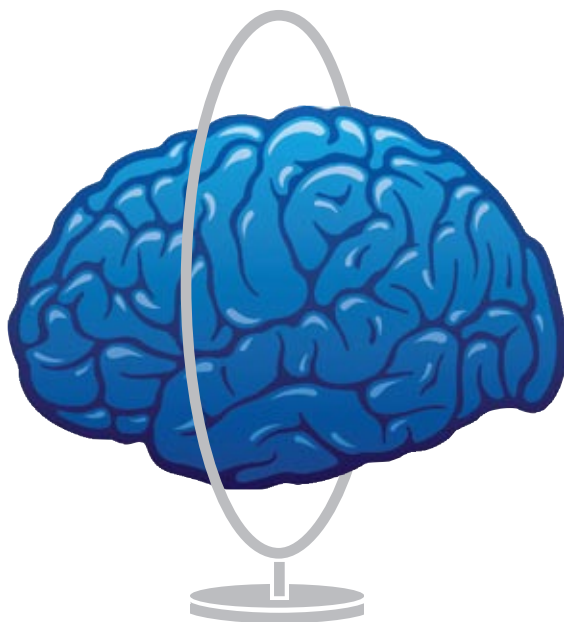
One obstacle to such efforts is that some psychi-

atric patients have problems recognizing wit because social or memory impairments prevent them from understanding the intentions of the joke teller or from holding a joke in mind from start to punch line. Because of a failure to empathize, autistic persons also fail to see the humor in many jokes.

But for most of us, humor may be the balm we need to more calmly overcome the obstacles of everyday existence, to make friends and even to stave off physical pain. According to 18th-century philosopher Immanuel Kant, laughter is one of a trio of tactics humans may use to counterbalance life’s troubles. The others are hope and sleep. **M**

(Further Reading)

- ◆ **Humor.** Willibald Ruch in *Character Strengths and Virtues: A Handbook and Classification*. Edited by C. Peterson and M.E.P. Seligman. American Psychological Association and Oxford University Press, 2004.
- ◆ **Do Cheerfulness, Exhilaration, and Humor Production Moderate Pain Tolerance? A FACS Study.** Karen Zweyer, Barbara Velker and Willibald Ruch in *Humor* 17-1/2, pages 85–119; 2004.
- ◆ **Personality Predicts Activity in Reward and Emotional Regions Associated with Humor.** Dean Mobbs et al. in *Proceedings of the National Academy of Sciences USA*, Vol. 102, No. 45, pages 16502–16506; November 8, 2005.
- ◆ **The Influence of Humor on Desirability.** Eric R. Bressler and Sigal Balshine in *Evolution and Human Behavior*, Vol. 27, No. 1, pages 29–39; January 2006.
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Brain Trainers

Put your cortex through its paces with these software games

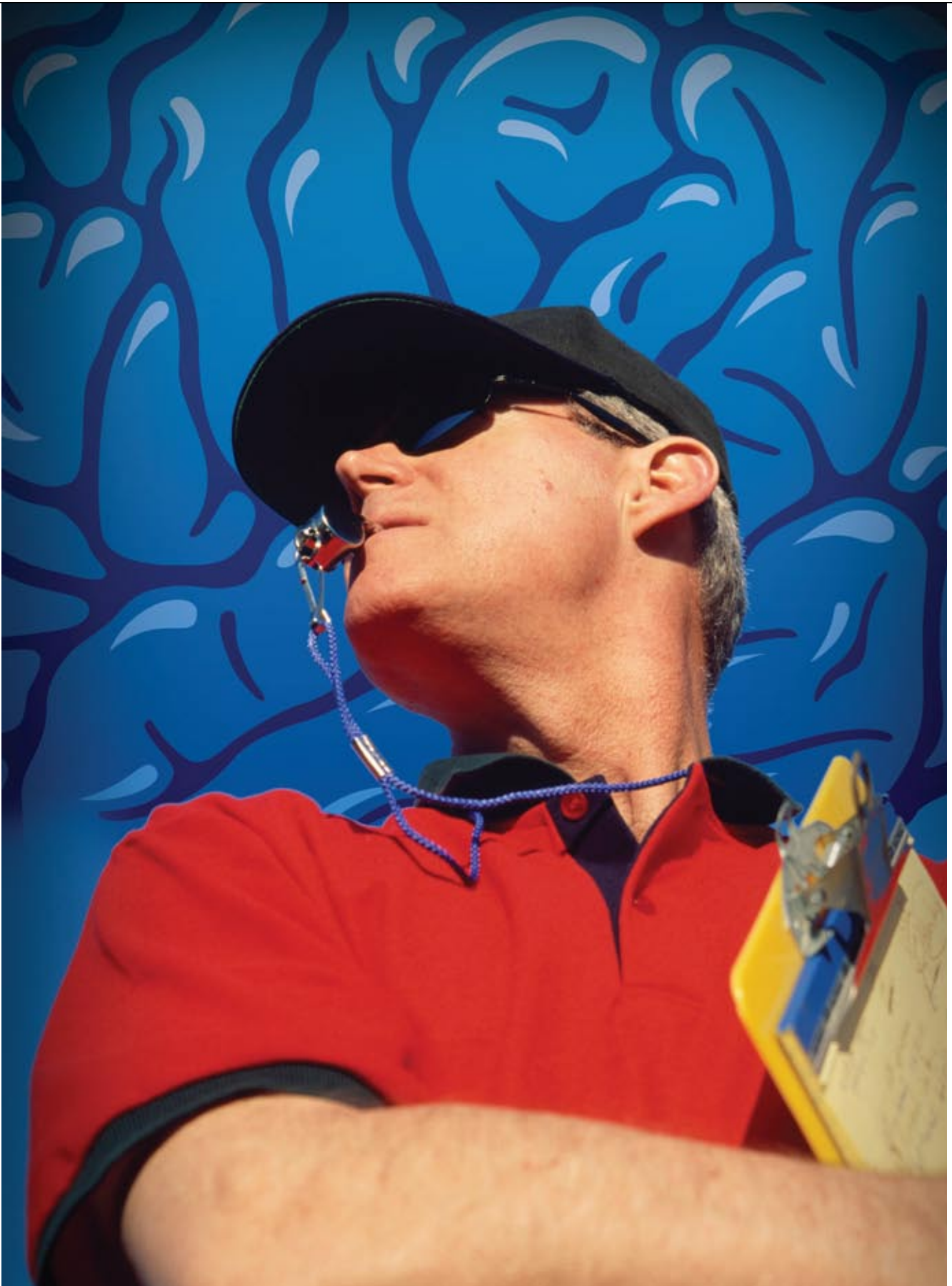
By Kaspar Mossman

Michael Merzenich, neuroscientist at the University of California, San Francisco, is ruthless as he describes how my 37-year-old brain is going to turn to mush over the years to come.

“You’re going to slowly decline in operating speed,” he says. “Your brain will become noisier and noisier in its processing.” And I will have more and more trouble figuring out exactly what it was I just heard or saw. The villain: age-related cognitive decline, which Merzenich says is a combination of physical changes and something called negative brain plasticity—the cerebral equivalent of what has happened to Arnold Schwarzenegger’s biceps.

A way to combat negative brain plasticity is to train regularly using any of an increasingly wide range of software products designed expressly for the purpose, says Merzenich, who founded Posit Science, which makes one such package.

JULIE FELTON / iStockphoto (brain above and background on opposite page); PATTI MCCONVILLE Getty Images (coach)



“Like physical exercise equipment, a brain exercise program doesn’t do you any good if you don’t use it,” one expert says.

Cognitive training is growing in popularity as baby boomers age. From 2005 to 2007 the U.S. brain fitness business increased from \$100 million to \$225 million, according to a report by SharpBrains, a market research company specializing in cognitive health. The growth was driven to a large extent by the success of Nintendo’s Brain Age [see my review of it and two other brain-training games in “Circuit Training”; *SCIENTIFIC AMERICAN MIND*, June/July 2006]. Research does confirm that regular brain exercise is beneficial to elderly people. ACTIVE, a nationwide clinical trial of 2,802 seniors that began in 1998, found that training in specific areas such as “processing speed” resulted in improvements that persisted at least five years.

I recently tried out eight of the latest brain fitness programs, training with each for a week. The programs ranged widely in focus, quality and how fun they were to use. “Like physical exercise equipment, a brain exercise program doesn’t do you any good if you don’t use it,” says Andrew J. Carle, director of the Program in Assisted Living/Senior Housing Administration at George Mason University. And people tend not to use boring equipment. “I remember when NordicTrack was the biggest

thing out there. Everyone ran out and bought one, and 90 percent of them ended up as a clothes rack in the back of your bedroom.”

After eight weeks of testing, I have learned some useful things about the software, although I certainly do not feel any smarter. That is not a surprise; I am not old yet, and I do not have cognitive difficulties. “If you have a serious problem,” says Jonas Jendi, CEO of Cogmed America, “the training is worth a lot more.”

There is the question of whether any of these programs are as good as exercising your brain on your own—by playing chess, say, or learning to play a musical instrument. Possibly not, but they are convenient packages that integrate training from many areas.

Is any one of the programs aimed at adults better than the others? Hard to say, and a proper comparative study may never be done. Start with the reviews below, which are organized by program target areas, and then take advantage of the many free trial offers online to see what works best for you. What matters most is whether you enjoy using one and whether it challenges you at the right level. Will you stick with it, or will it become a clothes rack? Your brain health is at stake.

Aural Appreciation

MAKER: Posit Science

NAME: Brain Fitness Program Classic

FOR: Seniors

PRICE: \$395 (single user); \$495 (two users)

WHAT YOU GET: CD-ROM, instruction manual, headphones

WHERE TO BUY: www.positscience.com

Posit Science’s software aims to strengthen the fundamental components of speech comprehension.



Brain Fitness Program Classic improves your ability to recognize sounds as speech and comprehend language. It begins at the most elementary levels—upward and downward frequency swoops common in spoken language—and progresses to syllables, words, sentences and stories. Its effectiveness is backed by scientific trials carried out with children and older adults.

Brain Fitness has a gold-plated user interface, as if you are at an expensive private clinic. The on-screen buttons are huge. The instructions are geared toward users whose response times are a little slower than those of the average middle-age adult—it is pretty clear what you are supposed to do most of the time, although older adults may find the long intro sections more helpful than I did.

During the training period I could notice my hearing acuity improve, in the way you would become able to discern the woodwinds in a Mozart symphony after taking a music appreciation class.

I found the Brain Fitness exercises extremely repetitive, however, and thus about as much fun as running on a treadmill. The designers try to compensate for this lack of novelty with images and Flintstones-like animations, which provide the user with a reward for sticking it out. Waiting to see exactly

what bland shenanigans the piano player and his dog would get up to in the next clip kept me motivated sufficiently to finish the week. Merzenich, now 66, says that an improved version of Brain Fitness, out sometime in the spring of 2009, will be more game-like and entertaining.

Neuro Cardio

MAKER: HappyNeuron, Inc.

NAME: Brain Fitness

FOR: Adults

PRICE: \$89.95 for CD-ROM; \$9.95/month or \$99.95/year for online membership

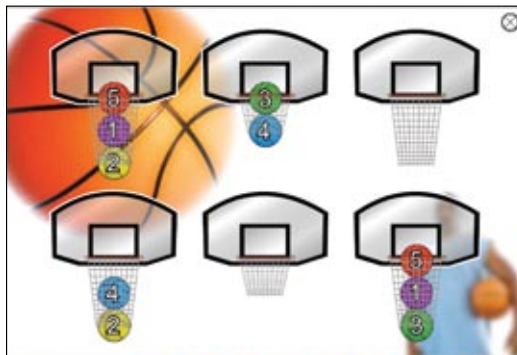
WHAT YOU GET: CD-ROM or online membership

WHERE TO BUY: CD-ROM at www.amenclinics.com/store in Games section; online membership at www.happyneuron.com

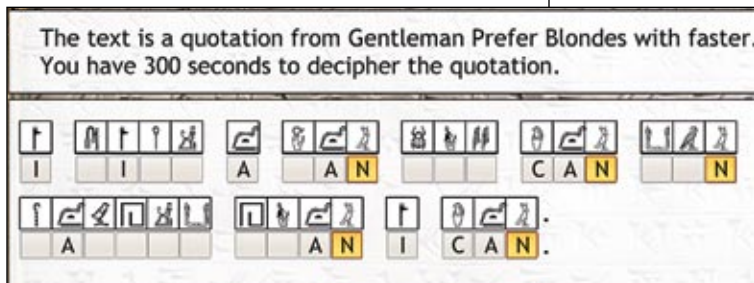
When I signed on to HappyNeuron's Web site, I was greeted by an electronic "coach" that offered me a program tailored to my needs and ability. The coach is like a trainer at a fitness club, says Laura Fay, CEO of HappyNeuron, the U.S. subsidiary of a French company that first released its software in Europe in 2002. Like a coach, "it attempts to make an appropriate challenge," Fay says. "But it never stretches the goal so far you would injure yourself."

The coach did not speak, but using HappyNeuron's Brain Fitness felt like doing cardio with a trainer who has a French accent. The instructions had quirky syntax and occasional Franco spelling, although it is obvious that someone has redesigned the games on the surface to appeal to Americans. Basketball in New York, for one: the object is to rearrange various numbers of balls in different nets. But to a North American sports fan, there is just something wrong about three basketballs sitting one on top of the other in a hoop.

I enjoyed Decipher, in which you have to decode



Two Brain Fitness gray matter benders: rearranging balls (left) and decoding quotes from pseudoglyphs (below).



a quote from fake Egyptian hieroglyphs. The sources of the quotes range from Shakespeare to rappers such as The Game. (Useful clue: rappers like to mention their own names a lot.)

Underlying the games, Fay explains, is the theory that there are five distinct domains of cognitive activity: memory, attention, language, visuospatial skills and executive function. The games are designed to stimulate the neural networks in brain regions that have been linked previously to these activities by functional magnetic resonance imaging.

Games on the Go

MAKER: Nintendo

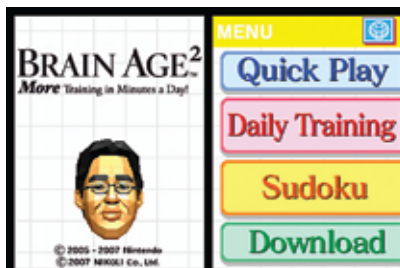
NAME: Brain Age²

FOR: Adults

PRICE: \$19.99 for game; \$129.99 for DS console

WHAT YOU GET: Handheld game console and game chip

WHERE TO BUY: Many locations, some listed at www.nintendo.com/consumer/retail/retail_retailers.jsp

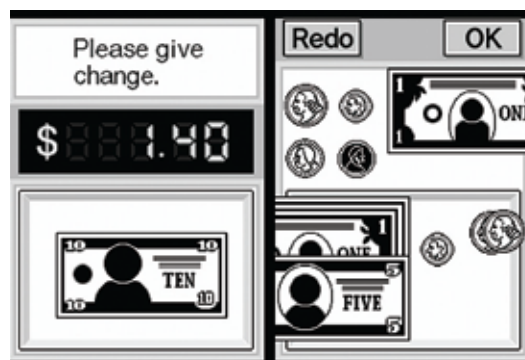


Playing Nintendo's Brain Age² on the Washington, D.C., Red Line train into work one morning, I look up from my console to see my seatmate, a young fellow, intent on his own Nintendo game—one involving a spaceship firing off a lot of missiles. "I'm reviewing this program for a magazine," I say, hoping he won't think my mental faculties are actually in poor repair.

Change Maker, one of the daily training tasks in Brain Age², demands that you come up with the correct change for a transaction.

I need not have worried. “What’s the ideal brain age, something in your 20s, right?” asks the man, John Benton, 23, a congressional assistant. Benton knows about Brain Age² because he played the first version when it came out a few years ago. “I always scored pretty old.” This news is good for me because after a week of play, my official brain age is still 52. Benton also has the same beef I did with Nintendo’s character-recognition software: “You write something, and it thinks you wrote something else.”

Brain Age² is loosely based on the research of Ryuta Kawashima, a neuroscientist at Tohoku University in Japan. Kawashima’s bobbing noggin greets



you when you start and carries on one-sided conversations about the time of day or how you are faring. In my case, usually, “Are you tired? Dust yourself off and try again tomorrow.”

You begin with simple games, such as making words out of a rotating circle of letters. The more you play, the more games are unlocked. And the games in Brain Age² are, for the most part, different from those in the original Brain Age, making it fun to discover what new workouts the game designers cooked up to exercise my prefrontal lobes. It is a good thing that Brain Age² dangles the incentive of variety if you play regularly, rather than if you improve your scores, because I did not get any better over time.

