6 TOP MYTHS IN POP PSYCHOLOGY *page 42*

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March/April 2010
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Are You Mentally Healthy?

Take Our Quiz
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THE POWER TO PERSUADE

How masters of "supersuasion" can change your mind *page 24*

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SPECIAL REPORT

Better Paths to Learning

BRAIN CANCER UPDATE

Taking Aim at Tumor Sources

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COVER PHOTOILLUSTRATION BY AARON GOODMAN; SUIT BY KENNETH COLE

Convince Me

I didn't need it, but it was the perfect thing for anyone who considered herself artistic and liked to make detailed drawings, I had to agree. The art supplies salesperson smiled ingratiatingly at me as our conversation morphed into a pitch I literally felt I couldn't refuse. We had struck up a chat about art, and he somehow found a way to make an expensive pen-and-ink set seem indispensable by echoing back to me things I had said I valued in my drawings and in my tools. When he would point out its virtues, he'd say, "Don't you agree?" Yes, I did. And at the end, I forked over $25—at the time, more than I would spend for a week of groceries as an undergrad—and I could not figure out what he had done to make me buy that set. He literally had changed my mind.

Now I know more about why that happened and even have some ideas about how to make it happen myself with other people—and so will you when you read the cover story by psychologist Kevin Dutton, "The Power to Persuade." Dutton provides several simple secrets that confer surprising influence. I hope I've convinced you to turn to page 24.

Evidence is persuasive to me as a science journalist, and that is why I have always appreciated the work of Scott O. Lilienfeld, a psychologist, columnist and member of *Mind*'s board of advisers. Lilienfeld's emphasis on evidence-based psychology has helped sort wheat from chaff in that field. Now we are gratified to present to readers an article he has co-authored with Steven Jay Lynn, John Ruscio and the late Barry L. Beyerstein entitled "Busting Big Myths in Popular Psychology." The feature holds up six myths to evidence-based scrutiny. You may be surprised. The article begins on page 42.

Oh, and that pen-and-ink set? I've never used it, although I still have it. Always felt too guilty to do so because of what it cost. But that's a subject for another article.

Mariette DiChristina
Editor in Chief
editors@SciAmMind.com

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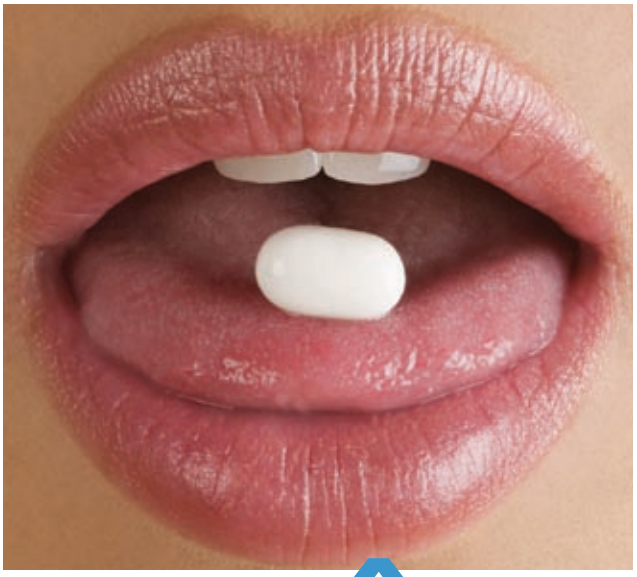
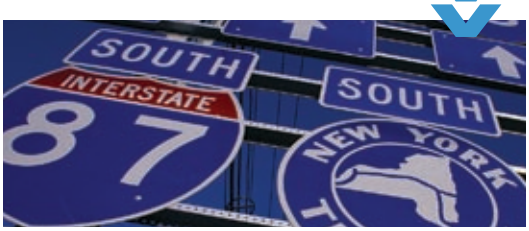
FEATURES

PHOTOILLUSTRATION BY AARON GOODMAN

DEPARTMENTS





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SMARTS VS. SENSE

Regarding "Rational and Irrational Thought: The Thinking That IQ Tests Miss," by Keith E. Stanovich: I have been teaching at the college level for more than a dozen years, and I've often wondered why some of my best and brightest students utterly fail in certain tasks that less "intellectual" students are able to excel in.

Thank you for the introduction to "dysrationalia," a phenomenon that seems to explain a lot. I look forward to more insightful articles like this one in your pages.

Ryan G. Van Cleave
Sarasota, Fla.

Dysrationalia! Finally, there is a diagnostic term to describe the all too prevalent affliction that we commonly refer to as "lack of common sense."

Debra Grob
Belmar, N.J.

Most of the research on decision making and cognition in general has essentially shown that we are not rational decision makers. The best option, therefore, is to work on honing our gut instinct to increase the probability that the outcome of a choice will be rational.

Business psychologist Robin Hogarth summarizes this counterintuitive idea in *Educating Intuition* (University of Chicago Press, 2001).

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

MOM WAS RIGHT

In regards to "Love the One You're With," by Nicholas A. Christakis and James H. Fowler, my mother could have saved you a lot of ink. Back in the 1960s when I was a teenager, she often told me, "Who you love depends on who's around."

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

CHILDHOOD ANXIETY

I found "Why We Worry," by Victoria Stern, to be interesting and well written. The article hit home with me because I suffered from that kind of extreme anxiety when I was six years old and my grandmother died. No one would tell me she was dead—they just kept saying she "passed away."

This led me to believe my mother would "pass" and be gone forever. I took to following her everywhere, including hiding under the couch when I was supposed to be in bed. I ended up on phenobarbital for several months, supposedly to help me get over my night terrors—at the age of six!

I am heartened to see that serious and productive research continues to be done for those who suffer from a disorder that can be crippling. Kudos!

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

BABY DRAMA

Thank you for "Dangerous Liaisons," by Ophelia Austin-Small. A childhood friend of mine recently became an unbearable drama queen. I now believe her behavior is actually a symptom of postpartum depression, but simply knowing the cause does not help me deal with her.

This article's tips were very enlightening. Thanks again!

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

Good guys wear white because our brain links the color black with filth and contagion.

BLACK AND WHITE

Concerning "The Color of Sin," by Wray Herbert [We're Only Human], I believe the association between morality and whiteness (and evil and blackness) is as clear as night and day. Night is a time when human beings' main survival sense—vision—is weakened or nullified. Other animals with a better sense of smell or hearing have the advantage.

Darkness, therefore, equals danger.

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

Herbert commented briefly on the concept of different races having different reactions to the colors black and white, but he did not mention different cultures. In China, for example, white is the color of death (or mourning) rather than purity. Brides do not wear white there. I wonder if the Chinese—or people from other cultures for whom black and white are not so clearly related to stain and purity—would behave differently on the psychological experiments described in this article.

Suzanne Hillman
via e-mail

GROWING PAINS

Obviously the body's perception of itself must be plastic, as Frederik Joelving reports in "Evolving Mental Maps" [Head Lines]. If it were not, we would be in dire trouble when as teenagers we undergo a growth spurt.