Maybe part of my problem was that I played only on the train. Brain Age², played on a handheld controller, would seem to be ideal for train commuters—it lets you skip games you don’t like so you don’t have to be the obnoxious guy apparently barking “Rock, paper, rock, rock, scissors” at his BlackBerry. But the paradox of convenience, I found, is that you need a quiet environment to concentrate. The yammering voices on a crowded subway car—not to mention valid thoughts that you might be missing your stop—are distracting.

Supermind

MAKER: Cognifit

NAME: MindFit/Cognifit Personal Coach

FOR: Seniors

PRICE: \$139 for download; \$149 for boxed CD-ROM; \$19.99/month for online membership

WHAT YOU GET: Download, CD-ROM or online membership

WHERE TO BUY: www.e-mindfitness.com

MindFit is the brainchild of Shlomo Breznitz, a psychologist at the University of Haifa in Israel and CEO of Cognifit, a company based in Israel with offices in the U.S. and Europe. The ideal training regimen is an hour a week, split into three sessions. “If you can increase your short-term memory by one to two items,” Breznitz says, “it can be revolutionary in everyday life.”

I tested a beta version online called Cognifit Personal Coach. I signed in and immediately the program conducted an exhaustive—and exhausting—assessment. One test worked hand-eye coordination, requiring me to track a ball through a maze. I fear that in Cognifit’s database my name is linked to a high klutz factor, although I do not think it is all my fault. Perhaps the game’s designers had not considered this fact, but ordinary mouse pads are not de-



Find this word search too easy? Cognifit will soon have you searching for tiny words hidden in giant matrices.

signed for dragging the mouse around for stretches of six inches or longer. As a result, I failed the test. Thereafter I was subjected to more coordination exercises to remedy my alleged deficiency.

Nevertheless, I genuinely enjoyed some of the games. Supermind, a version of the board game Mastermind in which you deduce a sequence of symbols, was one. In another, I had to find words hidden

crossword-style in a giant matrix. I laughed, however, at short words such as “BELL” camouflaged in a giant carpet of letters.

Cognifit Personal Coach differs from the competition, according to Breznitz, in a way that is not apparent to the user. It uses sophisticated artificial intelligence to tabulate the user’s scores in different cognitive dimensions and to carefully calibrate challenges. If the program senses you are reaching a plateau in a particular mode, for instance, it will give you a break for a while. “Then you can come back later and go farther,” Breznitz says. He uses Cognifit himself but says that what really keeps him sharp is



working with bright young programmers who ask him tough questions.

Cognifit’s Bell-Boy challenge tests your ability to measure elapsed time.

Cortex Sport

MAKER: Lumosity

NAME: Lumosity

FOR: Adults of all ages

PRICE: \$9.95/month; \$79.95/year

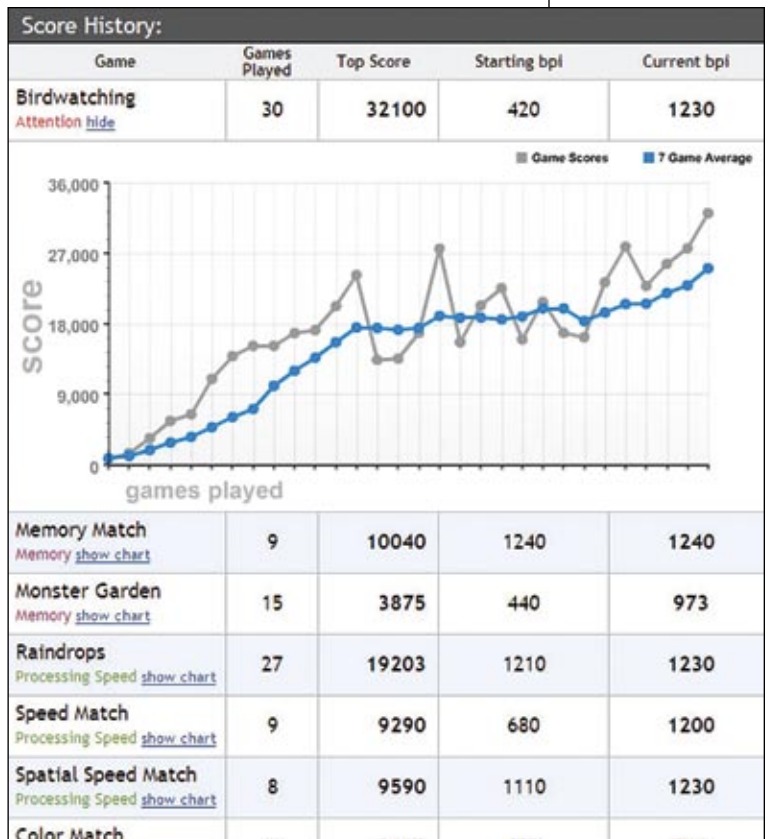
WHAT YOU GET: Online membership

WHERE TO BUY: www.lumosity.com

Lumosity was the program I was most eager to play each day. Its content appears not to be much different from that of its competitors. But its user interface is as well designed as Nintendo’s.

My only complaint was that my daily training was over so quickly. Complete sessions took less than 15 minutes. Can such short stints accomplish anything? On the other hand, I realize, I have been doing stomach crunches for less than 15 minutes a day for the past few months, and my abs are more beach-worthy than they were before I began. Maybe the same holds true for the brain.

Ostensibly, the goal is to increase a quantity called your “lumosity.” This notion rang my quack-alert bell at first, but it is just intended to whet your competitive appetite. Each training session you are



Point your camera at the bird and recall the letter to score. Here 36 photos remain; user has 1,167 points.

assigned four or five games, and you progress through a primer stage to modules covering attention, memory, processing speed and cognitive control. Then you hit extended stages devoted to each of these modes.

Lumosity’s games are standard issue but tarted up in a way that makes them genuinely fun. For example, in an exercise to work visuospatial attention

Lumosity tracks your progress over the course of six weeks.

(The Author)

KASPAR MOSSMAN is a writer and editor based in Washington, D.C.

you stare at a four-by-four grid on which cartoon monsters pop up along with vegetable loot. After the graphics disappear, you have to trace a route that avoids the monsters but picks up bonus veggie points. And I loved the bird-watching game, in which

pigeons, storks, and so on appear briefly at random locations, and you have to click a camera icon where they were while remembering the letters that flashed in the middle of the screen. The game's appeal, I confess, owes something to skeet shooting.

Brain Strainer

MAKER: MyBrainTrainer
NAME: MyBrainTrainer
FOR: Adults of all ages
PRICE: \$9.95/three months; \$29.95/year
WHAT YOU GET: Online membership
WHERE TO BUY: www.mybraintrainer.com

If Posit Science's program felt like an exclusive, if boring, Swiss clinic, MyBrainTrainer felt like the office of one of those doctors who advertise between the true-crime shows on daytime TV.

The homepage is unbelievably cluttered—in effect, giving you your first brain workout. It was a challenge just figuring out how to get to the games. On day three, after the first exercise I was shunted back to what appeared to be the wrong page and spent



The crowded introductory screen to MyBrainTrainer. Just using the program takes a lot of brainpower.

several minutes clicking on anything that seemed promising. Once I got back to the right page, however, it was unclear whether I was supposed to play each game once or twice.

The games appear to be as valid as any. But I imagine that many users would quickly become discouraged and give up on MyBrainTrainer.

Perception Practice

Once you've bulked up your prefrontal cortex, you may be interested in improving your visual perception. Both Cognifit and Posit Science offer programs to do this. But if you have an appetite for violence and destruction, there are more exciting options. "Although video-game playing may seem to be rather mindless," conclude the authors of a 2003 study published in the journal *Nature*, "it is capable of radically altering visual attentional processing." The games tested by the researchers? Counter-Strike, Halo 3 (below) and Grand Theft Auto III, among others. —K.M.



Do the Twist

MAKER: University of Bern, Switzerland
NAME: BrainTwister
FOR: Seniors or children who have ADHD
PRICE: \$60 (one user); \$325 (site license)
WHAT YOU GET: CD-ROM, including manual in PDF form
WHERE TO BUY: www.apn.psy.unibe.ch/lenya/apn/live/anwendung/braintwister-e.html

Working memory, the short-term storage that allows you to focus your attention, is crucial for reading comprehension and problem solving. Better working memory correlates with academic and professional success.

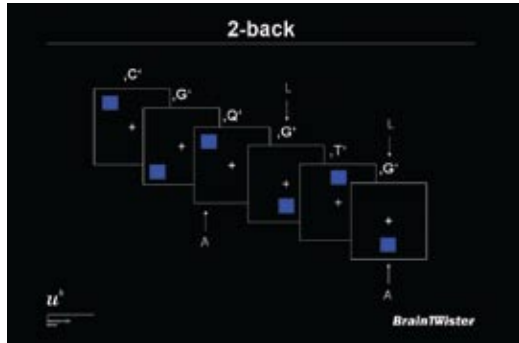
A few years ago Martin Buschkuhl was a doctoral student at the University of Bern in Switzerland conducting a study that attempted to increase working memory in older people. His subjects played a suite of brain-training games. "After the study ended, a lot of participants asked if they could have the pro-

COURTESY OF MICROSOFT AND BUNGIE (Image from Halo 3)

gram to take home,” says Buschkuehl, now a researcher at the University of Michigan at Ann Arbor. Buschkuehl and his Ph.D. supervisor Walter Perrig decided to make a version for use on Macs or PCs, which they called BrainTwister.

BrainTwister is intended for older people who are faced with cognitive decline or for young children who have conditions such as attention-deficit hyperactivity disorder (ADHD). But anyone who would actually benefit from BrainTwister would need a coach or instructor to get started and keep motivated. I had to use all my computer savvy to get the program going, and then I had to delve into the manual to figure out exactly what I was supposed to be doing.

What was it like to use once I got going? Although the games are basic—one of them asks you to remember a series of animals while clicking the right or left mouse button to indicate if each rooster or cow is upside down or right side up—the difficulty accelerates every time you get a test right. BrainTwister quickly had me begging for mercy. I found myself trying different strategies such as mnemonics, chanting a string of the animals’ names or just trusting my cave-man instincts to remember what they looked like. I



Audiovisual 2-back: you must verify that sounds and images in a long series match those presented two steps previously.

managed six or seven. Buschkuehl says that a girl once reached an “incredible” number of animals, 12 or 13, by humming a tune.

BrainTwister also features a fearsome N-back exercise in which you are presented with a long sequence of images, one at a time, and have to remember whether the image on the screen is the same as that which appeared one, two, three or more places previously. N-back, clearly, is not for wimps. Try the version that combines both audio and vision only if you like to bleed from your ears and eyeballs at the same time.

Work It, Baby

MAKER: Cogmed America

NAME: Working Memory Training

FOR: Children who have ADHD

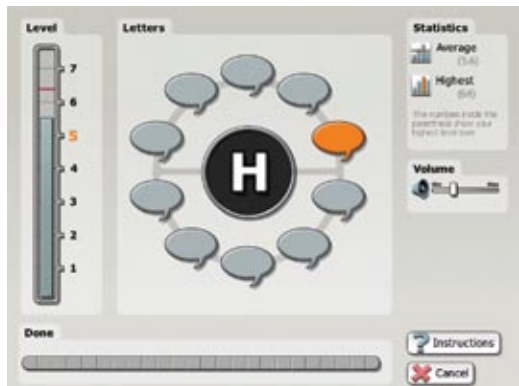
PRICE: Varies; includes practitioner fee

WHAT YOU GET: CD-ROM and coaching assistance

WHERE TO BUY: Qualified practices listed at www.cogmed.com/cogmed/articles/en/78.aspx

Like BrainTwister, Cogmed’s Working Memory Training is more work than fun. That doesn’t mean it is unpleasant, though—just that you have to be dedicated. “In the U.S. our target user is an 11-year-old boy with attention issues like ADHD,” says Jonas Jendi, CEO of Cogmed America. Cogmed insists that its product be used only with the help of a licensed coach—a psychologist or physician selected by Cogmed who has undergone a one-day training session. In the U.S. there are 105 such practices.

Working Memory Training consists of eight exercises in a friendly design scheme reminiscent of a certain Swedish furniture store. Ideally you would use the program five times a week for five weeks. It takes about half an hour to get through the exercises, which resemble those from BrainTwister: staring at a matrix of gray buttons, you must remember the order in which they flash orange; you listen to a se-



One of Cogmed’s eight working memory exercises: you must remember a series of letters and the spatial sequence of illuminated balloons.

ries of letters or numbers and then recite them in reverse order. But there is no N-back, thank God. And although Cogmed’s program is like BrainTwister in that when you get something wrong the exercises get easier again, the decline in difficulty is more cushioned and therefore less discouraging.

Cogmed originated in Sweden. The exercises in Working Memory Training are based on research by Torkel Klingberg of the Karolinska Institute in Stockholm, and their efficacy is well documented. **M**

(Further Reading)

◆ **Long-Term Effects of Cognitive Training on Everyday Functional Outcomes in Older Adults.** Sherry L. Willis et al. in *JAMA*, Vol. 296, No. 23, pages 2805–2814; December 20, 2006.



Perturbed Personalities

Scientists are peering into the brains of people with borderline personality disorder and finding clues to the roots of this disabling illness

By Andreas Meyer-Lindenberg

Glenn Close's unforgettably vivid portrayal in the movie *Fatal Attraction* gave viewers a front-row look at the damaging mental illness known as borderline personality disorder (BPD). By itself, this ailment accounts for up to 10 percent of patients under psychiatric care and 20 percent of those who have to be hospitalized. The defining characteristic is pervasive instability in the patient's life, especially in relationships. People who suffer from BPD also have difficulty controlling their impulses and regulating their emotions. [*For more symptoms of the illness, see box on page 43.*] Their behavior exerts a tremendous toll not only on themselves but also on their friends and colleagues, as well as on the health care system.

Despite the importance of this disorder, surprisingly little is known about what brain mechanisms might underlie it. Over the past few years, however, scientists have found intriguing hints. Structural imaging studies have indicated, for example, that parts of the brain's limbic system, which regulates various aspects of emotion, are abnormally small in patients with BPD, and the areas that appear most reduced in volume govern negative moods. Investigations of functional abnormalities show that these same limbic areas—including the amygdala—tend to be hyperactive. Some researchers theorize that the smaller size of limbic structures reflects a loss of inhibitory neurons, which might mean these patients' brains have a weaker rein on behavior and negative emotions, leading to impulsivity and overly negative reactions to events.

In a 2008 paper in *Science*, neuroscientist Brooks King-Casas and his colleagues at the Baylor College of Medicine showed that aside from lacking emotional restraint, individuals with BPD have problems correctly perceiving social gestures from others. In addition, the team has illuminated

an additional brain structure that plays an important role in the disease.

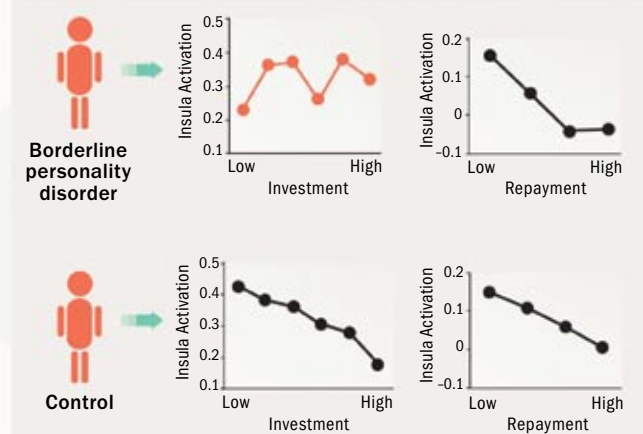
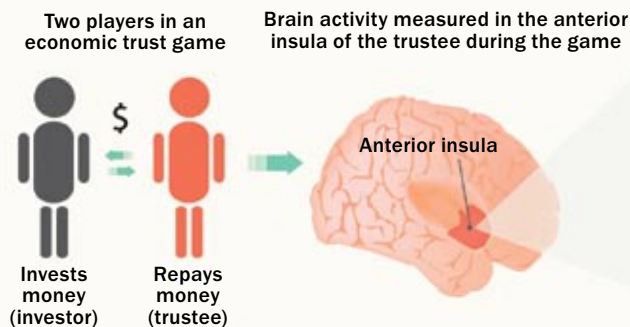
The researchers took an innovative game theory approach to probe the roots of the disturbed interpersonal communication characterizing the disorder. This technique, which involves the use of interactive competitions to gain insights into human social behavior and decision making, also holds promise for investigating other types of social interactions and interpersonal pathologies.