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

CREDIT-CARD ERROR

Michael Manchester wrote to Ask the Brains to wonder why most of his customers are confused by his instructions to swipe their credit card with the magnetic stripe "toward me." In the face of repeated failure, can anyone explain why he hasn't simply changed his instruction to something like "swipe the card with the magnetic stripe facing away from you?" It is my gut feeling that such an instruction would result in far less confusion, which would not only relieve Mr. Manchester's stress at work but also poke a hole in the "phonological loop" versus "intelligent interpretation of meaning" theory given in your magazine. If, on the other hand, the same customers who fail to intelligently interpret "stripe toward me" also misinterpret "stripe away from you," the failure rate would not change, and I would be proved incorrect.

Wayne Keyser
Eldersburg, Md.

Why are people proposing a variety of social solutions, such as the store clerk giving the directions differently, to what is simply a technical problem? This issue is simply the result of a design fault in the user interface of the card reader. The card reader should be designed to accept the card in either direction.

"istaines"
adapted from a comment at
www.ScientificAmerican.com/
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SEEING IN STEREO

Neuroscientist Terry Sejnowski's explanation of mental calculations in Ask the Brains got me thinking. A long time ago I noticed that if I watched a movie or television with only one eye I would get more of a sensation of depth than when watching with both eyes. This seemed to make sense to me because I figured that the brain uses many variables to determine depth (including size, occlusion, movement, and so on), but it probably gives priority to stereo vision.

Closing one eye removes stereo vision from the equation, thereby reducing the impact of seeing the flat two-dimensional screen and allowing the other depth cues in the moving images to come to the fore. Try it sometime—especially when there is a scene with a lot of relative movement, such as a swimming school of fish.

"zselway"
adapted from a comment at
www.ScientificAmerican.com/
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ERRATA "Why We Worry," by Victoria Stern, incorrectly states that antianxiety drugs such as Valium and Xanax inhibit the neurotransmitter GABA. In fact, these drugs increase the activity of GABA, which itself acts as an inhibitor, thereby quelling anxious arousal.

"What Does a Smart Brain Look Like?" by Richard J. Haier, misstated the order of the authors on one paper for the Further Reading. The correct citation is "Brain Imaging Studies of Intelligence and Creativity: What Is the Picture for Education?" by Richard J. Haier and Rex E. Jung, in *Roeper Review,* Vol. 30, No. 3, pages 171–180; 2008.

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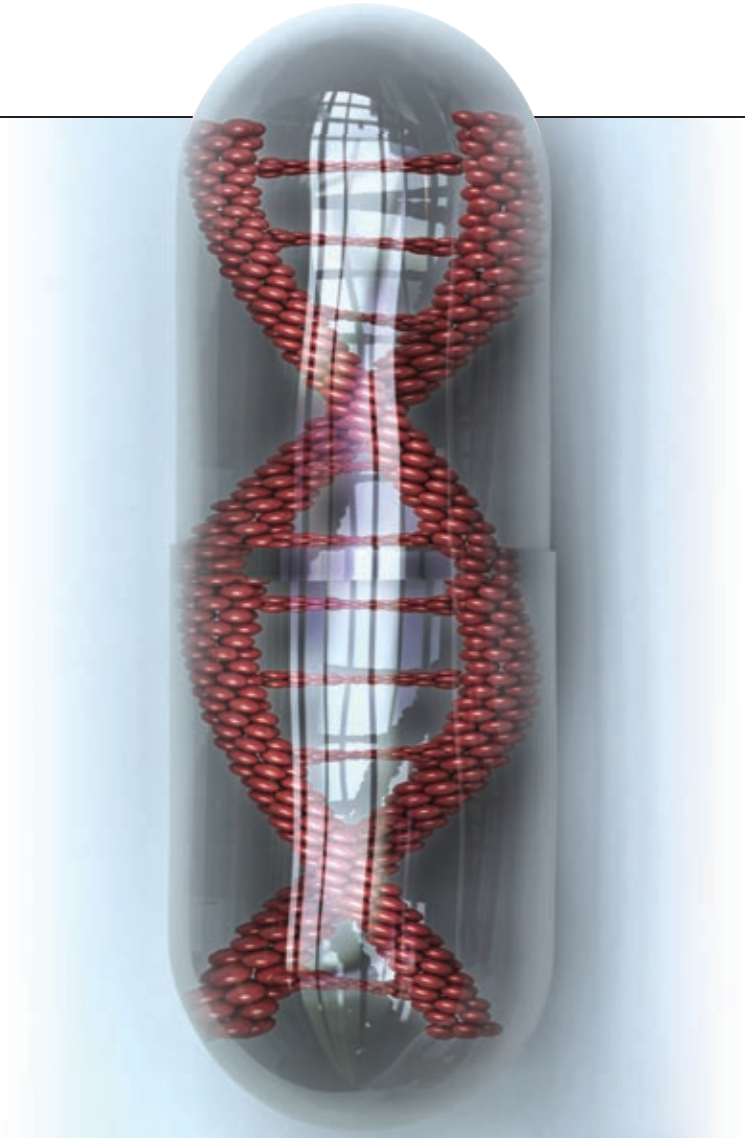

>> MEDICINE

Gene Target Beats Oil Remedy

Therapy shows promise in a deadly degenerative brain disease

The 1992 tearjerker *Lorenzo's Oil* told the true story of one family's struggle to save their son from X-linked adrenoleukodystrophy (ALD), a deadly degenerative brain disease. Unfortunately, over the ensuing years, the oil of the film's title, a dietary supplement, has not panned out as the cure many people hoped it would be. Now a paper in the November 2009 issue of *Science* suggests that the long-sought cure may come from gene therapy—a famously hyped approach to treatment that tragically caused the death of a teenage experimental subject in 1999.

Since then, however, researchers have continued to cautiously pursue gene therapy for certain disorders with known genetic origins. ALD, for instance, is caused by mutations in a gene called *ABCD1,* leading to unusually high levels of a type of fatty acid that damages the material insulating some neurons. It affects about one in 20,000 six- to eight-year-old boys, leading to death before adolescence. The main treatment is still bone marrow transplantation: a risky procedure that relies on finding a suitable donor, explains Patrick Aubourg, a neurologist at France's INSERM research institute.

Now Aubourg and his team have showed in a preliminary trial that gene therapy stopped ALD in two boys for whom they could not find matching bone marrow donors. After fishing stem cells from each individual's own blood, the researchers inserted a normal version of the *ABCD1* gene into some of the cells and transplanted them back into the kids.

The results were promising: ALD progression halted within 14 to 16 months. A year later neither child had further brain damage or leukemia (a side effect in some past gene therapy trials). The researchers have now treated a third individual and are preparing for larger trials in Europe and the U.S. —*Andrea Anderson*

AGE FOTOSTOCK

>> LANGUAGE

Chimps Talk with Their Hands

Right-handed gesturing in apes hints at the origins of human language

The origins of language have long been a mystery, but mounting evidence hints that our unique linguistic abilities could have evolved from gestural communication in our ancestors. Such gesturing may also explain why most people are right-handed.