Investing in Trust

In King-Casas's study, pairs of people exchanged money over 10 rounds of a game. Each pair consisted of an investor, who decided on an amount of money to front—knowing those funds would triple—and a trustee, who received the expanded sum and could decide how much of it to keep and how much to pay back. If the investor chose to advance \$10, then the trustee would have \$30 to split ($\10×3) between himself or herself and the investor. In this experiment, some transactions occurred between two mentally healthy individuals; in other exchanges, the

(The Author)

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Brain scans of people with borderline personality disorder (BPD) reveal their social impairment. BPD patients, acting as trustees who return varying proceeds to investors, show no relation between insula activity and investment amount (orange line). But activity in typical

trustees does follow an investor's behavior (black line), indicating that they read social signals that BPD patients do not. In both patients and mentally healthy players, the insula tracks the amount of money the player is about to return to an investor (graphs at right).

trustee (but not the investor) suffered from BPD. Although this game is at first glance only about money, it actually probes the nature of cooperation and the development of trust, both of which require sensing and responding to the social messages implied by a colleague's behavior. Thus, a socially sensitive trustee realizes that being generous builds trust—and will also pay off, because an investor is likely to respond in future rounds with increased investments. Such cooperation produces mutual profits much greater than if the investor just keeps most of the money for himself or herself. On the other hand, an investor who does not trust the other player will not put in much money, and as a result both members of the pair will be less well off.

Monetary offerings were uniformly high early on, but in later rounds investors were offering significantly less to the trustees with BPD than to the mentally healthy trustees, pointing to a breakdown of trust and cooperation in exchanges involving partners with BPD. Although trust fragments even in normal relationships, the mentally healthy trustees restored confidence through a “coaxing” strategy, in which they encouraged wary investors with generous returns, which are a sign of trustworthiness. Healthy players used this strategy twice as often as individuals with BPD did, indicating that people who have this disorder lack the social skills essential for establishing and maintaining cooperative relationships.

FAST FACTS

Rocky Relationships

- 1>> Borderline personality disorder (BPD) accounts for up to 10 percent of patients under psychiatric care and 20 percent of those who have to be hospitalized. People who have BPD suffer from unstable personal relationships, along with an inability to control their impulses and regulate their emotions.
- 2>> Parts of the brain's limbic system, which governs emotion, are abnormally small as well as hyperactive in patients with BPD. According to one interpretation of these findings, a loss of inhibitory neurons in BPD might underlie both impulsivity and overly negative reactions to events.
- 3>> New research suggests that individuals with BPD also have problems correctly perceiving social gestures and that a brain structure called the anterior insula plays a key role in the disorder.

Self-Centered Brains

To find out why the players with BPD behaved this way, the researchers used neuroimaging to study brain activation of trustees confronted with a small investment, which usually signals a lack of trust on the investor side. The functional magnetic resonance imaging scans revealed a crucial difference between BPD trustees and healthy players. In healthy subjects, a region of the brain called the anterior insula seemed to neurally represent the investment level, so that small contributions from a partner corresponded to a large activation in the trustee's brain, and vice versa. In the brains of BPD subjects, however, no such relation existed.

As expected from earlier work, activity in this same brain area also mirrored the amount of money a trustee was about to return to the investor, so that a large amount of insula activation in the trustee's brain predicted a small payment from the trustee. In this case, however, both players with BPD and healthy volunteers displayed the same neural pattern. Thus, although in healthy subjects the insula

SOURCE: "TRUST ME ON THIS," BY ANDREAS MEYER-LINDENBERG, IN SCIENCE, VOL. 321, AUGUST 8, 2008. REPRINTED WITH PERMISSION FROM AAAS

Crossing the Border

Borderline personality disorder is fairly common, affecting 2 percent of adults, mostly young women. Symptoms of the disorder include:

- Bouts of anger, depression and anxiety that are temporary, lasting hours or at most a day, but during which a person may injure himself or herself or abuse drugs and alcohol.
- Distortions in thinking that may lead someone to alter his or her goals frequently, switching jobs, friends, gender identity or values.
- Feeling fundamentally bad or unworthy, a perception that hardens in isolation, prompting frantic attempts to avoid being alone.
- Extreme sensitivity toward rejection and normal separations from loved ones.
- Tumultuous relationships that may be characterized by dramatic shifts from intense love to extreme anger toward others.
- Impulsive behaviors such as spending sprees, binge eating and risky sex.

SOURCE: National Institute of Mental Health



encoded both “distrustful” offers from investors and “stingy” repayments, the insula activity in people with BPD reflected only their own actions. Their impairment seemed to selectively concern the portrayal of the other player.

The anterior insula has long been associated with the representation of unpleasant bodily sensations such as pain. In addition, many studies have shown that this area strongly responds to uncomfortable social contact, including interactions that seem unfair, frustrating or risky. This body of work suggests that the anterior insula tracks information about the intentions and behavior of others and colors them with a feeling of discomfort. If that interpretation is accurate, then one reason BPD subjects may be impaired in maintaining cooperation is that they do not have the “gut feeling” (resulting from the anterior insula signal) that there is a problem with the relationship. Unable to detect the breakdown of trust, BPD sufferers do not work to repair it and are less likely to trust others at all.

Genetic Roots

This exciting finding prompts many new questions. The first is: What causes this abnormal brain activity? Most research indicates that BPD commonly arises from a combination of a genetic predisposition and severe trauma in early childhood. Not everyone who is traumatized as a child gets BPD, but a combination of risk genes may heighten the impact of trauma on the developing brain.

Although no one has identified specific genes that cause BPD, many of the personality components of the ailment, including impulsiveness and aggression, are highly heritable. Moreover, researchers have linked genetic variants, such as those involved in the neurotransmission of serotonin, to the disorder. (Selective serotonin reuptake inhibitors such as Prozac, however, are not effective treatments for BPD, according to a recent study.) It would be of high interest to determine whether these genetic variants compromise the structure and function of the anterior insula. Because no brain region operates in isolation, neuroscientists should aim to fully characterize the brain network of which the insula is a part.

Beyond BPD, scientists may want to apply the game theory strategy used in this study to other severe mental illnesses, such as schizophrenia or autism, in which social dysfunction plays a pivotal role. Researchers, patients and therapists should all welcome such an advance. **M**

(Further Reading)

- ◆ **Neuroimaging and Genetics of Borderline Personality Disorder: A Review.** Eric Lis et al. in *Journal of Psychiatry and Neuroscience*, Vol. 32, No. 3, pages 162–173; May 2007.
- ◆ **The Rupture and Repair of Cooperation in Borderline Personality Disorder.** Brooks King-Casas et al. in *Science*, Vol. 321, pages 806–810; August 8, 2008.
- ◆ **Trust Me on This.** Andreas Meyer-Lindenberg in *Science*, Vol. 321, pages 778–780; August 8, 2008.

**MIND
MATTERS**



Each week in **Mind Matters**, www.SciAm.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. **Mind Matters** is edited by **Jonah Lehrer**, the science writer behind the blog **The Frontal Cortex**, <http://scienceblogs.com/cortex>



Knowing Your

When might a positive HIV test be wrong? Are your chances of surviving cancer better in the U.S. or in England? Learn how to put aside unjustified fears and hopes and how to weigh your real risk of illness—or likelihood of recovery

In a 2007 campaign advertisement, former New York City mayor Rudy Giuliani said, “I had prostate cancer, five, six years ago. My chances of surviving prostate cancer—and thank God, I was cured of it—in the United States? Eighty-two percent. My chances of surviving prostate cancer in England? Only 44 percent under socialized medicine.” Giuliani used these statistics to argue that he was lucky to be living in New York and not in York. This statement was big news. As we will explain, it was also a big mistake.

In 1938 in *World Brain* (Methuen & Co.), English writer H. G. Wells predicted that for an educated citizenship in a modern democracy, statistical thinking would be as indispensable as reading and writing. At the beginning of the 21st century, nearly everyone

living in an industrial society has been taught reading and writing but not statistical thinking—how to understand information about risks and uncertainties in our technological world. That lack of understanding is shared by many physicians, journalists and politicians such as Giuliani who, as a result, spread misconceptions to the public.

Statistical illiteracy is not rooted in inherent intellectual deficits—say, in the lack of a “math gene”—but rather in societal and emotional forces. These influences include the paternalistic nature of the doctor-patient relationship, the illusion of certainty in medicine, and the practice of presenting health information in opaque forms that erroneously suggest big benefits and small harms from interventions. When citizens do not understand the



Chances

*By Gerd Gigerenzer, Wolfgang Gaissmaier, Elke Kurz-Milcke,
Lisa M. Schwartz and Steven Woloshin*

numbers, they are susceptible to political and commercial manipulation of their anxieties and hopes. The result can be serious damage to physical health and emotional well-being.

We show you how to spot three types of statistical manipulation and confusion in medicine, to translate opaque figures into ones that make sense and to use that information to make better medical decisions. To avoid such misunderstandings in the first place, we argue that medical journals, the media and others should communicate risk in more easily understood forms. In addition, we recommend introducing young children to statistical thinking and teaching statistics as a way of solving real-world problems rather than as a purely mathematical discipline.

Trust Your Doctor?

Medicine has held a long-standing antagonism toward statistics. For centuries, treatment was based on an ethic of personal trust as opposed to quantitative facts, which were dismissed as impersonal or irrelevant to the individual. Even today many doctors think of themselves as artists, relying more on intuition and faith in their own judgment than on numbers. For their part, many patients prefer to trust their doctors rather than even asking for data to analyze. For example, in a 2008 unpublished survey by one of us (Gigerenzer) and his colleagues, two thirds of more than 100 American economists said they had not weighed any pros and cons of getting a prostate cancer screening test but simply followed their doctor's recommendation.

PANELS FROM LEFT: AGE FOTOSTOCK; GETTY IMAGES; LIGHTSCAPES PHOTOGRAPHY, INC./CORBIS; GETTY IMAGES; DICE: LEV MEL / iStockphoto

Individuals often shy away from statistics because they have an emotional need for certainty.

Moreover, individuals often shy away from statistics because they have an emotional need for certainty—a concept at odds with statistical literacy, which prepares us to make decisions in the face of uncertainty [see box on opposite page]. Much of the public harbors illusory certainty about the reliability of tests such as those for cancers and HIV, suggests a survey Gigerenzer conducted in 2006.

Furthermore, statistically unsophisticated patients and their doctors tend to wildly overestimate the benefits of screening tests and are blind to their harms. For example, mammography reduces the risk of a woman in her 50s dying from breast cancer from about five to four in 1,000 over some 13 years, but 60 percent of a random sample of U.S. women believed the benefit to be 80 times as high. Americans are similarly overenthusiastic about total-body computed tomographic scans: in a random sample of 500 Americans, nearly three quarters said they would prefer a free total-body CT scan to \$1,000 in cash. Yet no professional medical organization endorses such scans, and several discourage them because screening tests such as this one can result in

important harm from a cascade of medical quandaries and invasive treatments triggered by ambiguous findings.

A citizen in a modern technological society faces a bewildering array of medical decisions. Should a pregnant woman undergo prenatal screening for chromosomal anomalies at age 35? Should parents send their teenage daughters to be vaccinated against human papillomavirus, to protect them against cervical cancer, despite a few reports that the vaccine (Gardasil) could lead to paralysis? If people want to make informed decisions, they need to understand health statistics. In particular, they need to understand the difference between absolute and relative risks and how to use natural frequencies to infer the true chances of disease from a positive test result. Individuals also should know to trust mortality rates over five-year survival statistics when evaluating screening tests, which look for disease in healthy people. We deal with each of these issues in turn.

Absolute Risks

In October 1995 the U.K. Committee on Safety of Medicines warned that third-generation oral contraceptive pills increased the likelihood of potentially life-threatening blood clots in the legs or lungs twofold—that is, by 100 percent. This information was passed on in “Dear Doctor” letters to 190,000 general practitioners, pharmacists and directors of public health and in an emergency announcement to the media. The news caused great anxiety, and women stopped taking the pill, which led to an estimated 13,000 additional abortions in the following year in England and Wales. For every additional abortion, there was also one extra birth, including some 800 more conceptions among girls younger than 16. (Ironically, abortions and pregnancies are associated with an increased risk of thrombosis that exceeds that of the third-generation pill.)

Such panic could have been avoided had the data been reported in a more straightforward manner. The evidence showed that about one in every 7,000 women who took the second-generation pill had a blood clot; this number increased to two in 7,000 among women who took third-generation pills. That is, the *absolute* risk increase was only one in 7,000 even though the *relative* risk increase was indeed 100 percent. Absolute risks are typically small numbers, whereas the corresponding

FAST FACTS

Know Your Numbers

1» Statistical illiteracy is rooted not in intellectual deficits but in the doctor-patient relationship, the illusion of certainty in medicine, and the practice of presenting health information in opaque forms that erroneously suggest big benefits and small harms from interventions.

2» Without understanding the numbers, citizens are susceptible to political and commercial manipulation of their anxieties and hopes. The result can be serious damage to physical health and emotional well-being.

3» People need to understand the difference between absolute and relative risks and how to use natural frequencies to infer the true chances of disease from a positive test result. Individuals also should know to trust mortality rates over five-year survival statistics when evaluating screening tests.

4» To boost statistical literacy, we also recommend introducing young children to statistical thinking and teaching statistics in school as a way of solving real-world predicaments rather than as a purely mathematical discipline.

Living with Uncertainty

Although people often apply a need for certainty to test results and treatments, no unequivocal answers or absolute cures exist. Risk is unavoidable; it comes with all action or inaction. Here are questions to ask about all risks:

>>1 Risk of what? Understand the outcome to which the risk refers. Is it the risk of dying from a disease, getting the disease or manifesting a symptom?

>>2 What is the time frame? Time frames such as “the next 10 years” are easier to imagine than the widely used “lifetime” risks. They are more informative because risks change over time, and yet such time frames are long enough to enable action.

>>3 How big is the risk? Because there are no zero risks, size is what matters. That number should be expressed in absolute terms—for instance, 13 out of 1,000 50-year-old female smokers die of heart disease within 10 years—or in comparative terms, relating the risk to other ones. For example, a 50-year-old female smoker has about the same chance of dying of heart disease as of lung cancer within the next decade—and these chances are about seven times higher than her risk of perishing in a car accident.

>>4 Does the risk apply to me? Find out if the risk is based on studies of people like you—individuals of your age or sex or with health problems similar to yours.



>>5 What are the harms of “finding out?” Screening tests may lead to false alarms, prompting unnecessary anxiety. When women participate in a 10-year program of annual mammography, every other woman without cancer can expect one or more false-positive test results. Worse, screening tests often detect abnormalities that would never cause symptoms, leading to unnecessary surgery and other invasive treatments.

relative changes tend to look big—particularly when the base rate is low.

Reporting relative risks can create unrealistic hopes as well as undue anxiety. Many patients and doctors evaluate a treatment or test more favorably if benefits are expressed in terms of relative risk reduction. In a 2007 review of experimental studies, for example, psychologist Judith Covey of the University of Durham in England found that when the benefit of a drug was presented in the form of relative risk reduction, 91 percent of Danish general practitioners would recommend it to their patients. But when given the absolute risk reduction, only 63 percent would recommend the same drug.

Information brochures, doctors, medical journals and the media continue to inform the public in terms of relative changes, in part because big numbers make better headlines and generate more attention. One leaflet even conflated the two, stating that hormone replacement therapy (HRT) “has been proven to protect women against colorectal cancer (by up to more than 50 percent),” whereas the risk of breast cancer “may possibly increase by 0.6 percent (six in 1,000).” The data reveal that the 50 percent benefit corresponds to an absolute num-

ber that is less than six in 1,000—meaning that HRT produces more cases of cancer than it prevents. But according to a 2003 study, 60 of 80 women concluded the exact opposite from the leaflet.

Absolute risks are more informative because they take into account information about background rates. Given the absolute risks, a person can derive the relative risks—but not vice versa. After all, a relative risk reduction of 50 percent could describe either a substantial mortality reduction from 200 to 100 in 10,000 patients or a much smaller one from two to one in 10,000 patients. Randomized trials provide some of the best information in med-

STROKE
STROKE

LIPITOR cuts the risk by nearly half.
In patients with type 2 diabetes and at least one other risk factor for heart disease, LIPITOR reduced the risk of stroke by 48%.

This advertisement expresses Lipitor's potency as an impressive-sounding 48 percent relative risk reduction. But the benefit in absolute terms is a far less striking 1.3 percent: after four years, 2.8 percent of patients taking a sugar pill had a stroke as compared with 1.5 percent taking Lipitor.

What most doctors don't know: a positive mammogram may mean a mere one in 10 chance of cancer.

icine, but unless the results are reported adequately, people will not be able to assess them.

Natural Frequencies

Consider a woman who has just received a positive result from a mammogram and asks her doctor: Do I have breast cancer for sure, or what are the chances that I have the disease? In a 2007 continuing education course for gynecologists, Gigerenzer asked 160 of these practitioners to answer that question given the following information about women in the region:

- The probability that a woman has breast cancer (prevalence) is 1 percent.
- If a woman has breast cancer, the probability that she tests positive (sensitivity) is 90 percent.
- If a woman does not have breast cancer, the probability that she nonetheless tests positive (false-positive rate) is 9 percent.

What is the best answer to the patient's query?

- A. The probability that she has breast cancer is about 81 percent.
- B. Out of 10 women with a positive mammogram, about nine have breast cancer.
- C. Out of 10 women with a positive mammogram, about one has breast cancer.
- D. The probability that she has breast cancer is about 1 percent.

Gynecologists could derive the answer from the statistics above, or they could simply recall what they should have known anyhow. In either case, the best answer is C; only about one out of every 10 women who test positive in screening actually has breast cancer. The other nine are falsely alarmed. Prior to training, most (60 percent) of the gynecologists answered 90 percent or 81 percent, thus grossly overestimating the probability of cancer. Only 21 percent of physicians picked the best answer—one out of 10.

Many physicians do not know the probabilities that a person has any disease given a positive screening test—that is, the positive predictive value of that test. Nor can they estimate it from conditional probabilities such as the test's sensitivity (the probability of testing positive in the presence of the disease) and the false-positive rate. Such innumeracy causes undue fear. Months after receiving a false-positive mammogram, one in two women reported considerable anxiety about mammograms and breast cancer, and one in four reported that this anxiety affected her daily mood and functioning.

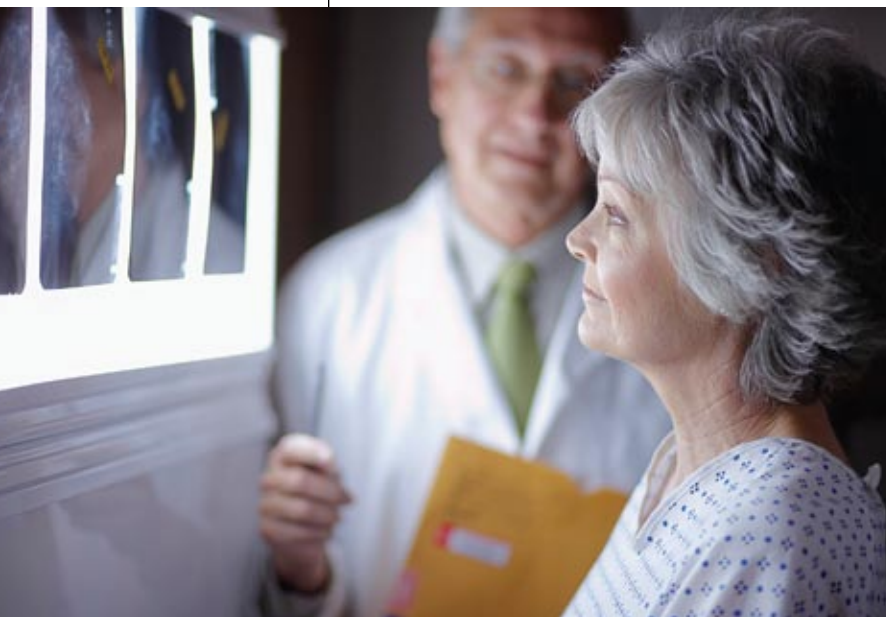
Doctors would more easily be able to derive the correct probabilities if the statistics surrounding the test were presented as natural frequencies. For example:

- Ten out of every 1,000 women have breast cancer.
- Of these 10 women with breast cancer, nine test positive.
- Of the 990 women without cancer, about 89 nonetheless test positive.

Thus, 98 women test positive, but only nine of those actually have the disease. After learning to translate conditional probabilities into natural frequencies, 87 percent of the gynecologists understood that one in 10 is the best answer. Similarly, psychologist Ros Bramwell of the University of Liverpool in England and his colleagues reported in 2006 that only one out of 21 obstetricians could correctly estimate the probability of an unborn child actually having Down syndrome given a positive test. When they were given the relevant natural frequencies, 13 out of 20 obstetricians arrived at the correct answer.

Physicians need to inform patients that no test is perfect, that every test result needs to be interpreted

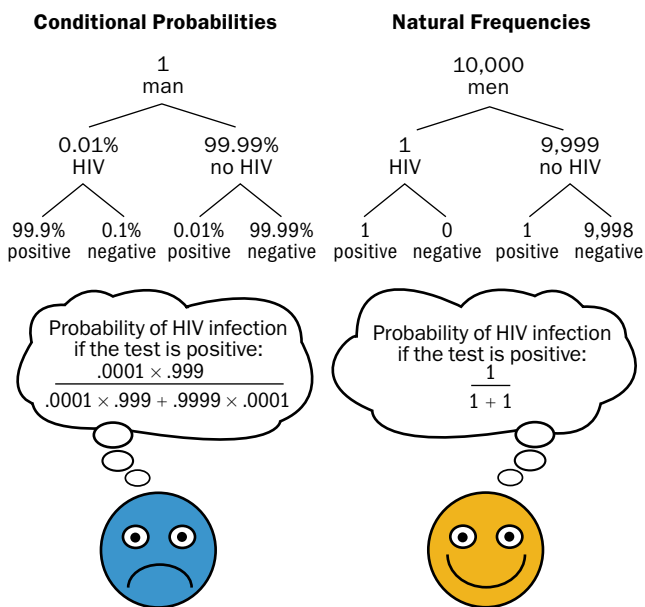
Positive mammograms can cause considerable anxiety. A positive result would be far less alarming, however, if women knew that it might mean a mere 10 percent chance of having breast cancer. In 10 years of testing, one in every two women without cancer can expect at least one positive mammogram.



CORBIS

Forecasting Infection

If your HIV test is positive and you are a man at low risk of infection, what are the chances that you actually harbor the virus? Conditional probabilities (*left*) leave us with a confusing calculation. Invoking natural frequencies (*right*) leads to an easy answer: out of every 10,000 men, one is expected to be infected with HIV and will test positive; out of the uninfected men, one should also test positive. Thus, two test positive, and one of these is infected. In other words, your chances of infection given a positive result are not 100 percent; instead they are 50 percent.



with care, or that a test needs to be repeated. Every woman who gets a mammogram should be told that many of the suspicious results are false alarms. A similar uncertainty exists with all such tests, even HIV tests. At a 1987 AIDS conference, then Florida senator Lawton Chiles reported that of 22 blood donors in Florida who had been notified that they had tested positive for HIV, seven committed suicide. Although the test for HIV picks up 99.9 percent of true infections, and 99.99 percent of its negative results are accurate, a very low base rate among low-risk heterosexual men means the chance of infection can be as low as 50 percent when a man tests positive in screening [see box above]. (When the base rate is higher, however, as it is in the case of homosexual men who have unprotected sex or intravenous drug users who share needles, the chance of true infection with a positive HIV test result is almost certain. So the base rate in a population determines the meaning of a positive test result.)

Mortality Matters

While running for president, Giuliani claimed that health care in the U.S. was superior to that in England. He apparently used data from the year 2000, when 49 British men in every 100,000 were diagnosed with prostate cancer, of whom 28 died within five years—about 44 percent. Using a similar approach, he cited a corresponding 82 percent five-year survival rate in the U.S., suggesting that Amer-

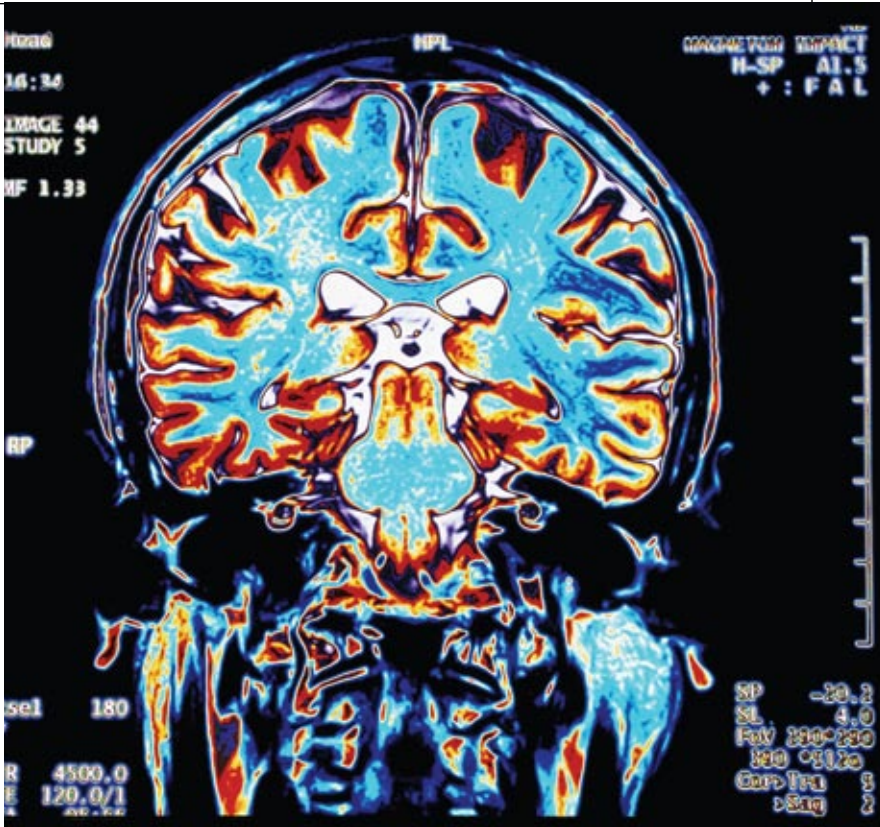
icans with prostate cancer were twice as likely to survive as their British counterparts were. That implication, however, is false because these survival statistics largely reflect diagnostic differences between the two countries rather than better treatment and prolonged survival in the U.S.

To understand why, imagine a group of prostate cancer patients diagnosed (by their symptoms) at age 67 in the U.K., all of whom die at 70. Each survived only three years, so the five-year survival of this group is 0 percent. Now imagine that the same group is diagnosed in the U.S., where doctors detect most prostate cancer by screening for prostate-specific antigens (PSA). (The PSA test is not routinely used in Britain.) These U.S. patients are diagnosed earlier, at age 60, but they all still die at age 70. All have now survived 10 years, and thus their five-year survival rate is 100 percent. Even though the survival rate has changed dramatically,

(The Authors)

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SOURCE: "HELPING DOCTORS AND PATIENTS MAKE SENSE OF HEALTH STATISTICS," BY G. GIGERENZER ET AL., IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST*, VOL. 8, NO. 2; 2007



Magnetic resonance images such as the one above (of a healthy brain) may be used to diagnose brain cancer. Companies and organizations offer such scans as screening tools, suggesting that people need one to be sure they do not have a brain tumor. But brain cancer is quite rare, and there is no evidence that screening is beneficial.

nothing has changed about the time of death. This example shows how setting the time of diagnosis earlier can boost survival rates (lead-time bias), even if no life is prolonged or saved [see illustration on opposite page].

Spuriously high survival rates can also result from overdiagnosis, the detection of abnormalities that are technically cancer but will never progress to cause symptoms in the patient's lifetime. Say 1,000 men with progressive cancer do not undergo screening. After five years 440 are still alive, which results in a survival rate of 44 percent. Meanwhile in another population of men, PSA screening detects 1,000 people with progressive cancer and 2,000 people with nonprogressive cancer (who by definition will not die of cancer in five years). These nonprogressive cases are now added to the 440 who survived progressive cancer, which inflates the survival rate to 81 percent. Although the survival rate changed dramatically, the number of people who die has not changed at all.

In the U.S., screening for prostate cancer using the PSA test in the late 1980s led to an explosion in

the number of new prostate cancer diagnoses. In Britain, the effect has been much smaller because of far less use of the PSA test. This diagnostic disparity largely explains why five-year survival for prostate cancer is higher in the U.S. (The most recent figures are 98 percent five-year survival in the U.S. versus 71 percent in Britain.)

Despite the difference in survival rates, mortality rates in the two countries are close to the same: about 26 prostate cancer deaths per 100,000 American men versus 27 per 100,000 in Britain. That fact suggests the PSA test has needlessly flagged prostate cancer in many American men, resulting in a lot of unnecessary surgery and radiation treatment, which often leads to impotence or incontinence.

Because of overdiagnosis and lead-time bias, changes in five-year survival rates have no reliable relation to changes in mortality when patterns of diagnosis differ. And yet many official agencies continue to talk about five-year survival rates. A recent report by the U.K. Office for National Statistics noted that five-year survival for colon cancer was 60 percent in the U.S. as compared with 35 percent in Britain. Experts dubbed this finding "disgraceful" and called for a doubling of government spending on cancer treatment. In fact, the mortality rate for colon cancer in Britain is about the same as that in the U.S.

In an even stranger case, an ad for the prestigious University of Texas M. D. Anderson Cancer Center conflated survival rates with mortality rates: "as national mortality rates for prostate cancer fluctuated between 1960 and 1990, five-year survival rates for prostate cancer among M. D. Anderson patients continued to improve" (emphasis added).

Mortality rates are far more reliable indicators of the value of screening programs than are five-year survival rates, which boost survival because of earlier diagnoses and overdiagnoses. So should a man get a PSA test or a smoker undergo a CT scan to screen for lung cancer? Both exams find more early-stage cancers—but neither has been shown to reduce mortality.

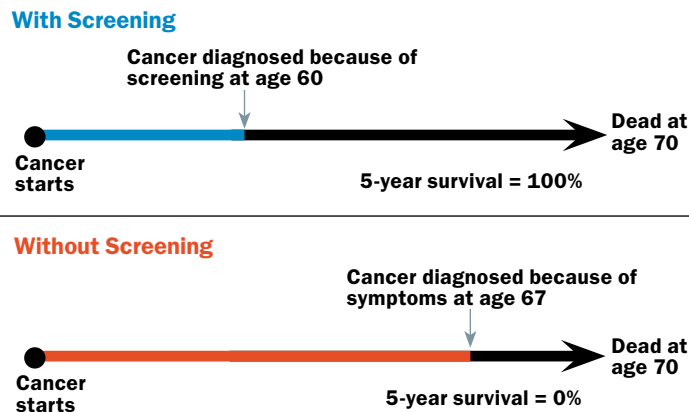
People commonly regard screening as a safeguard for their health, even if an illness is rare. But additional testing may lead to unnecessary medical interventions that can result in harm, which means there is nothing "safe" about this strategy. And for the many overdiagnosed patients, treatment can only cause harm. An epidemic of diagnoses can be as dangerous to our health as disease is.



More Science

See the *Psychological Science in the Public Interest* article, "Helping Doctors and Patients Make Sense of Health Statistics," on which this story is based, at the Association for Psychological Science's Web site: www.psychologicalscience.org

Survival statistics depend on the timing of diagnosis, making such figures misleading. A cancer diagnosis at age 60 (top) can dramatically boost five-year survival rates compared with a diagnosis seven years later (bottom) without changing the time of death.



Solving Problems

Statistical misunderstandings would be far less frequent if researchers, doctors and the media used straightforward figures instead of confusing ones: absolute risks instead of relative risks, natural frequencies instead of conditional probabilities, and mortality rates instead of five-year survival rates. In addition to changing the reporting of health statistics, we need to better educate our young people in the science of risk.

Today the U.S. mathematics curriculum centers on the mathematics of certainty—from arithmetic to calculus—and instruction in probability and statistics occurs too late. As H. G. Wells suggested, statistics should be taught as early as reading and writing. Indeed, the U.S. National Council of Teachers of Mathematics has been pushing educators for years to begin instruction in statistics and probability in primary school. If children learned to deal with an uncertain world in a playful way, much of the collective statistical illiteracy would be history.

Furthermore, teachers need to approach statistics differently. Instead of instructing students about how to apply formulas to toy problems involving cards and dice, teachers should show them how to use numbers to solve real-world predicaments. Statistics might even be wrenched away from math educators to create a problem-solving field connected to teaching health in schools. Such a new field might help young people make better decisions about drugs, alcohol use, driving, biotechnology and other relevant health issues.