Researchers at the Yerkes National Primate Research Center recently examined captive chimpanzees and found that most of them predominantly used their right hand when communicating with one another—for example, when greeting another chimp by extending an arm. The animals did not show this hand preference for noncommunicative actions, such as wiping their noses. Such lateralized hand use suggests that chimpanzees have a system in their left brain hemisphere that is coupled to the production of communicative gestures, says study author William Hopkins. The same cerebral hemisphere is host to most language functions in humans, which hints that an ancestral gestural system could have been the precursor for language, he says.

That notion is supported by previous studies that have shown anatomical asymmetries in chimpanzees' brains in areas that are considered to be homologues of human language centers, such as Broca's area, Hopkins says. "Chimps that gesture with their right hand typically have a larger left Broca's area, and those that don't show a [hand] bias typically don't show any asymmetry in the brain," he notes.

The idea that language emerged from an ancestral gestural system located in the left brain hemisphere could explain why the vast majority of people are right-handed, Hopkins says. If gesturing was strongly selected for in human evolution, then the fact that most people are right-handed is a consequence of that. This hypothesis challenges the long-held view that the opposite scenario is true: that right-handedness emerged for motor skills such as tool use and that communication built on the developed asymmetry in the motor system later.

—Nicole Branan

>> PERCEPTION

Monkeys Get the Creeps, Too

Like humans, animals do not care for realistic animations of themselves

The flop of the 2004 animated film *The Polar Express* is largely blamed on the "creepy" feeling people get when they look at very realistic-looking robots or human animations. These too real facsimiles fall into the so-called uncanny valley, between acceptably fake-looking human representations and real, healthy humans. Psychologists have long wondered whether this aversion has an evolutionary basis, and new research on macaques suggests that it does.

Princeton University researchers presented images of real monkey faces, unrealistic animated faces and realistic animated faces to five monkey subjects and recorded how long they gazed at each. Similar to the human response to objects in the uncanny valley, the monkeys avoided looking at the most realistic animated faces. The scientists, who published their results in the *Proceedings of the National Academy of Sciences USA,* speculate that realistic animations might resemble sickly or diseased animals because they lack subtle cues of health such as normal skin texture and hue—and that an aversion to such sights may have evolved to keep us healthy. *—Melinda Wenner*

>> SEX

A Female Viagra?

Women with low libido get a boost from a new drug

Women who suffer from chronically low levels of sexual desire may soon be able to fix the problem with a pill. In a review of three recent clinical trials, scientists determined that after 24 weeks of treatment with the drug flibanserin, women reported significantly more sexual desire and an increase in satisfactory sexual encounters. The drug was initially developed as an antidepressant, and although it failed to alter mood in trials, researchers noticed it seemed to be helping women with low sex drives. How the drug works is not yet entirely clear, but it is known to alter the levels of serotonin in the brain. Although more trials are needed before flibanserin could become available commercially, it shows promise as the first drug demonstrated to treat low libido in women—the most common sexual problem in females—by targeting the brain. *—Emily Anthes*

DORLING KINDERSLEY/GETTY IMAGES (*chimp*); CASTLE ROCK/SHANGRI-LA ENTERTAINMENT/THE KOBAL COLLECTION (The Polar Express); AGE FOTOSTOCK (*pill on tongue*)

>> DRUGS

Are Antidepressants Safe for Pregnant Women?

Recent research shows a risk to fetuses and infants

GETTY IMAGES

Americans take more antidepressants than they do any other type of prescription drug, and pregnant women are no exception. One out of every eight pregnant women in the U.S. takes selective serotonin reuptake inhibitors (SSRIs) to treat depression or other mood disorders. A handful of recent studies suggest that these drugs could have adverse effects on infant health: they may increase the risk for rare heart defects, premature delivery, low birth weight and withdrawal symptoms. Nevertheless, some doctors argue that the benefits these drugs provide still outweigh the potential risks.

Worries over the use of SSRIs during pregnancy first surfaced in journal articles published in the 1980s, but it was not until 2005 that the U.S. Food and Drug Administration conceded that babies born of mothers who take paroxetine (sold as Paxil and Seroxa) during their first trimester are up to twice as likely to exhibit fetal heart defects. A 2005 study published in the *Lancet* also found that some newborns born of mothers taking paroxetine suffer from withdrawal symptoms such as convulsions and abnormal crying for several days.

More recently, pregnancy risks associated with other SSRIs have also come to light. A study published in the September 26 issue of the *British Medical Journal* monitored nearly 500,000 Danish children from nationwide registries and found that women who take sertraline (Zoloft), citalopram (Celexa) and fluoxetine (Prozac) are more likely to give birth to babies with heart defects, although the overall risk is still quite low. A study in press in the *Journal of Clinical Psychopharmacology* notes that women treated with SSRIs during late pregnancy are more likely to give birth to small and premature babies. A study published in the October 2009 *Archives of Pediatric and Adolescent Medicine* suggests that women taking SSRIs are twice as likely to have preterm births as compared with the general population and that their babies are more likely to spend time in the neonatal intensive care unit.

So should women stop taking SSRIs when they are pregnant? Not necessarily, says Emilio Sanz, a clinical pharmacologist at the University of La Laguna in Tenerife, Canary Islands, and co-author of the 2005 *Lancet* study. He notes that untreated depression increases the risk of prematurity, low birth weight and neonatal complications, too. Sengwee Darren Toh, an epidemiologist at the Harvard School of Public Health, points out that these similar outcomes make it "quite difficult to tease out effects of the drugs from those of underlying depression."

Sanz and Toh point out, however, that many women who take SSRIs have not been diagnosed with clinical depression—some take the drugs for obsessive-compulsive disorder, pain management or even severe premenstrual symptoms. For these kinds of conditions, there may be other, potentially safer options. For instance, in September 2009 a report from the American Psychiatric Association and the American College of Obstetricians and Gynecologists argued that psychotherapy is a suitable treatment for some pregnant women suffering from mild forms of depression or other mood disorders. Doctors have to "distinguish between real depression and just blues, sadness, feeling down," Sanz says. —*Melinda Wenner*

>> TECHNOLOGY

Divining the Right Drug

A new device may take the guesswork out of prescribing an antidepressant that works

OSCAR BURRIEL *Photo Researchers, Inc. (person);* GETTY IMAGES *(EEG line)*

Imagine suffering from the crushing weight of major depression, then finally getting diagnosed and starting treatment with a drug—only to realize after two months that the medication, despite its unpleasant side effects, is not alleviating your depression. Unfortunately, this experience is far from rare: more than two thirds of patients with depression have no luck with the first medication they are prescribed and must also endure the withdrawal effects that come with discontinuing a drug before trying a new one. Finding the right treatment can prove a lengthy, painful process of trial and error. A new technology, however, may bypass this ordeal by gauging very early in a treatment regimen how well a drug is working based on the patient's brain waves.

The technology, called quantitative electroencephalography (QEEG), measures a person's brain-wave pattern with EEG and then compares it with a database of normal samples to detect abnormal function. In a study published in the September 2009 issue of the journal *Psychiatry Research,* scientists used QEEG to record brain activity in subjects with major depressive disorder before they began treatment, after one week on an antidepressant and after eight weeks on the drug—the period it takes such drugs to achieve full effect. Changes in the QEEG readout after just one week of medication predicted 74 percent of the time whether patients would experience either a recovery or a remission of symptoms by the end of eight weeks.