In an excellent example of this approach, one secondary school textbook tells the real story of a 26-year-old single mother who tested positive in a routine HIV test, lost her job, moved into a halfway house with other HIV-positive residents, had unprotected sex with one of them, eventually devel-

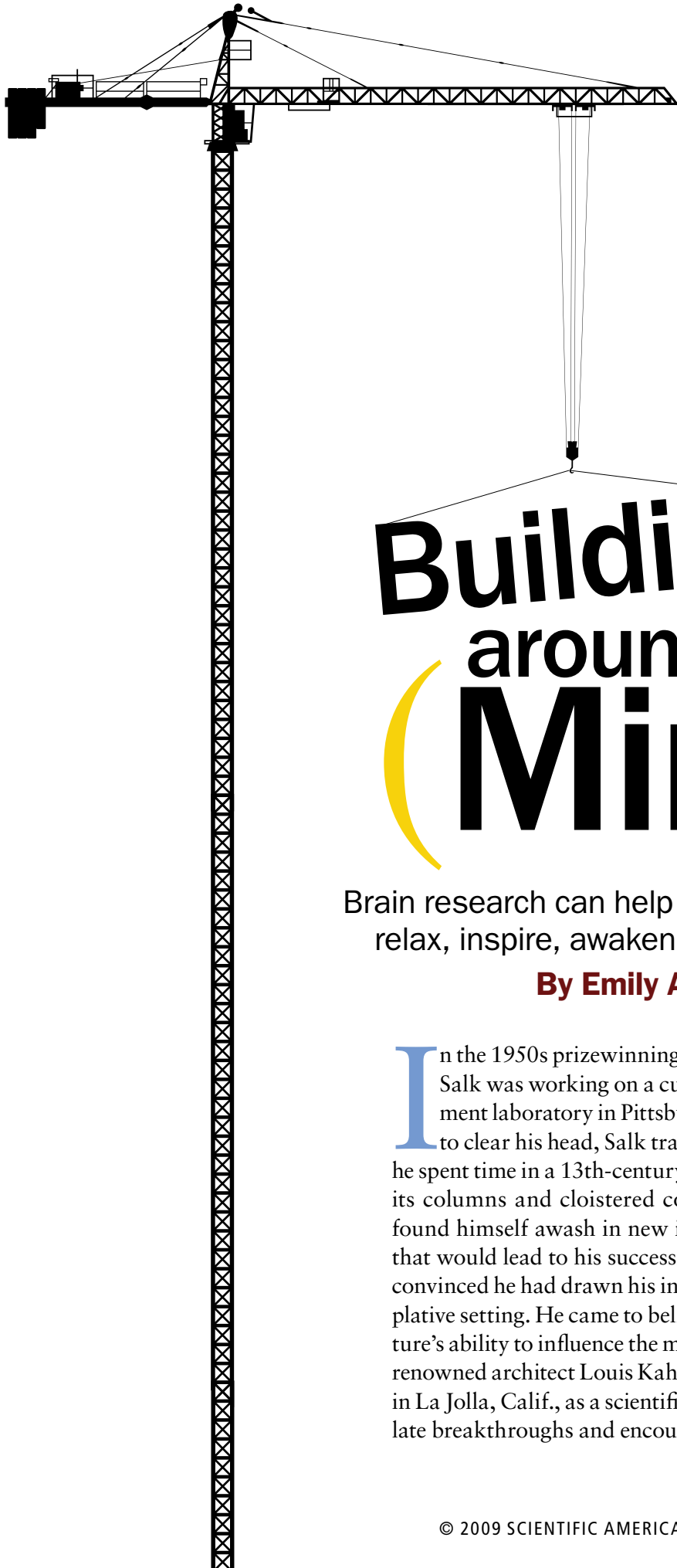
oped bronchitis, and was asked by her new doctor to take the HIV test again. She did, and the result was negative, as was her original blood sample when it was retested. The woman had lived through a nightmare because her physicians did not realize that a positive test result is not definitive but that instead, in this woman's case, it means just a 50 percent chance of being infected, because she was in a low-risk group.

Statistical literacy can change lives, helping individuals make better personal choices, recognize misleading advertisements and public service messages, and develop a more relaxed attitude toward their health. The dream of statistical literacy embodies the Enlightenment ideal of people's emergence from their self-imposed immaturity. In Immanuel Kant's words, "Dare to know!" **M**

(Further Reading)

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- ◆ **Healthy Skepticism.** Lisa M. Schwartz, Steven Woloshin and H. Gilbert Welch in *Washington Post*. Available at www.vaoutcomes.org/washpost.php

SOURCE: "HELPING DOCTORS AND PATIENTS MAKE SENSE OF HEALTH STATISTICS," BY G. GIGERENZER ET AL., IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST*, VOL. 8, NO. 2, 2007

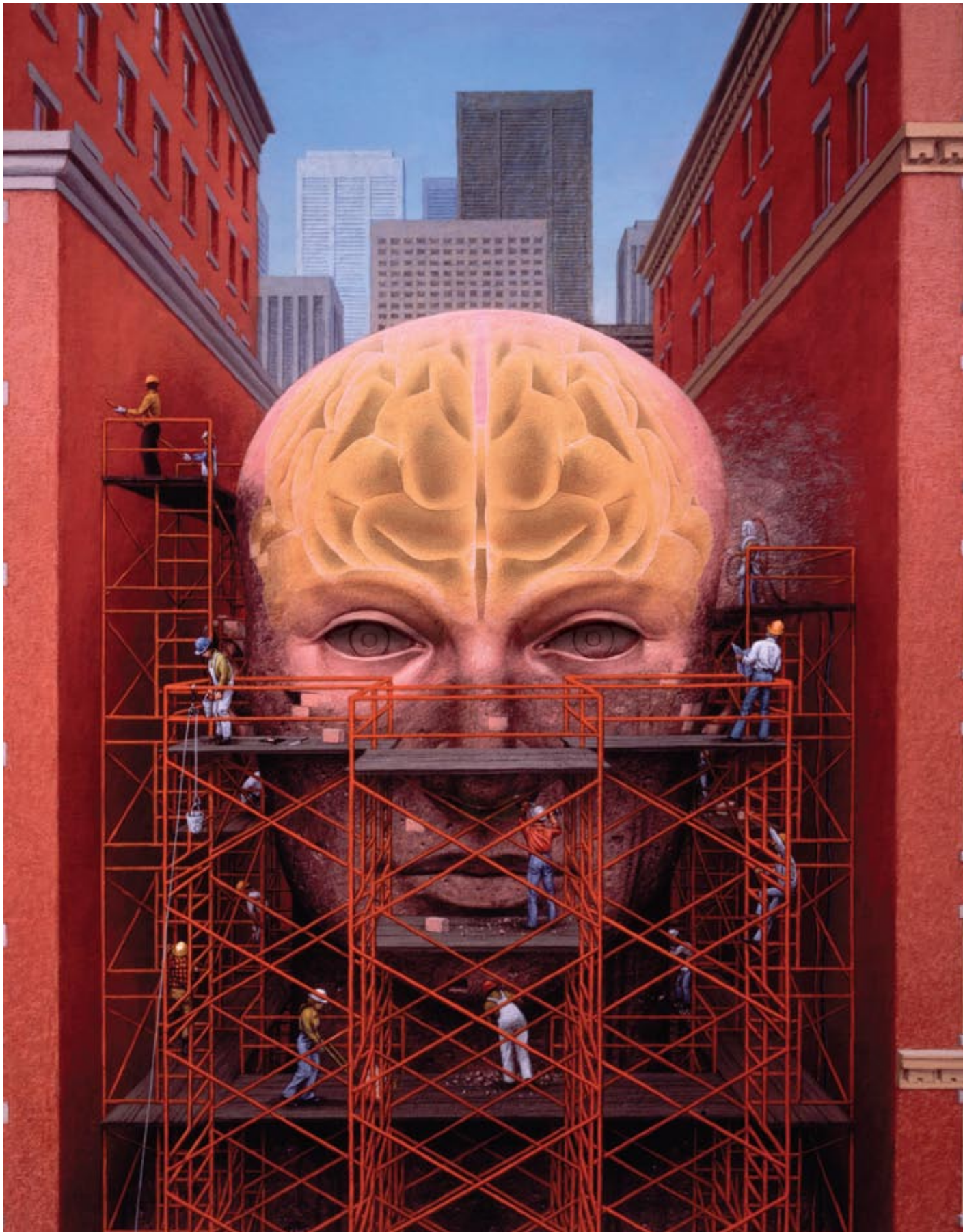


Building around the (Mind)

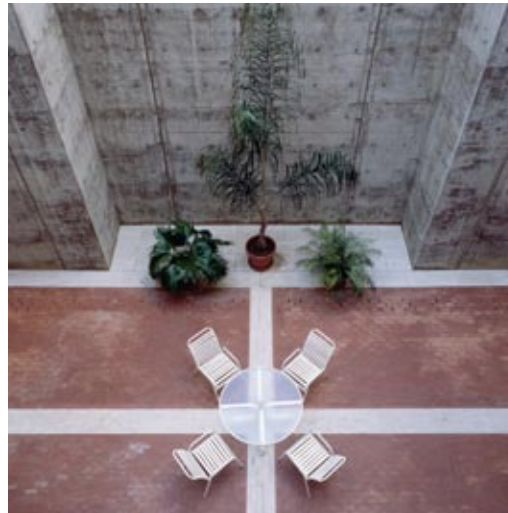
Brain research can help us craft spaces that relax, inspire, awaken, comfort and heal

By Emily Anthes

In the 1950s prizewinning biologist and doctor Jonas Salk was working on a cure for polio in a dark basement laboratory in Pittsburgh. Progress was slow, so to clear his head, Salk traveled to Assisi, Italy, where he spent time in a 13th-century monastery, ambling amid its columns and cloistered courtyards. Suddenly, Salk found himself awash in new insights, including the one that would lead to his successful polio vaccine. Salk was convinced he had drawn his inspiration from the contemplative setting. He came to believe so strongly in architecture's ability to influence the mind that he teamed up with renowned architect Louis Kahn to build the Salk Institute in La Jolla, Calif., as a scientific facility that would stimulate breakthroughs and encourage creativity.



Higher ceilings encourage people to think freely, one expert says,



Architects have long intuited that the places we inhabit can affect our thoughts, feelings and behaviors. But now, half a century after Salk's inspiring excursion, behavioral scientists are giving these hunches an empirical basis. They are unearthing tantalizing clues about how to design spaces that promote creativity, keep students focused and alert, and lead to relaxation and social intimacy. Institutions such as the Academy of Neuroscience for Architecture in San Diego are encouraging interdisciplinary research into how a planned environment influences the mind, and some architecture

schools are now offering classes in introductory neuroscience.

Such efforts are already informing design, leading to cutting-edge projects, such as residences for seniors with dementia in which the building itself is part of the treatment [see box on page 58]. Similarly, the Kingsdale School in London was redesigned, with the help of psychologists, to promote social cohesion [see illustration on opposite page]; the new structure also includes elements that foster alertness and creativity. What is more, researchers are just getting started. "All this is in its infancy," says architect David Allison, who heads the Architecture + Health program at Clemson University. "But the emerging neuroscience research might give us even better insights into how the built environment impacts our health and well-being, how we perform in environments and how we feel in environments."

Jonas Salk, inventor of the polio vaccine, hoped the expansive social spaces of his Salk Institute in La Jolla, Calif., would inspire the scientists who worked there.

FAST FACTS

Creative Construction

1» Architects have long intuited that the places we inhabit can affect our thoughts, feelings and behaviors. Now behavioral scientists are giving their hunches an empirical basis.

2» Scientists are unearthing tantalizing clues about how to design spaces that promote creativity, keep students focused and alert, and lead to relaxation and social intimacy. The results inform architectural and design decisions such as the height of ceilings, the view from windows, the shape of furniture, and the type and intensity of lighting.

3» Such efforts are leading to cutting-edge projects such as residences for seniors with dementia in which the building itself is part of the treatment.

Higher Thought

Formal investigations into how humans interact with the built environment began in the 1950s, when several research groups analyzed how the design of hospitals, particularly psychiatric facilities, influenced patient behaviors and outcomes. In the 1960s and 1970s the field that became known as environmental psychology blossomed.

"There was a social conscience growing in architecture around that time," says John Zeisel, a Columbia University-trained sociologist who, as president of Hearthstone Alzheimer Care, specializes in the design of facilities for people who have dementia. Architects began to ask themselves, Zeisel adds, "What is there about people that we need to find out about in

PETER APRAHAMIAN Corbis

which may lead them to make more abstract connections.

order to build buildings that respond to people's needs?" The growth of the brain sciences in the late 20th century gave the field a new arsenal of technologies, tools and theories. Researchers began to consider "how can we utilize the rigorous methods of neuroscience and a deeper understanding of the brain to inform how we design," says Eve Edelstein, a visiting neuroscientist at the University of California, San Diego, and adjunct professor at the New School of Architecture and Design, also in San Diego.

Now research has emerged that could help illuminate Salk's observation that aspects of the physical environment can influence creativity. In 2007 Joan Meyers-Levy, a professor of marketing at the University of Minnesota, reported that the height of a room's ceiling affects how people think. She randomly assigned 100 people to a room with either an eight- or 10-foot ceiling and asked participants to group sports from a 10-item list into categories of their own choice. The people who completed the task in the room with taller ceilings came up with more abstract categories, such as "challenging" sports or sports they would like to play, than did those in rooms with shorter ceilings, who offered more concrete groupings, such as the number of participants on a team. "Ceiling height affects the way you process information," Meyers-Levy says. "You're focusing on the specific details in the lower-ceiling condition."

Because her earlier work had indicated that elevated ceilings make people feel physically less constrained, the investigator posits that higher ceilings encourage people to think more freely, which may lead them to make more abstract connections. The sense of confinement prompted by low ceilings, on the other hand, may inspire a more detailed, statistical outlook—which might be preferable under some circumstances. "It very much depends on what kind of task you're doing," Meyers-Levy explains. "If you're in the operating room, maybe a low ceiling is better. You want the surgeon getting the details right." Similarly, paying bills might be most efficiently accomplished in a room with low ceilings, whereas producing great works of art might be more likely in a studio with loftier ones. How high the ceiling actually is, Meyers-Levy points out, is less important than how high it feels. "We think you can get these effects just by manipulating the perception of space," she says, by using light-

colored paint, for instance, or mirrors to make the room look more spacious.

Natural Focus

In addition to ceiling height, the view afforded by a building may influence intellect—in particular, an occupant's ability to concentrate. Although gazing out a window suggests distraction, it turns out that views of natural settings, such as a garden, field or forest, actually improve focus. A study published in 2000 by environmental psychologist Nancy Wells, now at Cornell University, and her colleagues followed seven- to 12-year-old children before and after a family move. Wells



Ample daylight and greenery boost attentiveness and academic performance. The spacious courtyard of the Kingsdale School in London also encourages social interaction.

and her team evaluated the panoramas from windows in each old and new home. They found that kids who experienced the greatest increase in greenness as a result of the move also made the most gains on a standard test of attention. (The scientists controlled for differences in housing quality, which turned out not to be associated with attention.) Another experiment demonstrated that college students with views of nature from their dorm rooms scored higher on measures of mental focus than did those who overlooked entirely man-made structures.

Green play space may be especially beneficial for students with attention disorders. Landscape architect and researcher William Sullivan of the University of Illinois and his colleagues studied 96 children with attention deficit disorder (ADD). The scientists asked parents to describe their children's ability to con-

concentrate—say, on homework or spoken directions—after the kids engaged in activities such as fishing, soccer and playing video games in which they were exposed to varying amounts of greenery. “The parents reported that their children’s ADD symptoms were least severe after they’d been in or observing green spaces,” says Sullivan, whose results were published in 2001.

Such findings may be the result of a restorative effect on the mind of gazing on natural scenes, according to an idea developed by psychologists Stephen Kaplan and Rachel Kaplan, both at the University of Michigan at Ann Arbor. By this theory, the tasks of the modern world can engender mental fatigue, whereas looking out at a natural setting is relatively effortless and can give the mind a much needed rest. “A number of studies have shown that when people look at nature views, whether they’re real or projected on a screen, their ability to focus improves,” Stephen Kaplan says.

Nature views may be more rejuvenating than urban scenes are, Sullivan adds, because humans have an innate tendency to respond positively toward nature—an explanation dubbed the biophilia hypothesis. “We evolved in an environment that predisposes us to function most effectively in green spaces,” he says. In a December 2008 paper in *Psychological Science*, Ste-

phen Kaplan also proposes that urban settings are too stimulating and that attending to them—with their traffic and crowds—requires more cognitive work than gazing at a grove of trees does.

Using nature to boost attention ought to pay off academically, and it seems to, according to a study that will be published in spring 2009 and that was led by C. Kenneth Tanner, head of the School Design & Planning Laboratory at the University of Georgia. In their analysis of more than 10,000 fifth-grade students in 71 Georgia elementary schools, Tanner and his colleagues found that students in classrooms with unrestricted views of at least 50 feet outside the window, including gardens, mountains and other natural elements, had higher scores on tests of vocabulary, language arts and math than did students without such expansive vistas or whose classrooms primarily overlooked roads, parking lots and other urban fixtures.

Seeing the Light

In addition to greenery, the natural world has something else to offer building occupants: light. Daylight synchronizes our sleep-wake cycle, or circadian rhythm, enabling us to stay alert during the day and to sleep at night. Nevertheless, many

“We evolved in an environment that predisposes us to function



Buildings that figuratively bring the outside in, by providing views of nature, can improve their occupants’ ability to concentrate.

institutional buildings are not designed to let in as much natural light as our mind and body need.

A lack of light can be a particular problem for schoolchildren. “You take a child who probably didn’t get enough rest, dump them off in front of a school where there’s very little natural light, and guess what? They have jet lag,” Tanner says. A 1992 study followed Swedish schoolchildren in four different classrooms for a year. The research showed that the kids in classrooms with the least daylight had disrupted levels of cortisol, a hormone that is regulated by the body’s circadian rhythms.