"There appear to be changes in brain electrical activity that occur as early as a week, when the patient isn't feeling any different," says Andrew Leuchter, a psychiatrist at the University of California, Los Angeles, and lead author of the study. The result "proved [this QEEG-based technique] was in the range of something that could be useful to patients," he states.

Further research is needed to verify the technique's promise, so Leuchter estimates it may be several years before QEEG can be used in the clinic. Still, the technique presents a much needed way to judge a drug's efficacy, says psychologist D. Corydon Hammond, a professor at the University of Utah School of Medicine, who was not involved in the study. "Psychiatry has been in drastic need of more scientific and objective methods for medication selection for years," Hammond says. He praised the study as "important" and added, "Many more like it are needed and with other conditions besides depression." —*Allison Bond*

>> ATTENTION

Accentuating the Negative

Our brain responds more strongly to negative emotional cues than to positive ones

Consider the following statements: "War continues." "No sign of peace." Does our brain treat these two sentences differently, despite their identical meaning? A new study suggests it does. British researchers showed that we are better at detecting words that carry negative meaning than those that are positive. Volunteers were exposed to a word for a fraction of a second—too short a time to consciously read the word—and then asked to guess whether the word was neutral or had emotional content (either positive or negative). The subjects were most accurate at detecting the negative words.

The word "war" may capture our attention more quickly than "peace."

The mechanisms underlying this phenomenon are not clear, but lead author David Carmel, who is now a postdoctoral researcher at New York University, speculates that the brain might process negative stimuli faster than positive ones. A different explanation could be that information processing is equally fast for both types of information but that negative words better capture our attention, causing the processing to start earlier.

—*Nicole Branan*

>> COGNITION

How Fantasies Affect Focus

Thoughts about love or sex make the mind more creative or analytical

Fantasizing about sex gets more than just your juices flowing—it also boosts your analytical thinking skills. Daydreaming about love, on the other hand, makes you more creative, according to a study published in the November 2009 *Personality and Social Psychology Bulletin.*

Previous research suggests that our problem-solving abilities change depending on our states of mind and that love—a broad, long-term emotion—triggers global brain processing, a state in which we see the big picture, make broad associations and connect disparate ideas. Sex, on the other hand—more specific and here and now—initiates more local processing, in which the brain zooms in and focuses on details. Researchers at the University of Amsterdam, University of Groningen and Jacobs University Bremen wondered whether thinking about love might actually help people perform better on creative tasks, whereas imagining sex might prime people to do better on tasks requiring analytical thinking.

The researchers asked 30 subjects to imagine a long, loving walk with their partners and asked 30 others to think of casual sex with someone they did not love. Then they gave the subjects cognitive tests. As predicted, the love-primed ones performed much better on creative tasks and scored worse on analytical questions, whereas the reverse was true of those who thought about sex. The researchers also subliminally primed a separate group of subjects to think about love or sex and got similar results.

"I was surprised about the strength of the effects," says author Jens Förster, a social psychologist at the University of Amsterdam. The researchers wonder whether the "big picture" perspective that lovebirds share strengthens their relationship, too, by helping couples overlook personal weaknesses and daily hassles. *—Melinda Wenner*

ISTOCKPHOTO (*hearts*); BRANDI POWELL *Getty Images* (*woman*)

>> NEUROSCIENCE

Abuse and Attachment

A stifled fear response may explain why young victims stand by their abusers

The scenario is all too common—children who are abused develop an attachment to their abuser that interferes with their desire to seek help or leave the situation. Experts have struggled to understand this seemingly destructive behavior, but the underlying causes have remained hidden. Now new research from scientists who study attachment in rats offers insight into what may be happening in abused children's brains.

Rats are especially responsive to smells during infancy, which may help foster the parental bond. Psychologist Regina M. Sullivan of New York University showed in 2000 that young rats are drawn to almost any odor, even when the odor is associated with a stressful stimulus, such as a mild heat shock. In other words, baby rats are attracted to the very thing that hurts them, rather than being repelled as older rats would be.

What is happening in the young rats' brains to foster attachment instead of aversion or fear? In a new paper in *Nature Neuroscience,* Sullivan and Gordon Barr, a psychologist at the Children's Hospital of Philadelphia, found the answer in the rats' amygdala, a brain region associated with anxiety and fear. In the amygdala of rats attracted to the aversive odors, there were lower than normal levels of the neurotransmitter dopamine. This lack of dopamine activity may have turned off their brain's fear response, enabling attraction to take place instead. A similar mechanism may occur in abused children, Sullivan says, although how much the amygdala is involved with early human attachment is unclear. Barr suggests this behavior probably evolved as a survival tactic. "The animal has to be able to survive, which means it has to be attached to its caregiver no matter what the quality of care," he says. *—Erica Westly*

JUPITERIMAGES

LEARNING

Multimedia Memory Boost

A video before bed or a recording played while asleep can enhance learning

CAL CRARY Getty Images (sleeping woman); LUCIDIO STUDIO, INC. Getty Images (hand at chalkboard)

Listen and Learn

Learning by listening to information as we sleep has long been a mainstay of science fiction—and wishful thinking—but a new study suggests the idea may not be so farfetched. What we hear during deep sleep can strengthen memories of information learned while awake.

Researchers at Northwestern University taught 12 subjects to associate 50 images with specific positions on a computer screen. When the subjects saw each image, they also heard a matching noise—for instance, on seeing a cat, they heard a meow. Then the subjects each took a 60- to 80-minute nap. While they were in slow-wave sleep (a deep-sleep phase marked by slow electrical oscillations in the brain), the researchers played the noises that matched 25 of the images they had been studying. On waking, the subjects were asked to perform the same image-matching task. They were much better at correctly placing the images for which they had heard the noise cues while they napped. The participants reported they had no idea sounds had been played during their naps, and when asked to guess which sound cues they heard, they were just as likely to pick the wrong ones as the right ones.

"We were certainly surprised," says co-author Ken Paller, director of the Cognitive Neuroscience Program at Northwestern, explaining that he did not expect such strong results. Although previous research has suggested that sleep alone can help consolidate memories, this study is the first to show that sound cues can strengthen specific spatial memories. Paller and his colleagues will next explore how long these effects last and whether aural cues can strengthen other types of memories as well. Until then, go ahead and play those French tapes while you snooze—it couldn't hurt. *—Melinda Wenner*

A Movie and a Nap

Practice makes perfect, but can simply watching help, too? Yes, if you sleep on it right away, reports a study from the Netherlands Institute for Neuroscience. Ysbrand Van der Werf and his colleagues tracked how well people learned to tap their fingers in a specific sequence—without any practice. Watching a video of the finger-tapping task led to faster and more accurate first attempts at the target sequence only when study participants slept within 12 hours of the video, before being tested. The finding not only points to a promising way to augment practicing when learning a new physical skill, it could also help people regain skills after injuries such as stroke. *—Michele Solis*

For more on learning techniques, see the Special Section beginning on page 32.