Adequate sunlight has also been shown to improve student outcomes. In 1999 the Hescong Mahone Group, a consulting group based in California that specializes in building



Daylight calibrates our sleep-wake cycle, thereby affecting our body and mind. One study suggests that the more natural light a classroom has, the faster the academic progress of the students in it.

ruptions. Providing bright daytime light, the researchers believe, could have helped restore their proper rhythms and thus have improved overall brain function.

The wavelength of light is also crucial. Our circadian systems are primarily regulated by short-wavelength blue light; the photoreceptors that feed back to the suprachiasmatic nucleus, a part of the hypothalamus that regulates our daily rhythms, relay the most nerve impulses to the brain when they detect blue light. This short-wavelength light—present in sunlight—lets the brain and body know it is daytime. (In contrast, our rods and cones, which

most effectively in green spaces,” one architect says.

energy-efficient structures, collected scores on standardized tests of math and reading for more than 21,000 elementary school students in three school districts in three states: California, Washington and Colorado. Using photographs, architectural plans and in-person visits, the researchers rated the amount of daylight available in each of more than 2,000 classrooms on a scale of 0 to 5. In one school district—Capistrano, Calif.—students in the sunniest classrooms advanced 26 percent faster in reading and 20 percent faster in math in one year than did those with the least daylight in their classrooms. In the other two districts, ample light boosted scores between 7 and 18 percent.

Retirement homes can also be too dark to keep circadian clocks ticking away normally. In a study published in 2008 neuroscientist Rixt F. Riemersma-van der Lek of the Netherlands Institute for Neuroscience and her colleagues randomly selected six of 12 assisted-living facilities in Holland to have supplemental lighting installed, bringing the luminosity to approximately 1,000 lux; the other six provided dimmer lighting of around 300 lux. On tests taken at six-month intervals over three and a half years, the residents of the more brightly lit buildings showed 5 percent less cognitive decline than occupants of the six darker buildings did. (The additional lighting also reduced symptoms of depression by 19 percent.) Other studies show that circadian rhythms keep the brain functioning optimally by calibrating hormone levels and metabolic rate, for example. Elderly people—especially those with dementia—often have circadian dis-

ruptions. (They are also responsible for vision, fire maximally when exposed to green or yellow-green light.)

Researchers recommend using blue light-emitting diodes (LEDs) and full-spectrum fluorescent lights in buildings during the day; both have enough blue light to trigger the circadian system and keep occupants awake and alert. After dark, buildings could switch to lamps and fixtures with longer-wavelength bulbs, which are less likely to emit light detected by the circadian system and interfere with sleep at night. “If you can give people a lighting scheme where they can differentiate between day and night, that would be an important architectural decision,” says Mariana Figueiro, program director of the Lighting Research Center at Rensselaer Polytechnic Institute.

A Room to Relax

Although bright light might boost cognition, recent work suggests it counteracts relaxation and openness—effects that might be more important than alertness in some settings. In a 2006 study counselors interviewed 80 university students in-

(The Author)

EMILY ANTHES is a freelance science and health writer living in Brooklyn, N.Y. Her work has appeared in *Seed*, *Scientific American Mind*, *Discover*, *Slate*, *New York*, and the *Boston Globe*, among other publications.

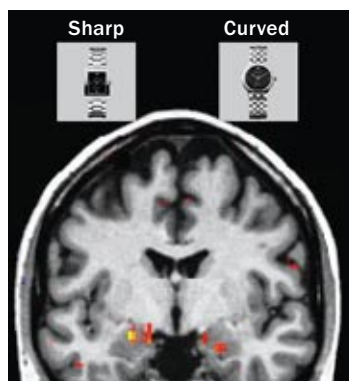
No Exit

The residences of people who suffer from dementia may have special architectural requirements. For example, seniors with cognitive impairments often try to leave their assisted-living facilities, ending up lost, cold or worse. One surprisingly straightforward solution to this problem: disguising the exits. Placing doors to the outside along—instead of at the end of—hallways, shrinking the size of the “exit” sign, covering the doorknobs with cloth and making the doors solid (with no windows to the outdoors) can reduce residents’ attempts to leave. In 2003 John Zeisel, a sociologist and president and co-founder of Hearthstone Alzheimer Care, whose facilities are located in Massachusetts and New York, studied a total of 427 residents at 15 different special care units for people with Alzheimer’s disease. Zeisel and his colleagues correlated the residents’ psychological functioning (as measured by a number of standardized assessments) with various features of the physical environments in which they lived. Among other findings, the researchers revealed that those who lived in facilities with well-disguised exits had fewer symptoms of depression than did residents of homes with more prominent exit doors. Zeisel speculates that in institutions whose exit doors are inconspicuous, staff members are less worried about patient safety and give residents more freedom and independence, thereby boosting their mood.



Disguising exit doors such as these in homes for people with Alzheimer’s disease may improve the mood of the residents.

Exit camouflage is just one environmental intervention that could help senior citizens with dementia, Zeisel says. For instance, memory-impaired patients have trouble forming cognitive maps of their environments, so the Hearthstone facilities make liberal use of landmarks, posting a variety of photographs in the hallways to help patients find their way. And helping them navigate the corridors can, in turn, reduce their distress, aggression and anxiety, according to Zeisel. “A large number of the so-called symptoms of Alzheimer’s disease are a result of environmental factors that are not well suited to these people’s needs,” he maintains. —E.A.



Viewing sofas and other objects with sharp corners produces greater activation (red and yellow patches) of the amygdala, a brain area involved in fear and arousal, than does looking at furniture with curved contours. The heightened activity may underlie a sense of danger, which people associate with sharp angles. Smooth shapes are more soothing, studies hint.

dividually in either a dim or a brightly lit counseling room. The students then completed a questionnaire about their reactions to the interview. The students questioned in the dim room felt more relaxed, viewed the counselor more positively and shared more information about themselves than those counseled in the brighter room did. The findings suggest that dim light helps people to loosen up. If that is true generally, keeping the light low during dinner or at parties could foster relaxation and intimacy.

A room’s contents can be similarly soothing—or the opposite. Neuroscientist Moshe Bar of Harvard Medical School and Maital Neta, then his research assistant, showed subjects photographs of various versions of neutral objects, such as sofas and watches. The examples of each item were identical except that some had curved or rounded edges, whereas others had sharp, squared-off perimeters. When asked to make snap judgments about these objects, subjects significantly preferred those with curves. Bar speculates that this preference exists because we associate sharp angles with danger. (The brain may sense a greater hazard, for instance, from a cave in which jagged rocks protrude from the walls than from one in which rounded rocks do the same.) “Maybe sharp contours are coded in our brains as potential threats,” he says.

Bar provided some support for this theory in a 2007 study in which subjects again viewed a series of neutral objects—this time while their brains were scanned using functional magnetic resonance imaging. The neuroscientist found that the amygdala, which is involved in fear processing and emotional arousal, was more active when people were looking at objects with sharp angles. “The underpinnings are really deep in our brain,” Bar explains. “Very basic visual properties convey to us some higher-level information such as ‘Red alert!’ or ‘Relax, it’s all smooth; there’s no threat in the area.’” He acknowledges that an object’s contour is not the only element that informs our aesthetic preferences, and his research is still in its early stages. But all other things being equal, filling a living room or waiting room with furniture that has rounded or curved edges could help visitors unwind.

Furniture choices can also influence human interaction.

COURTESY OF JOHN ZEISEL (exit doors); FROM “VISUAL ELEMENTS OF SUBJECTIVE PREFERENCE MODULATE AMYGDALA ACTIVATION,” BY MOSHE BAR AND MAITAL NETA, IN NEUROPSYCHOLOGIA, VOL. 45, NO. 10, 2007. COPYRIGHT 2007, REPRINTED WITH PERMISSION FROM ELSEVIER (brain scan)

Some of the earliest environmental psychology research focused on seating plans in residential health care facilities; scientists discovered that the common practice of placing chairs along the walls of resident day rooms or lounges actually prevented socializing. A better plan to encourage interaction, researchers found, is organizing furniture in small groupings throughout the room. A 1999 study by psychologists at the Otto-von-Guericke University of Magdeburg in Germany and Uppsala University in Sweden examined seating in a different setting. Over eight weeks and more than 50 lessons, the researchers rotated a class of fourth-grade students between two seating arrangements: rows of desks and a semicircle of desks around the teacher. The semicircle configuration increased student participation, boosting the number of questions pupils asked. Other studies suggest that putting desks in rows encourages students to work independently and improves classroom behavior.

Carpeting can also grease the social wheels. In hospitals, carpet increases the amount of time patients' friends and families spend visiting, according to a 2000 study led by health care design expert Debra Harris, now president and CEO of RAD Consultants in Austin. Such social support may ultimately speed healing. Of course, carpeting is much harder to clean than traditional hospital flooring—and may present a health hazard in some settings—so it may not be appropriate for places such as an emergency room, where there is high patient turnover and plenty of mess. But rooms, buildings or wards that are home to long-term patients, such as assisted-living facilities, may benefit from carpets.

So far scientists have focused mainly on public buildings, such as hospitals, schools and stores. Thus, a homeowner interested in boosting his or her mind through design must do some extrapolating. "We have a very limited number of studies, so we're almost looking at the problem through a straw," Clemson's Allison says. "Now we need to find more general patterns. How do you take answers to very specific questions and make broad, generalized use of them? That's what we're all struggling with."

The struggle should pay off, experts believe, because when designers fabricate buildings with the mind in mind, the occupants benefit. Well-designed special care units for Alzheimer's patients reduced anxiety, aggression, social withdrawal, depression and psychosis, according to a 2003 study by Zeisel and his colleagues. And school design can account for be-



tween 10 and 15 percent of variation in elementary school students' scores on a standardized test of reading and math skills, suggests a 2001 report by investigators at the University of Georgia.

"Because of advances in neuroscience, we can begin measuring the effects of the environment at a finer level of detail than we have before," U.C.S.D.'s Edelman says. "We can understand the environment better, we can understand our responses better, and we can correlate them to the outcomes. I just get chills when I think about it." **M**

(Further Reading)

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Think Better: Tips from a Savant

You may never have the memory of Rain Man, but you can still get tips for improving your cognitive performance from this extraordinary thinker

Daniel Tammet is author of two books, *Born on a Blue Day* and *Embracing the Wide Sky*, the latter of which came out in January. He is also a linguist and holds the European record for reciting the first 22,514 digits of the mathematical constant pi. *Scientific American Mind* contributing editor Jonah Lehrer chats with Tammet about the way his memory works, why the IQ test is overrated, and a possible explanation for extraordinary feats of creativity.

SCIENTIFIC AMERICAN MIND: Your recent memoir, *Born on a Blue Day*, documented your life as an autistic savant. You describe, for example, how you are able to quickly learn new languages and remember scenes from years earlier in cinematic detail. Are you ever surprised by your own abilities?

DANIEL TAMMET: I have always thought of abstract information—numbers, for example—in visual, dynamic form. Numbers assume complex, multidimensional shapes in my head that I manipulate to form the solution to sums or compare when determining whether they are prime or not.

For languages, I do something similar in terms of thinking of words as belonging to clusters of meaning so that each piece of vocabulary makes sense according to its place in my mental architecture for that language. In this way, I can easily discern relations between words, which helps me to remember them.

In my mind, numbers and words are far more than squiggles of ink on a page. They have form, color, texture, and so on. They come alive to me, which is why as a young child I thought of them as my “friends.” I think this is why my memory is very deep, because the information is not static. I say in my book that I do not crunch numbers (like a computer). Rather I dance with them.

None of this is particularly surprising for me. I have always thought in this way so it seems entirely natural. What I do find surprising is that other peo-

ple do not think in the same way. I find it hard to imagine a world where numbers and words are not how I experience them!

MIND: In *Embracing the Wide Sky*, you criticize the IQ test as a vast oversimplification of intelligence. You write: “There is no such thing as proofs of intelligence, only intelligence.” Could you explain what you mean by that?

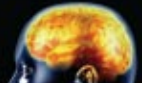
TAMMET: When I was a child, my behavior was far from being what most people would label “intelligent.” It was often limited, repetitive and antisocial. I could not do many of the things that most people take for granted, such as looking someone in the eye or deciphering a person’s body language, and only acquired these skills with much effort over time. I also struggled to learn many of the techniques for spelling or doing sums taught in class because they did not match my own style of thinking.

I know from my own experience that there is much more to intelligence than an IQ number. In fact, I hesitate to believe that any system could really reflect the complexity and uniqueness of one person’s mind or meaningfully describe the nature of his or her potential.

The bell curve distribution for IQ scores tells us that two thirds of the world’s population has an IQ somewhere between 85 and 115. This means that some four and a half billion people around the globe share just 31 numerical values (“he’s a 94,” “you’re

Daniel Tammet, who can recite the first 22,514 digits of the mathematical constant pi.

MIND MATTERS



Each week in **Mind Matters**, www.SciAm.com/mind-and-brain, researchers explain and discuss their disciplines' most notable recent findings. **Mind Matters** is edited by Jonah Lehrer, the science writer behind the blog *The Frontal Cortex* and the book *Proust Was a Neuroscientist*.

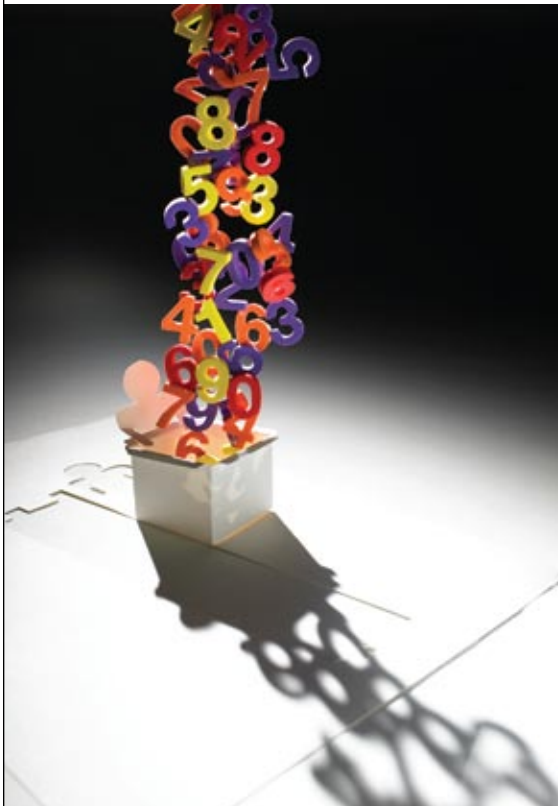
Numbers have different shapes and colors for Tammet, making large sets of them easier to remember.

a 110," "I'm a 103"), equivalent to 150 million people worldwide sharing the same IQ score. This sounds a lot to me like astrology, which lumps everyone into one of 12 signs of the zodiac.

Even if we cannot measure and assign precise values to it in any "scientific" way, I do very much think that intelligence exists and that it varies in the actions of each person. The concept is a useful and important one for scientists and educators alike. My objection is to thinking that any "test" of a person's intelligence is up to the task. Rather we should focus on ensuring that the fundamentals (literacy, etcetera) are well taught and that each child's diverse talents are encouraged and nourished.

MIND: You also describe some recent scientific studies on what happens inside the brain when we learn a second language. Do you think this research should change the way we teach languages?

TAMMET: Thanks to the advances in modern scanning technology, we know more today than



(The Author)

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ever before just what's happening inside the brain when we're learning a language. That we can speak at all is nothing less than an astonishing cognitive achievement.

Learning a second language, particularly when that language is not one that the person has to use on a regular basis, is an extremely difficult task. I think it is a mistake to underestimate the challenges of it. Students should be aware that the difficulties they will face are inherent in what they are doing and not any failing on their part.

One of the most interesting scientific discoveries about how language works (and how it could be taught) is "phonaesthesia"—that certain sounds have a meaningful relation to the things they describe. For example, in many languages the vowel sound "i" is associated with smallness—little, tiny, petite, *niño*, and so on—whereas the sound "a" or "o" is associated with largeness—grand, gross, *gordo*, etcetera. Such links have been found in many of the world's languages. These findings strongly imply that learners would benefit from learning to draw on their own natural intuitions to help them understand and remember many of the foreign words that they come across.

Another finding, by cognitive psychologists Lera Boroditsky, Lauren A. Schmidt and Webb Phillips, might also offer a useful insight into an important part of learning a second language. The researchers asked German and Spanish native speakers to think of adjectives to describe a range of objects, such as a key. The German speakers, for whom the word "key" is masculine, gave adjectives such as "hard," "heavy," "jagged" and "metal," whereas the Spanish speakers, for whom "key" is feminine, gave responses such as "golden," "little," "lovely" and "shiny." This result suggests that native speakers of languages that have gendered nouns remember the different categorization for each by attending to differing characteristics, depending on whether the noun is "male" or "female." It is plausible that second-language learners could learn to perceive various nouns in a similar way to help them remember the correct gender.