>> EMOTIONS

Be Sad and Succeed

People in a bad mood have better judgment and pay more attention to details

Next time you find yourself in a bad mood, don't try to put on a happy face—instead tackle a project that has been stymieing you. Melancholy might just help you hit peak performance, reports Joseph Forgas, a professor of psychology at the University of New South Wales, in the journal *Australasian Science.* Forgas reviewed several of his studies in which researchers induced either a good or bad mood in volunteers. Each study found that people in a bad mood performed tasks better than those in a good mood. Grumpy people paid closer attention to details, showed less gullibility, were less prone to errors of judgment and formed higher-quality, persuasive arguments than their happy counterparts. One study even supports the notion that those who show signs of either fear, anger, disgust or sadness—the four basic negative emotions—achieve stronger eyewitness recall while virtually eliminating the effect of misinformation. [For more on how a negative mood boosts cognition, see "Depression's Evolutionary Roots," by Paul W. Andrews and J. Anderson Thomson; SCIENTIFIC AMERICAN MIND, January/February 2010.]

—Elizabeth King Humphrey

>> PSYCHOLOGY

Accents Trump Skin Color

Kids prefer friends whose speech sounds similar to their own, regardless of race

Children, like adults, use three visible cues—race, gender and age—to arrange their social world. They prefer to make friends with kids similar to them on these traits. New research shows that verbal accents may be equally important in guiding youngsters' social decisions—in fact, accents may be even more important than race.

Working at Harvard University, developmental psychologist Katherine D. Kinzler and her colleagues first showed American five-year-olds photographs of different children paired with audio clips of voices and asked which ones they preferred as a friend: a child who spoke English, one who spoke French, or one who spoke English with a French accent. Even though the subjects understood the French-accented English, they were almost four times more likely to choose the native English speaker as a friend.

Going one step further, Kinzler and her team showed that an accent is more meaningful than race in signifying whether someone belongs in your social group. Replicating previous research, they found that under silent conditions children chose as potential friends children of the same race. Yet when the potential friends spoke, white children preferred a black child speaking with a native accent over a white child who spoke English with a foreign accent.

Why was accent more important than race? "Race, as a psychological category, may be relatively modern in terms of human evolution," explains Kinzler, now at the University of Chicago. In prehistoric times, "a neighboring group might have sounded different even if they did not look different," she says. Preference for our own race might have developed later, after the more ancient preference for our own accent. The next step is to see whether living in bilingual or multilingual countries might change this early inclination.

—Agata Gluszek

AMANAIMAGES/CORBIS (*man at laptop*); GETTY IMAGES (*children*)

>> IMAGING

Belief in the Brain

Sacred and secular ideas engage identical areas

Religious belief may seem to be a unique psychological experience, but a growing body of research shows that thinking about religion is no different from thinking about secular things—at least from the standpoint of the brain. In the first imaging study to compare religious and nonreligious thoughts, evaluating the truth of either type of statement was found to involve the same regions of the brain.

Researchers at the University of California, Los Angeles, used functional MRI to evaluate brain activity in 15 devout Christians and 15 nonbelievers as the volunteers assessed the truth or falsity of a series of statements, some of which were religious ("angels exist") and others nonreligious ("Alexander the Great was a very famous military ruler"). They found that when a subject believed a statement—whether it was religious or not—activity appeared in an area called the ventromedial prefrontal cortex, which is an area associated with emotions, rewards and self-representation.

And although the nonbelievers rejected about half of the statements the believers accepted, the brain scans of both groups were indistinguishable, providing further proof that evaluating truth or falsity is independent of the content of the statement in question. "The fact that we found the same brain processing between believers and nonbelievers, despite the two groups' completely different answers to the questions [about religion], is pretty surprising," says Jonas Kaplan, a research psychologist at U.C.L.A. and co-author of the study. The finding adds to the mounting evidence against the notion, popular in the scientific community as well as among the general public, that religious faith is somehow different from other types of belief, explains co-author Sam Harris, also of U.C.L.A. In contrast to this assumption, he says, "Believing the sun is a star is rather the same as believing Jesus was born of a virgin." [For more on the neuroscience of religion, see "Searching for God in the Brain," by David Biello; SCIENTIFIC AMERICAN MIND, October/November 2007.]

—Allison Bond

Alexander the Great or an angel: Believing in either's existence is the same in the brain.

ERICH LESSING (*left*) AND ALINARI (*right*) *Art Resource, NY*

>> BEHAVIOR

Why We Return to Bad Habits

A common mental miscalculation causes us to overestimate our self-control

AGE FOTOSTOCK

If you have ever lost weight on a diet only to gain it all back, you were probably as perplexed as you were disappointed. You felt certain that you had conquered bad eating habits—so what caused the backslide? New research suggests that you may have succumbed to a cognitive distortion called restraint bias. Bolstered by an inflated sense of impulse control, we overexpose ourselves to temptation and fall prey to impulsiveness.

Northwestern University psychologists first asked a group of smokers to take a self-control test. Unknown to the participants, the test was a pretense to randomly label half the group as having high self-control and half as having low self-control. After hearing their supposed result, participants played a game that involved watching the 2003 movie *Coffee and Cigarettes* while challenging themselves with one of four levels of temptation, each with its own cash reward. They could keep a cigarette unlit in their mouths (for the most money), unlit in their hand, on a nearby desk or (for the lowest reward) in another room. Participants earned a prize only if they avoided smoking for the entire 95-minute film.

Smokers told that they had high self-control exposed themselves to significantly more temptation than their counterparts—opting on average to watch the movie while holding a cigarette—and they failed to resist lighting up three times as often as those told they had low self-control.

"Restraint bias offers insight into how our erroneous beliefs about self-restraint promote impulsive behavior," says lead author Loran F. Nordgren of Northwestern's Kellogg School of Management. "It helps us to understand puzzles in addiction research such as why recovered addicts often relapse after they have broken free of withdrawal symptoms." The lesson? When you've made progress avoiding your indulgences and that little voice in your head tells you it's okay to start exposing yourself to temptation again—ignore it.

—David DiSalvo

Bright Horizons™ 8

W. MEDITERRANEAN

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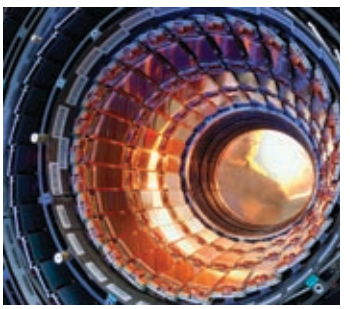
SCIENTIFIC AMERICAN TRAVEL



PARTICLE PHYSICS

Speaker: **James Gillies, Ph.D.**

Particle Physics: Using Small Particles to Answer The Big Questions — Particle physics is the study of the smallest indivisible pieces of matter — and the forces that act between them. Join Dr. Gillies and catch up on the state of the art and challenges ahead as physicists continue a journey that started with Newton's description of gravity. We'll look at the masses of fundamental particles, dark matter, antimatter, and the nature of matter at the beginning time.

The Large Hadron Collider: the World's Most Complex Machine — The LHC is a machine of superlatives — a triumph of human ingenuity, possibly the most complex machine ever built. James Gillies traces particle physics technologies from the invention of particle accelerators in the 1920s to today, and then focuses on the LHC itself. You'll get a perspective on how these tools have allowed us to make phenomenal progress in understanding the Universe, and how they have revolutionized our everyday lives.