Regardless of how exactly a person learns a second language, we do know for sure that it is very good for your brain. There is good evidence that language learning helps individuals to abstract information, focus attention, and may even help ward off age-related declines in mental performance.

MIND: You advocate a theory of creativity defined by a cognitive property you call "hyperconnectivity." Could you explain?

Rare forms of creative imagination are the result of a convergence of normally disconnected thoughts, memories, feelings and ideas.



TAMMET: I am unusually creative—from visualizing numerical landscapes composed of random strings of digits to the invention of my own words and concepts in numerous languages. Where does this creativity come from?

My brain has developed a little differently from most other people's. Aside from my high-functioning autism, I also suffered from epileptic seizures as a young child. In my book, I propose a link between my brain's functioning and my creative abilities based on the property of hyperconnectivity.

In most people, the brain's major functions are performed separately and not allowed to interfere with one another. Scientists have found that in some brain disorders, however, including autism and epilepsy, cross-communication can occur between normally distinct brain regions. My theory is that rare forms of creative imagination are the result of an extraordinary convergence of normally disconnected thoughts, memories, feelings and ideas. Indeed, such hyperconnectivity within the brain may well lie at the heart of all forms of exceptional creativity.

MIND: How were you able to recite from memory the first 22,514 numbers of pi? And do you have advice for people looking to improve their own memory?

TAMMET: As I have already mentioned, numbers to me have their own shapes, colors and textures. Various studies have long demonstrated that being able to visualize information makes it easier to remember. In addition, my number shapes are semantically meaningful, which is to say that I am able to visualize their relation to other numbers. A simple

example would be the number 37, which is lumpy like oatmeal, and 111, which is similarly lumpy but also round like the number three (being 37×3). Where you might see an endless string of random digits when looking at the decimals of pi, my mind is able to “chunk” groups of these numbers spontaneously into meaningful visual images that constitute their own hierarchy of associations.

Using your imagination is one very good way to improve your own memory. For example, actors who have to remember hundreds or even thousands of lines of a script do so by actively analyzing them and imagining the motivations and goals of their characters. Many also imagine having to explain the meaning of their lines to another person, which has been shown to significantly improve their subsequent recall.

Here is another tip from my book. Researchers have found that you are more likely to remember something if the place or situation in which you are trying to recall the information bears some resemblance—color or smell, for example—to where you originally learned it. A greater awareness therefore of the context in which we acquire a particular piece of information can help improve our ability to remember it later on. **M**

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Road Warriors

Often played for laughs, road rage is a real phenomenon with serious consequences for driver safety and society

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

CONSIDER the following recent sobering reports:

- A motorist shot and killed the driver of another car “because he was driving too slowly.”
- A large crowd was blocking the parking lot exit of a nightclub. A driver who was growing impatient with waiting for an opening drove his car straight into the crowd, seriously injuring seven people.
- When Jack Nicholson got cut off, the actor waited until both he and the other driver were stopped at a red light, then got out of his car, and hit the windshield and roof of the other car with his golf club. He returned to his car and drove away.

Of course, *you* wouldn't do such things. Or would you?

You might, because road rage is remarkably common. In one survey of more than 500 drivers, 90 percent reported that during the past year they either were a victim of road rage or had witnessed it. These statistics actually may be underestimates. For one thing, many respondents may not want to admit to road rage because it is socially undesirable. Also, more people report being the target rather than the initiator of road rage, supporting the idea that initiators may not be fessing up.

Psychologist Elisabeth Wells-Parker of Mississippi State University and her associates have suggested that the term “road rage” implies specific incidents of anger and aggression directed intention-



ally at another driver, vehicle or object. When the behavior erupts, the presence of firearms can worsen the situation. As physician Matthew Miller of the Harvard School of Public Health and his colleagues have pointed out, 11 percent of a randomly selected sample of 790 drivers reported that they always or sometimes carried a gun (usually loaded) in their vehicle.

Who Are These People?

Anybody can be susceptible. Road ragers are men and women, young and old, rich and poor, mentally disturbed and healthy, people with and without generalized anger problems, and members of various ethnicities. Some become angry almost every time they drive, whereas others do so infrequently. Although aggressive retaliation, such as assault or murder, characterizes the extreme end of these behaviors, most crab-

by drivers engage in milder displays, such as verbal insults, obscene gestures, honking their horn, cutting off other drivers and chasing other cars.

Still, research does point to some similarities among those who are susceptible to belligerent acts when behind the wheel. People with aggressive tendencies across a variety of situations, including home and work, have an increased likelihood of road rage. Younger drivers are more prone than older drivers are. Men have historically displayed a greater predilection, although women recently have been catching up. Many road ragers are otherwise model citizens who are successful in work and in relationships and well respected in their communities.

Why do some people get angry and even violent in response to the irritating behavior of other drivers, whereas others do not? Psychologist Jerry Deffen-

(In one survey **90 percent of drivers** reported that in the past year they were a victim of road rage or witnessed it.)

COURTESY OF HAL ARKOWITZ (top); COURTESY OF SCOTT O. LILIENFELD (bottom); HARRY NOWELL age Fotostock (angry driver)

Why do some people get angry **and even violent** in response to other drivers, whereas others do not?

bacher of Colorado State University has proposed that some people have a trait for, or predisposition toward, this type of behavior that is triggered by the poor driving of other motorists. Many of his studies have found that those who display lower levels of the trait are far less likely to respond with road rage, even when exposed to the same triggers.

Other researchers have tried to uncover the nature of this trait, and their studies have found that those prone to road rage may show one or more of a variety of characteristics: general aggression (not limited to driving), high levels of stress, antisocial tendencies, or low impulse control and frustration tolerance. Researchers have also demonstrated that road ragers are sensitive to supposed attacks on their self-esteem. For example, in the clinical practice of one of us (Arkowitz), people with road rage problems perceived the irksome behaviors of other drivers as a sign of disrespect and a personal insult rather than attributing those behaviors to the other drivers' carelessness or recklessness. Arkowitz found it useful to help clients learn that "it is not about you." Certain psychological problems have also been found to relate to the road rage trait, including antisocial and borderline personality disorders as well as alcohol and substance abuse.

It is apparent that road ragers represent a very mixed bag of people. They may have only one of the attributes described above or several characteristics, or they may have other features we have yet to discover. Regardless of the initiating factors, however, road ragers seem to respond to various types of therapies.

Prevention and Treatment

Although prevention is the best option, studies have shown that treatment can be effective as well. Deffenbacher conducted two experiments in which subjects received either training in relaxation

only or training in relaxation along with other therapies intended to change subjects' dysfunctional thoughts about driving. In general, subjects did better with either of the two treatments than with no treatment. These studies were well designed, but we need to be cautious about generalizing the results to the wider population because all subjects were college students and thus do not represent the full range of road ragers.

Recently psychologist Tara E. Galovski of the University of Missouri–St. Louis and her colleagues evaluated a group treatment for road rage aimed at adults who were either self-referred or court-referred. Treatment consisted of four weekly two-hour sessions that included education about road rage and anger, recognition of being an angry driver, relaxation techniques, coping skills and training in different ways to think about anger-eliciting driving situations. Those who received treatment did far better than those who did not and curbed their aggressive behavior by more than 60 percent on average.

In addition to combating the problem with treatments for individuals, policy leaders could make changes that might reduce road rage in society at large. Sociologist Mark Asbridge of Dalhousie University in Halifax and his associates have made interesting recommendations. One of these is new or increased penalties for road rage. Laws already cover extreme forms, such as assault and dangerously aggressive driving. Asbridge and his co-workers suggest the possible value of broader adoption of an Australian national law that stipulates that drivers must not drive so as to "menace" other persons by threat

of personal injury or property damage. Other ideas include mass-media education about road rage and how to avoid it, societal changes such as reducing traffic congestion and promoting public trans-



In a road rage case, Jonathan Wade Ellington was convicted in 2006 of killing a hairdresser in Idaho by driving over her.

portation, court programs for convicted road ragers, and redesign of cars to prevent excessive headlight flashing and horn blowing; some cars have already been designed to prevent tailgating.

We conclude with a brief anecdote. Arkowitz used to drive to work on a road that prominently displayed a billboard advertising a funeral home. It showed a picture of the funeral home, along with five simple, but powerful, words: "Drive carefully, we can wait." We hope that greater awareness of road rage and its treatments will help keep them waiting for a long time to come. **M**

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

Send suggestions for column topics to editors@SciAmMind.com

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All Together Now

An explanation for synchronous swimming and other group rituals

BY WRAY HERBERT



Orderly marching in rows builds group cohesiveness.

THERE WAS A TIME when soldiers went into battle in columns and rows. They would line up and march in orderly formation toward the enemy, armed with spears, bayonets or some other weapon of close combat. The enemy would do the same thing. One of these well-oiled formations would kill more soldiers than the other—and win the battle.

Advances in firearms long ago made the marching formation obsolete. It just does not work with machine guns and guerilla warfare. Yet armies all over the world still train for this archaic kind of warfare. Indeed, militaries continue to place a high value on precision and synchrony that will never be used on a battlefield.

Why is that? Why do high schools have marching bands? Why do churches have choirs? And perhaps most perplexing of all, why do we have synchronized swimming? What is it about moving and chanting and singing in unison that appears to have universal appeal?

Bonding and Effervescence

Anthropologists and cultural historians have offered up a variety of theories about synchrony over the years, mostly having to do with group coherence. One theory, for example, holds that various communities benefit from the actual physical synchrony—or “muscular bonding”—which builds group cohesiveness. Another idea is that synchronous

activities lead to “collective effervescence”—positive emotions that break down the boundaries between self and group.

But neither of these theories has been proved, and what is more, neither is complete. Muscular bonding may explain the coherence of the 14th Infantry Regiment, but those guys do not seem very effervescent—not in the way that, say, carnival revelers are. And gross motor coordination does not explain the almost motionless chanting of Tibetan monks. Psychologists are looking for a unifying theory for the appeal of synchrony.

One idea, put forth by Stanford University psychologist Chip Heath and graduate student Scott S. Wiltermuth, is

MATT MENDELSON (Herbert); PETER TURNLEY Corbis (soldiers)

What is it about **moving and chanting and singing** in unison that appears to have universal appeal?

that all synchrony—movement and sound, and both together—is an ancient ritual that evolved for the economic benefit of the group. The primary goal of rhythmic dancing, marching and chanting is to solve the problem of the freeloader—the community member who hurts the collective good by taking but not contributing. Muscular bonding and collective joy are mere by-products of this more fundamental economic ritual.

Heath and Wiltermuth ran a series of experiments to test this idea. In the simplest version, the researchers took groups of Stanford students on walks around campus; some walked in step—marching, basically—whereas others just strolled the way people usually do. Later, after the subjects thought the experiment was over, the psychologists gave them all the Weak Link test, in which each volunteer chooses to act either self-interestedly or cooperatively, depending on what he or she anticipates others will do. The test measures the expectation that others will value the group over themselves.

The marchers acted more cooperatively than the strollers did. They also said that they felt more “connected” than the strollers did. Notably, they did not report feeling any happier, suggesting that positive emotions were not necessary for achieving the boost in group cohesiveness.

The psychologists wanted to do a more fine-grained test of their idea. It is well known that a sense of common identity and shared fate strengthens group cohesiveness, but the researchers wanted to see if synchrony contributes above and beyond this feeling. They did a rather elaborate test to find out. They had students perform tasks—moving plastic cups—that required differing degrees of coordination with others. While doing this, the subjects listened to “O Canada”



Part of synchrony's power is “muscular bonding.”

through headphones. Remember that these participants were from Stanford (and thus typically U.S. citizens), so the Canadian national anthem presumably had no emotional resonance for them; it was merely a synchronous act.

All the students had copies of the lyrics. Some sang the anthem and moved the cups in rhythm, whereas others just sang in unison or read the lyrics silently. Still others sang and moved to different tempos—kind of like a really bad dancer moving at odds with the music.

Then the researchers gave them the same Weak Link test, only this time there was real money involved. As before, those who had experienced synchrony were more economically cooperative than those who had not. The bad dancers were bad citizens, but the physical movement otherwise made no difference; choral singers were selfless with or without the swaying, suggesting that muscular bonding is (like joy) unnecessary to get the desired group coherence. The swaying might have been enjoyable, but the group singing was sufficient.

Tokens of Esteem

The Stanford team did this “O Canada” experiment again with a different but similar test called the public goods

game. Using tokens, participants choose whether to contribute to a public kitty or to their own private savings account. Self-interest has a higher payoff in the game, although the group benefits more if everyone acts unselfishly. The researchers got the same results as before, but the interesting finding was that, over the game's several rounds, the choral singers increased their contribution to the group, keeping

less money for themselves. They gave much more to the community fund in the last round than they did in the first, suggesting that the synchrony has persistent and growing effects.

The choral singers also said they felt as if they were more part of the team. They felt they had more in common with the others, and they trusted them somewhat more. Interestingly, as reported in the January issue of the journal *Psychological Science*, they also made more money in the end because they shared in the group bounty.

Synchrony rituals are powerful—so much so that they may have endowed certain groups with a competitive advantage over the eons, perhaps even causing some cultures to flourish while others perished. It is no wonder, then, that such potent impulses remain entrenched in today's churches and armies—and, yes, could even explain synchronized swimming. **M**

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

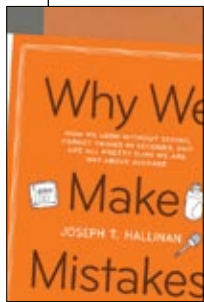
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books



PRONE TO GOOF

Why We Make Mistakes: How We Look without Seeing, Forget Things in Seconds, and Are All Pretty Sure We Are Way Above Average

by Joseph T. Hallinan. Broadway Books, 2009 (\$24.95)

In the early 1980s a group of Mayo Clinic doctors decided to look at old chest x-rays of patients who later developed lung cancer. The radiologists who had initially checked the scans had found them to be normal, but the team reexamining them saw that 90 percent of the tumors had actually been clearly visible.

Should this astronomical error rate surprise us? Not at all, journalist Joseph T. Hallinan says, because it's only human to make such "looked but didn't see" mistakes. Moreover, not seeing what is right in front of us is just one of a stunningly large array of shortcomings of the human brain that cause us to err, Hallinan claims. In *Why We Make Mistakes*, he provides the reader with an intriguing assortment of these failings.

The book is chock-full of fascinating examples, ranging from entertaining to horrifying to utterly bizarre (a South Wales group of vigilantes, for example, vandalized a doctor's office after confusing the words "pediatrician" and "pedophile"). We learn that humans tend to process information in specific contexts. That explains why, for hours, no one noticed the body of a Delaware woman who committed suicide by hanging herself on a tree at the end of October in 2005—people in the town thought it was a Halloween decoration.

But it's not just the limitations of our brains that cause us to make mistakes; equally at fault are our surroundings, which are often at odds with the way the human mind works, Hallinan says. Cars, for example, are rapidly turning into living rooms and offices, featuring access to phone, e-mail and text messaging, even though many studies have shown that humans are not capable of doing several things at once. Even worse, Hallinan warns, many "safety" devices work "by interrupting the driver at the worst possible time." And yet car crashes usually get blamed on the driver, not the

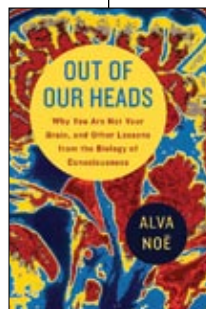
car. So, according to Hallinan, it's not difficult to figure out why we often don't learn from our mistakes and keep repeating them: "We haven't understood their root causes."

Why We Make Mistakes is an eye-opening account of our brain's imperfections and a frightening report of how little we do as a society to keep these shortcomings from becoming dangerous. It will make you think twice about answering your cell phone next time it rings while you are on the road. —Nicole Branam

THE HARD PROBLEM

Out of Our Heads: Why You Are Not Your Brain, and Other Lessons from the Biology of Consciousness

by Alva Noë. Hill and Wang, 2009 (\$25)



Your brain is a three-pound hunk of grayish jelly. Your mind hosts a stream of thoughts and sensations. Despite recent advances in neuroscience, we don't know how to get from one to the other: we still can't explain the mind in terms of the brain. Some believe that if we keep studying the brain with the tools we have, we will eventually work up to the conscious mind. Alva Noë, a philosopher at the University of California, Berkeley, is not so optimistic. In *Out of Our Heads*, his first book for a popular audience, he argues that we have been looking for consciousness in the wrong place.

"Consciousness does not happen in the brain," Noë claims. But his position is not as extreme as it sounds. The point is not that neural states are irrelevant to our experience but that if we are ever to understand the nature of conscious awareness we will have to consider more than just our "wet, sticky, meat-slab brains." The sense of consciousness, according to Noë, is the ongoing product of a wide-ranging interaction between the body of a living creature and the world it inhabits. The brain is only part of this story.