Angels, Demons, Black Holes, and Other Myths: Demystifying the LHC — Along with humankind's natural curiosity comes a fear of the unknown. As LHC's first beam day approached in 2008, a handful of self-proclaimed experts struck up an end-of-the-world tune — and the whole world knew they were there. Like its predecessors, the Large Electron-Positron Collider (LEP) and Relativistic Heavy Ion Collider (RHIC), the LHC never posed the slightest risk to humanity. However, the dangerous scientist has always made for a good story and that's something that Dan Brown exploited to the full when writing Angels and Demons. Dr. Gillies will cover the fact behind the fiction of Angels and Demons and black holes at the LHC, and share the behind-the-scenes on how CERN lived with the hype.

THE AMAZING BRAIN

Speaker: Jeanette J. Norden, Ph.D.

General Organization of the Central Nervous System — We begin with an introduction on how the central nervous system is divided into structural and functional areas. This knowledge will allow us to understand why after a stroke an individual might be blind, but not know it; why an individual might lose the ability to speak, but not to understand language; why an individual might be able to describe his wife's face, but not be able to pick her out from a crowd.

Cellular and Molecular Organization of the Central Nervous System — In this session we will focus on the structure of individual neurons and on how neurons in the central nervous system are believed to be connected to each other by an estimated 100 trillion synapses. This understanding of the structure of individual neurons and on how neurons communicate with each other allows us to have insight into disorders as diverse as depression and multiple sclerosis.

Parkinson's Disease and Other Disorders of the Motor System — Movement is a complex behavior controlled by a number of different subsystems in the brain and spinal cord. Knowing what each of these subsystems do to allow us to move will provide the knowledge necessary to understand the loss of normal motor movement in Parkinson's disease, spinal cord injury, and other disorders of the motor system.

Alzheimer's Disease — Alzheimer's disease is the most common neurodegenerative disease in the United States. We will explore what is currently known about this devastating disorder, and about the specific areas of the brain which are affected. Next we discuss the risk factors associated with Alzheimer's disease. Finally, we will end this lecture series with a discussion of what you can do to decrease your risk of getting this disease and on how to keep your brain healthy!

CST# 2065380-40

ASTRONOMY

Speaker: **Steven Dick, Ph.D.**

Life on Other Worlds — It's a unique time in human history as we explore for life beyond Earth. Where do we stand in the search for life, both inside the solar system and beyond? And what would be the impact of the discovery of extraterrestrial intelligence on our society? Dr. Dick's answers will beget more questions — get in on the discussion!

A Tour of the Universe: Astronomy's Three Kingdoms — Our view of the universe has evolved over the last century, from a static anthropocentric cosmos a few thousand light years across to a dynamically evolving universe spanning billions of light years. We've discovered cosmic objects like pulsars, quasars, and black holes. Travel with Dr. Dick through billions of light years of space and time as we explore the discovery and classification of objects in astronomy's three kingdoms: the planets, the stars, and the galaxies.

Exploration, Discovery, and Culture: The Importance of the Space Age — Fifty years into the Space Age and 40 years after the Apollo program put 12 men on the Moon, exploration is at a turning point. Should humans return to the Moon and go to Mars? Are robotic emissaries enough? What motivates spaceflight? Should we spend money on space with so many problems on Earth? Join Dr. Dick in contemplation of the importance of exploration to culture.

Cosmic Evolution and Human Destiny — We now see the universe in the context of 13.7 billion years of cosmic evolution. What are the implications of this understanding of space and time in the short and long term? How does it affect our religions and philosophies? What is the long-term destiny of humans? Join us in a journey through science fiction, science fact, and scientific extrapolation as we ponder human destiny in a new context.

MAGNETS

Speaker: **Michael Coey, Ph.D.**

What the Ancients Knew — The mysterious behavior of lodestones — rocks naturally magnetized by lightning strikes — and their strange love for iron was known in ancient China, Greece, Sumer, and Mesoamerica. The directional property was used first for geomancy and then, a millennium later, for navigation. The great voyages of discovery of Africa by the Chinese and America by the Europeans all depended on the compass. The ancients dreamt of levitation and perpetual motion. So do we.

Science Rules the Earth: OK? — Robustly polemical, but insistently evidence-based, William Gilbert's De Magnete (c. 1600) was the first modern scientific text. His insight that the Earth was a great magnet and insistence that data trumps speculation led to the heroic magnetic crusade of the 1830s, an understanding of how the Earth moves by plate tectonics, sunspots, and a way to date pottery. Join Dr. Coey and learn how science trumped charlatans with the truth and predictive power of their "magic".

The End of an Aether — The modern world began in 1820, when Hans-Christian Oersted stumbled on the connection between electricity and magnetism. The news spread like wildfire across Europe as electromagnetism spawned motors and generators, electric trains and mains power, telegraphs, radio and magnetic recording — all before 1900. If Maxwell's equations were the greatest intellectual achievement of the century, the origin of magnetism was one of its greatest puzzles — a puzzle that could only be understood with relativity, quantum mechanics, and Dirac's electrons with spin.

Billions of Magnets for Billions of People: How and Why — When the magnet shape barrier was shattered in 1950, the technology that serves our modern lives could emerge. Tune in and learn about the small, powerful rare-earth magnets that power countless gadgets and one of the greatest modern scientific miracles — magnetic recording. Why and how have magnets have multiplied a billion-fold? Is it true that today we now make more magnets than we grow grains of rice? Dr. Coey will give you the answers to these questions, plus those to questions you hadn't even pondered.

SCIENTIFIC AMERICAN TRAVEL

Cruise prices vary from $969 for an Inside Stateroom to $2,829 for a Full Suite, per person. For those attending our program, there is a $1,375 fee. Government taxes, port fees, and InSight Cruises' service charge are $270 per person. For more info **contact Neil at 650-787-5665 or neil@InSightCruises.com**

Private, Insider's Tour of CERN

October 26, 10am–4pm — From the tiniest constituents of matter to the immensity of the cosmos, discover the wonders of science and technology at CERN. Join Bright Horizons for a private pre-cruise, custom, full-day tour of this iconic facility.

Whether you lean toward concept or application there's much to pique your curiosity. Discover the excitement of fundamental research and get a behind-the-scenes, insider's look of the world's largest particle physics laboratory.

This trip is limited to 50 people. For questions and hotel pricing, please contact Neil or Theresa, or give us a call at (650) 787-5667.

Our full day will be led by a CERN official and physicist. We'll have an orientation; visit an accelerator and experiment; get a sense of the mechanics of the large hadron collider (LHC); make a refueling stop for lunch in the Globe of Science and Innovation; and have time to peruse exhibits and media on the history of CERN and the nature of its work.

To take advantage of this unrivaled insider access to CERN, rendezvous on October 26, 2010 in Geneva, Switzerland. The price is $175 and includes

- Entrance to CERN
- Lunch at CERN
- A round-trip transfer from our Geneva hotel to CERN
- And then the following day, October 27, the transfer from our hotel to Genoa, Italy.