It's a fair point, if not one that will be entirely surprising to biologists. As Noë showed convincingly in a previous book—*Action in Perception* (MIT Press, 2004)—we do not passively absorb data from our eyes and ears, as a camera or a microphone would, but rather scan and probe our environments so we

can act on them. It is a long way, however, from this view of perception to a coherent theory of consciousness.

Noë has a gift for condensing the literature on how we perceive and interact with the world. Yet he seems unable to build from these studies a convincing account of what consciousness is. Rather the book is an exercise in skepticism and criticism, much of it warranted. The problem is that where Noë clears away stale ideas, he offers little of substance to replace them. One comes away from the book without a definitive example of a conscious state that would require more than a brain.

Despite these problems, Noë's main point holds: if we want to understand the conscious mind, we will need to take a wider view of the whole organism interacting with its environment. One could imagine many researchers nodding their heads. The crucial issue, not emphasized by Noë, is that it is exceptionally hard to tease out how our surroundings and our own actions shape the way we perceive the world. That challenge, rather than a lack of curiosity or imagination, could be why there has been so little work on the subject. —Jascha Hoffman

film

BEYOND RAIN MAN

Autism in Film

For many years, if you wanted to rent a movie about autism, you had only one choice: *Rain Man*. Although it never hurts to revisit such a classic, in recent years there has been a virtual explosion of movies featuring autistic characters very different from *Rain Man*'s savant.

The most recent and critically acclaimed of these films, *The Black Balloon* (NeoClassics Films, 2008), is a



BELOW: UNITED ARTISTS/THE KOBAL COLLECTION (Rain Man); BLACK BALLOON PRODUCTIONS/THE KOBAL COLLECTION (The Black Balloon); WEINSTEIN CO./THE KOBAL COLLECTION (Snow Cake); MOZART PRODUCTIONS/COURTESY OF EVERETT COLLECTION (Mozart and the Whale)

dvd

► **WORLDS OF WORDS**

The Linguists

Order the DVD at www.thelinguists.com

There are 7,000 languages in the world—and one dies every two weeks. With it goes cultural knowledge built for generations as well as an irreplaceable piece of the puzzle that is the human brain's affinity for words. In an effort to record the most endangered languages before they disappear, Swarthmore College ethnographer David Harrison and linguist Greg Anderson of the Living Tongues Institute for Endangered Languages in Salem, Ore., embarked on a journey around the world. *The Linguists* chronicles their adventures and challenges, many fit for Indiana Jones. Some of the most nerve-racking and humorous moments of the documentary happen when the scientists try to communicate with the surviving elderly speakers: one of the last 25 people who speak Chulym in Siberia is nearly deaf; another alternates between swearing at the researchers and confessing her love for them.

When people stop speaking in their native tongue, we miss out on unique insights into the diverse ways the brain can work. Anderson and Harrison come across an unknown numerical system near its death in rural India, and their surprise and joy at the discovery are infectious. Harrison asks Orenchu Gomango to count in his native language, Sora. "When he said 13," Harrison explains, "he repeated the word we had just heard for 12 and added the word 'one' to it." Unlike English, which uses 10 as a base, Sora appears



to use 12 as its base. Until Gomango counts to 30, which translates to 20–10. "Now he's using 12 and 20 as a base. So, then, as he counts higher, which one is he gonna use? It turns out he's going to use both of them. So you get to 32, and that is 20–12." The linguists determine that the Sora word for 93, which translates to 4–20–12–1, is one of the most complicated numbers we might ever see in a language.

Back in Siberia, the researchers work with local children to create a storybook, the first book ever published in Chulym. "It's hard to really explain the satisfaction you can have watching people reconnect in essence with their history," Anderson says. But we sense he has little time to enjoy this small success. By the end of the film, we learn that half the Chulym speakers Anderson and Harrison interviewed have already passed away.

—Corey Binns

IRONBOUND FILMS, INC. (The Linguists)

story of two teenage brothers, one of whom is severely autistic. Both film critics and autism advocates herald the Australian film's realistic portrayal of the disorder. Elissa Down, who wrote and directed the movie, grew up with



two autistic brothers and no doubt drew on her own experiences when creating the characters and dialogue. (*The Black Balloon* is available on DVD in Australia and will be released in the U.S. later this year.)

In 2006's *Snow Cake* (IFC), Sigourney Weaver plays an independent au-



tistic woman who helps a guilt-ridden stranger, played by Alan Rickman, come to terms with his issues about love and death. The film received mixed reviews, but Weaver's performance was praised by many in the autistic community.

Mozart and the Whale (Sony Pictures, 2005) is a more light-hearted film about a romance between two young adults who have Asperger's syndrome, a form of autism marked by high IQ and social difficulties. The film,

starring Josh Hartnett and Radha Mitchell, is based on the book of the same title, which chronicles the relationship highs and lows of real-life couple Jerry and Mary Newport.

The next few years promise more autism-related movies, including both documentaries and feature films. There are even reports of a biopic of Temple Grandin, the autistic veterinary researcher made famous by Oliver Sacks in his book *An Anthropologist on Mars* (Knopf, 1995), with Claire Danes in the title role—so stay tuned. —Erica Westly



asktheBrains

Do blind people ever suffer from seasonal affective disorder? If so, can sunshine or tanning beds help?

—Kirstin Steele, Charleston, S.C.



Circadian and vision neuroscientist **Russell G. Foster** of the University of Oxford answers:

BECAUSE BLIND PEOPLE retain a newly discovered system of light-detecting cells, they, too, can suffer from seasonal affective disorder (SAD). Patients who have SAD struggle with serious mood changes in the fall and winter seasons. Symptoms include excessive sleepiness, low energy, and a tendency to crave sweets and starchy foods.

Normally our circadian rhythm is synchronized to the light/dark cycle, but in the absence of such cues our internal physiology starts to drift. The body clock of SAD sufferers may lose synchronization under the shorter periods and lower levels of winter light. Exposure to one to two hours of bright light in the morning often can help correct this disruption and alleviate SAD symptoms. A link between the occurrence of cataracts—clouding in the eye that leads to visual loss—and the development of SAD further suggests that light detection by the eye is key in this disorder.

Puzzlingly, some people who are completely blind—lacking the eye's photoreceptors known as rods and cones—can experience SAD. A decade ago scientists at Cornell University proposed that humans can detect light through their skin. But when researchers in the Netherlands tested this idea by exposing just the skin of SAD patients to bright light, they found the treatment had no effect at all. How, then, are they detecting light?

In 1999 we found that mice lacking rods and cones were nonetheless able to synchronize their circadian rhythm to the light/dark cycle. These observations led to the discovery of an additional photoreceptor system in the retina of humans

and other mammals consisting of a small number of photosensitive retinal ganglion cells (called pRGCs). These cells are most sensitive to blue light, and, significantly, blue light is most effective in alleviating the symptoms of SAD. We think that blind people can develop SAD because their other photoreceptor system—the pRGCs—remains intact. Likewise, although there are no known studies of light therapy in those who are visually impaired, we suspect light could be used to treat SAD symptoms in blind patients.

Does postpartum depression serve some evolutionary purpose?

—Clint Johnson, Ridgecrest, Calif.



Anthropologist **Edward H. Hagen** of Washington State University replies:

POSTPARTUM DEPRESSION (PPD), which afflicts 10 to 15 percent of new mothers, may have evolved as a strategic response to a lack of social support because it helped in passing on genes successfully. Many doctors believe PPD is triggered by the changes in a mother's hormones after giving birth, yet studies have failed to find much evidence for a link between extreme hormone fluctuations and PPD. The fact that fathers, who do not experience such changes, also suffer from PPD is strong evidence that it is not “just hormones.”

The finding that PPD often plagues people who have marital problems or little outside support led biologists Randy Thornhill and F. Bryant Furlow of the University of New Mexico and me independently to propose that PPD has an evolved function. Many animals improve their chances of passing on their genes if they desert their young when food or parenting help is scarce and invest instead in future offspring that are more likely to survive and reproduce.

This “parental investment theory”

“When a mother lacks support from the father or other family members, she may unconsciously conclude that she cannot successfully raise her infant, and she may reduce her efforts.”

should apply especially well to humans. Human children are “expensive” to raise, requiring years of parenting before they can survive on their own. When a mother lacks support from the father or other family members, she may unconsciously conclude she cannot successfully raise her infant. The ensuing emotional pain from PPD operates somewhat like physical pain: stop what you're doing—it's harming your reproductive fitness! Studies confirm that mothers with PPD do significantly reduce parenting efforts and often have thoughts of harming their baby.

This “psychic pain hypothesis” cannot explain the whole story, however, because few parents suffering from PPD abandon their newborn. I propose an additional function of PPD that is like a labor strike, in which a mother's reduced interest in her baby may serve to elicit help from others. Studies do suggest that higher levels of PPD symptoms in mothers motivate more child care by fathers, and increased social support is one of the best predictors for the remission of PPD.

These hypothesized functions for PPD are far from proved. If you or a loved one is suffering from PPD, contact a doctor immediately—treatments, including antidepressants and talk therapy, are available and effective. **M**

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

Head Games

Match wits with the Mensa puzzlers

1 TWISTER

Fill in the blanks in each sentence below with words that differ only in that they have two adjacent letters swapped.

John Adams was both a _____ and a _____ of the constitution.

I _____ the toast and must now bear the _____ of my spouse's scorn.

I got a _____ from some _____ who sneezed on me.

He _____ hard, but he _____ easily.

Every now and then an article about the marine _____ up in the paper.

2 MISSING PIECES

Fill in the blanks according to the clues.

a) M _ U _ _ _ _ G

b) M U _ _ _ G _ _

c) _ M U _ _ _ G

d) M _ _ _ U _ G _

e) _ M U _ _ _ _ G

f) _ _ _ M U _ _ _ _ G

g) M U _ _ _ _ G _ _

h) M _ _ U _ _ _ _ _ _ _ G

i) _ M U _ G _

Getting on a horse

Uncounted golf stroke

Entertaining

Assess wrongly

Trying to be like

Provoking

Negative campaigning

Not grasping

Stain

3 LIST LOGIC

ADD, BEE, LOO, _____.

Which word from the group below belongs in the list above?

ALL, BOO, COO, ERR, FEE, ILL, INN, MOO, ODD, OFF, SEE or TEE?

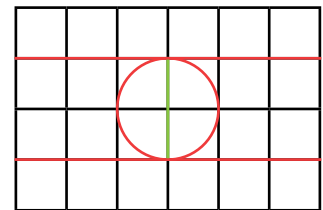
4 FIELD OF GEOMETRY

The following diagram is marked on a field.

The green line segment is 20 feet long. By randomly selecting a point in the field that is not already red or green, then making lines from that point to either end of the green segment, you can create a triangle.

What is the area (to the nearest square foot) of the part of the field in which any point chosen will create an obtuse triangle? (Reminder: an obtuse triangle has one angle that is greater than 90 degrees.)

 = 100 square feet



5 HEAD SPINNING

1	2	3	4	5
6	7	8	9	10
11	12	13	14	15
16	17	18	19	20
21	22	23	24	25

You are given a five-by-five grid with 25 cells.

By selecting a cell, you cause the contents of the cells above, below, left and right to rotate clockwise. For example, if you select cell 1, then the contents of 2 go into 6 and a blank is inserted in 2. If you select 9, then the contents of 4 go into 10, the contents of 10 into 14, the contents of 14 into 8, and the contents of 8 into 4.

In the grid to the right, using only three rotations, spell out the nickname of a brainy publication.

	S	D	I	
	M	A	I	
	M	C	N	

Answers

1. farmer, framer
burnt, brunt
cold, clod
trees, tires
corps, crops
2. a) MOUNTING
b) MULLIGAN
c) AMUSING
d) MISJUDGE
e) EMULATING
f) STIMULATING
g) MUDSLINGING
h) MISUNDERSTANDING
i) SMUDGE

3. ILL. A(bc)DD, B(cd)EE and L(mn)OO have a pattern that only I(j)(k)LL follows.
4. 1,514 square feet. The red lines indicate points where a right triangle will be formed. The two 10-by-60-foot rectangles above and below the red lines and the area within the red circle are the only places on the field that contain points that will form obtuse triangles. The area is $10 \times 60 + 10 \times 60 + 100 \times \pi$ square feet = 1,514 square feet.
5. Select cells 13, 19 and 13 again:
SDI SMISMI SCI
MAI CAD CAI AM
MCN MIN MND MIN D

1. farmer, framer
burnt, brunt
cold, clod
trees, tires
corps, crops
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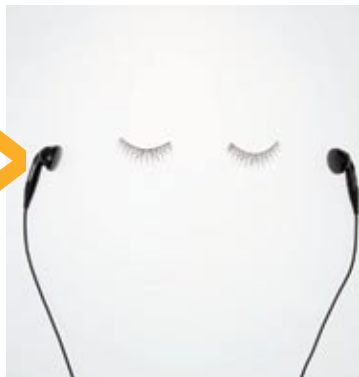
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Speaker: Lawrence Krauss, Ph.D.

A review of the revolutions that have taken place in cosmology over the past decade, including the discovery of Dark Energy, which permeates space and drives cosmic expansion. Tune in to Dr. Krauss and develop a deeper understanding of space, time, and gravity — one that is apt to change your picture of the universe.

The Undiscovered Country

Speaker: Lawrence Krauss, Ph.D.

We humans have undoubtedly questioned the origins of the cosmos for as long as we've walked the Earth but we've made spectacular progress in recent years. This progress forces us to discard much of what cosmology textbooks told us up until quite recently. Get the latest on competing ideas, their implications, and how they can be experimentally tested.

Postcards from Mars

Speaker: Jim Bell, Ph.D.

The NASA Mars Exploration Rovers Spirit and Opportunity landed on the Red Planet in January 2004, and have been driving, photographing, and analyzing their landing sites for the past five years. Prof. Bell has been the lead scientist in charge of the rovers' Panoramic Camera imaging system since the rovers were "born" nearly a decade ago. Come along for an amazing journey of geologic exploration and learn about the ways that both rovers have been utilized to discover convincing evidence that Mars was once warmer, wetter, and much more Earthlike than it is today.

Studying the Solar System in 3-D

Speaker: Jim Bell, Ph.D.

Don your red-blue glasses and join planetary imaging expert Prof. Jim Bell on a voyage of 3-D discovery of the solar system. Stereo pictures of Mars, the Moon, Saturn, asteroids, comets, and other places taken by astronauts and robotic space probes provide new details about the geology and history of our planetary neighbors. Learn about the ways that 3-D images are taken, and the ways that they are used by scientists and engineers involved in space exploration. Viewing the solar system in 3-D is the next best thing to being there!

Plate Tectonics

Speaker: David D. Blackwell, Ph.D.

Glide into an updated understanding of plate tectonics. Join Dr. Blackwell for a discussion of the development of the theory, its key principles, and its consequences. You'll learn about physical properties of the dynamic lithosphere, asthenosphere, and mantle layers versus chemical layers of the earth, driving forces of plate movement, and the relationship of plate boundaries to geological events such as earthquakes and the creation of topographic features like mountains, volcanoes, and oceanic trenches.

The Space Shuttle Program

Speaker: Guion S. Bluford, Jr., Ph.D.

Countdown to contemporary treasure — a first-hand account of life in space. Dr. Guion Bluford, a veteran of four Space Transportation System (STS) missions (STS 8, STS 61-A, STS 39, and STS 53) will present a look at the Space Shuttle Program, from its inception to the wrap up of its service in 2010. Learn about training for shuttle duty, noteworthy aspects of daily routine in space on the Discovery and Challenger, and gain a behind the scenes look at the science and technology projects executed by Shuttle astronauts.

The International Space Station

Speaker: Guion S. Bluford, Jr., Ph.D.

Join Dr. Bluford for a comprehensive survey of the International Space Station (ISS) Program. He will orient us to the history and complexities of this permanent human presence in space. From project inception to launch to ongoing development and daily living, pick up a new understanding of the logistics, function, and significance of the ISS.

The Future of the Space Program

Speaker: Guion S. Bluford, Jr., Ph.D.

Travel back to the future with an in-depth discussion on the future of the NASA Space Program. Dr. Bluford will address the issues and opportunities ahead as space exploration matures. You'll get the big picture of the Constellation Program (with its Aries, Orion, and Altair components) which will return humans to the moon and later take them to Mars. Come away with the insights and views on what lies ahead from Dr. Bluford, astronaut and aeronautical engineer.

Monoclonal Antibodies and Cancer Immunotherapy

Speaker: Noah Isakov, Ph.D.

Take a look under the hood of contemporary immunotherapy. From molecular biology to medicine, monoclonal antibodies are a valuable part of the scientist's toolkit. From his view deep in the trenches of immunobiology, Dr. Isakov will offer:

- An overview of antibody molecules
- A guide to the production of monoclonal antibodies with specificity against a predetermined pathogen
- The scoop on monoclonal antibody use in research, diagnosis, and therapy

For details contact: Neil Bauman
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