RIBOSOMES

Speaker: **Ada Yonath, Ph.D.** (2009 Nobel Laureate)

Introduction to Ribosomes and Their Influence on Life Processes — Proteins are vitally important to just about every imaginable aspect of living. They form the body's structures and are involved in all of life's processes in all living organisms. You'll earn the basics of these cellular nanomachines' function from translating the genomic amino acid sequences to protein folding. You'll also learn about the function of ribosomes in animal hibernation and the implications for human health.

Evolution and the Role of Ribosomes One Billion Years Ago — Ribosomes function almost identically in all living cells, and consequently they don't differ much between species. Careful analysis has revealed — deep within contemporary ribosomes — a region that appears be a remnant from the earliest days of life on Earth, even before protein biosynthesis. Current studies of this ancient vestige have shed light on feasible life-advancement pathways and are having an impact on our understanding of the earliest days of evolution.

Ribosome Architecture — The striking architecture of the ribosome is ingeniously composed as the framework for its unique capabilities: precise gene decoding; peptide bond formation; and polymerase activity. Adding together architectural, biochemical, kinetic, and genetic findings about this "protein factory", it now appears that the ribosome's flexibility not only relates to protein synthesis, but may also be connected to communication between the ribosome and cellular components. Dr. Yonath will brief you on the cutting edge of ribosomal science and the unfolding implications for cellular regulation, infectious disease, and cancers.

Antibiotics and Ribosomes — Get a behind-the-scenes look at the David-versus-Goliath world of ribosome-related antibiotics with Dr. Yonath, from how they work and what works in specific sorts of bacteria, to what makes bacteria susceptible and how bacteria become resistant to antibiotics. Add this vital information to your store of knowledge for understanding current public healthcare issues and medical decision making.

The Ethical Dog

Looking for the roots of human morality in the animal kingdom? Focus on canines, who know how to play fair

BY MARC BEKOFF AND JESSICA PIERCE

This dog is in a "play bow," indicating his desire to romp. Honest communication is a central tenet of canine society.

CORBIS

EVERY DOG OWNER knows a pooch can learn the house rules—and when she breaks one, her subsequent groveling is usually ingratiating enough to ensure quick forgiveness. But few people have stopped to ask why dogs have such a keen sense of right and wrong. Chimpanzees and other nonhuman primates regularly make the news when researchers, logically looking to our closest relatives for traits similar to our own, uncover evidence of their instinct for fairness. But our work has suggested that wild canine societies may be even better analogues for early hominid groups—and when we study dogs, wolves and coyotes, we discover behaviors that hint at the roots of human morality.

Morality, as we define it in our book *Wild Justice*, is a suite of interrelated other-regarding behaviors that cultivate and regulate social interactions. These behaviors, including altruism, tolerance, forgiveness, reciprocity and fairness, are readily evident in the egalitarian way wolves and coyotes play with one another. Canids (animals in the dog family) follow a strict code of conduct when they play, which teaches pups the rules of social engagement that allow their societies to succeed. Play also builds trusting relationships among pack members, which enables divisions of labor, dominance hierarchies and cooperation in hunting, raising young, and defending food and territory. Because this social organization closely resembles that of early humans (as anthropologists and other experts believe it existed), studying canid play may offer a glimpse of the moral code that allowed our ancestral societies to grow and flourish.

Playing by the Rules

When canids and other animals play, they use actions such as vigorous biting, mounting and body slamming that could be easily misinterpreted by the participants. Years of painstaking video analyses by one of us (Bekoff) and his students show, however, that individuals carefully negotiate play, following four general rules to prevent play from escalating into fighting.

Communicate clearly. Animals announce that they want to play and not fight or mate. Canids use a bow to solicit play, crouching on their forelimbs while standing on their hind legs (*above*). Bows are used almost exclusively during play and are highly stereotyped—that is, they always look the same—so the message "Come play with me" or "I still want to play" is clear. Even when an individual follows a play bow with seem-

ingly aggressive actions such as baring teeth, growling or biting, his companions demonstrate submission or avoidance only around 15 percent of the time, which suggests they trust the bow's message that whatever follows is meant in fun. Trust in one another's honest communication is vital for a smoothly functioning social group.

Mind your manners. Animals consider their play partners' abilities and engage in self-handicapping and role reversing to create and maintain equal footing. For instance, a coyote might not bite her play partner as hard as she can, handicapping herself to keep things fair. And a dominant pack member might perform a role reversal, rolling over on her back (a sign of submission that she would never offer during real aggression) to let her lower-status play partner take a turn at "winning" (*above*). Human children also behave this way when they play, for instance, taking turns overpowering each other in a mock wrestling match. [For more on childhood play, see "The Serious Need for Play," by Melinda Wenner; Scientific American Mind, February/March 2009.] By keeping things fair in this manner, every member of the group can play with every other member, building bonds that keep the group cohesive and strong.

Admit when you are wrong. Even when everyone wants to keep things fair, play can sometimes get out of hand. When an animal misbehaves or accidentally hurts his play partner, he apologizes—just like a human would. After an intense bite, a bow sends the message, "Sorry I bit you so hard—this is still play regardless of what I just did. Don't leave; I'll play fair." For play to continue, the other individual must forgive the wrongdoing. And forgiveness is almost always offered; understanding and tolerance are abundant during play as well as in daily pack life.

Be honest. An apology, like an invitation to play, must be sincere—individuals who continue to play unfairly or send dishonest signals will quickly find themselves ostracized. This has far greater consequences than simply reduced playtime; for instance, Bekoff's long-term field research shows that juvenile coyotes who do not play fair often end up leaving their pack and are up to four times more likely to die than those individuals who remain with others. Violating social norms, established during play, is not good for perpetuating one's genes.

Fair play, then, can be understood as an evolved adaptation that allows individuals to form and maintain social bonds. Canids, like humans, form intricate networks of social relationships and live by rules of conduct that maintain a stable society, which is necessary to ensure the survival of each individual. Basic rules of fairness guide social play, and similar rules are the foundation for fairness among adults. This moral intelligence, so evident in both wild canines and in domesticated dogs, probably closely resembles that of our early human ancestors. And it may have been just this sense of right and wrong that allowed human societies to flourish and spread across the world. M

Adult wolves rein in their strength when playing with pups, keeping the game fun and fair for everyone.

TIM FITZHARRIS *Minden Pictures*

When an animal misbehaves or accidentally hurts his play partner, he apologizes—**just like a human would**.

MARC BEKOFF is professor emeritus of ecology and evolutionary biology at the University of Colorado at Boulder and a scholar in residence at the Institute for Human-Animal Connection at the University of Denver. JESSICA PIERCE is an ethicist and associate faculty at the University of Colorado Health Sciences Center at the Center for Bioethics and Humanities.

(Further Reading)

- **Play Signals as Punctuation: The Structure of Social Play in Canids.** Marc Bekoff in *Behaviour,* Vol. 132, pages 419–429; May 1995.
- **Animals at Play: Rules of the Game.** Marc Bekoff. Temple University Press, 2008.
- **Wild Justice: The Moral Lives of Animals.** Marc Bekoff and Jessica Pierce. University of Chicago Press, 2009.

Playing the Body Electric

A combination of genetics and optics gives brain scientists an unprecedented ability to dissect the circuits of the mind

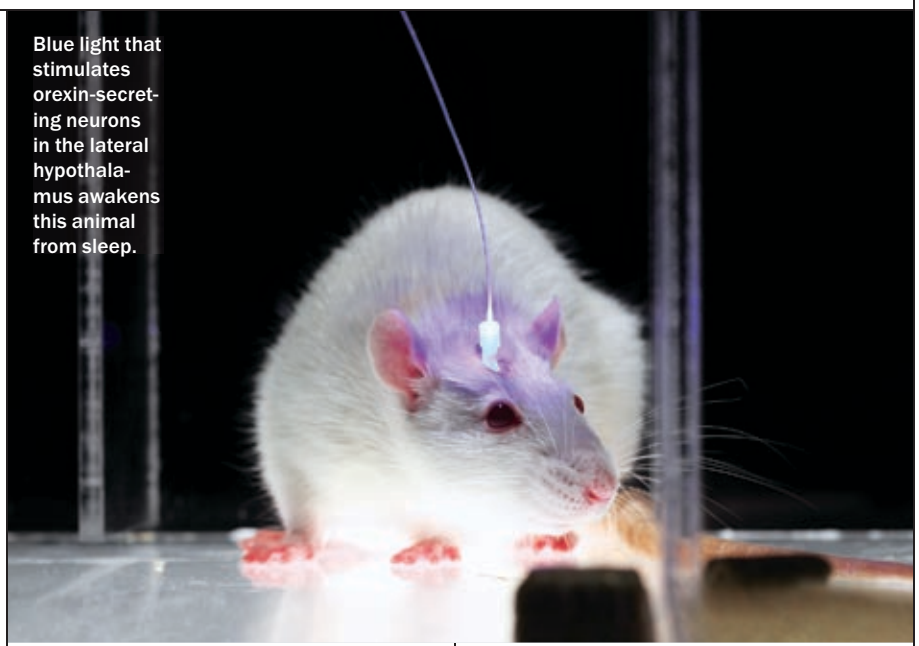
BY CHRISTOF KOCH

EACH NEW GENERATION of astronomers discovers that the universe is much bigger than their predecessors imagined. The same is also true of brain complexity. Every era's most advanced technologies, when applied to the study of the brain, keep uncovering more layers of nested complexity, like a set of never ending Russian dolls. We now know that there are up to 1,000 different subtypes of nerve cells and supporting actors—the glia and astrocytes—within the nervous system. Each cell type is defined by its chemical constituents, neuronal morphology, synaptic architecture and input-output processing.

Different cell types are wired up in specific ways. For example, a deep layer 5 pyramidal neuron might snake its gossamer-thin output wire, the axon, to a subcortical target area while also extending a connection to an inhibitory local neuron. Understanding how the brain's corticothalamic complex creates any one conscious sensation necessitates delineating these underlying circuits for the 100 billion cells in the brain.

Bulk tissue technologies such as functional brain imaging or electroencephalography identify specific brain regions related to vision, pain or memory. Yet they are unable to resolve details at the all-important circuit level. Brain imaging tracks the power consumption of a million neurons, irrespective of whether they are excitatory or inhibitory, project locally or globally, and so on. For progress on consciousness, something drastically more refined is needed.

Furthermore, as our understanding of the brain grows, our desire to intervene, to help ameliorate the many pathologies to which the mind is prey, grows commensurately. Yet today's tools (drugs and deep-brain stimulations) are comparatively crude, with undesirable side effects.



Blue light that stimulates orexin-secreting neurons in the lateral hypothalamus awakens this animal from sleep.

JOHN B. CARNETT *Popular Science Magazine*

To the rescue rides an amazing technology, a fusion of molecular biology with optical stimulation, dubbed optogenetics. It is based on some fundamental discoveries made by three German biophysicists—Peter Hegemann, Ernst Bamberg and Georg Nagel working on photoreceptors in ancient bacteria. These photoreceptors directly (rather than indirectly, like the ones in your eyes) convert incoming light in the blue part of the spectrum into an excitatory, positive electrical signal. The trio also isolated the gene for this protein, called channelrhodopsin-2 (ChR2). Bamberg and Nagel subsequently engaged in a fruitful collaboration with Karl Deisseroth, a professor of psychiatry and bioengineering at Stanford University, and Edward S. Boyden, now at the Massachusetts Institute of Technology.

The group took the ChR2 gene, inserted it into a small virus, and infected neurons with this virus. Many of the neurons took up the foreign instructions, synthesized ChR2 protein and inserted the photoreceptors in their membrane. In the dark, the receptors quietly sit there, with no discernible effect on their host cells. But illumination of the network with a brief flash (10 milliseconds) of blue light causes each of these bacterial photoreceptors to jolt their host cell a bit. Collectively, they reliably and repeatedly produce a spike in the membrane voltage. Spikes are the universal all-or-none pulses used by all but the tiniest nervous systems to communicate information among neurons. Each time the light is turned on, the cells spike reliably, exactly once. Thus, an entire population of neurons can be manipulated by precisely timed stabs of light.

The biophysicists added another photoreceptor to their tool kit. It derives from a different type of bacterium, one living in dry salt lakes in the Sahara Desert. Shining yellow light on it yields an inhibitory, negative signal. Through the same viral strategy, both photoreceptor types were then introduced into neurons. Once the neuron stably incorporates both types into its membrane, it can be excited by blue light and subdued by yel-

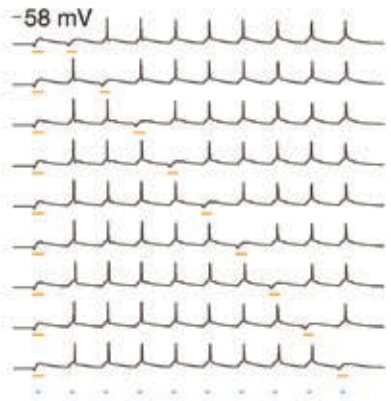
> Optogenetics allows testing of a specific hypothesis about the **neural basis of consciousness**.

low. Each blue flash evokes a spike, like a note sounding when a piano key is pushed down. But a simultaneous flash of yellow light can block that spike. Consider the "musical score sheet" recorded from one such neuron as it is played with light (*right*). This ability to precisely control electrical activity in one or more neurons is unprecedented.

But the benefits of this technology for discerning the circuits of the mind go much deeper, because the virus that carries the photoreceptor genes can also carry promoter sequences that express their payload only in neurons with the appropriate molecular address. So rather than exciting all the neurons in a particular neighborhood, it becomes feasible to focus on a subset that synthesize a particular neurotransmitter or that send their outputs to a specific place.

Deisseroth's group exploited this capability by introducing ChR2 into a subset of neurons located in the lateral hypothalamus, deep inside the mouse brain. Here about 750 cells produce orexin (also known as hypocretin), a hormone that promotes wakefulness. Mutations in the orexin receptors are associated with narcolepsy, a chronic sleep disorder. As a result of the manipulation, almost all the orexin neurons, but none of the other intermingled neurons, carried ChR2 photoreceptors. Furthermore, blue light via an optical fiber precisely and reliably generated waves of spikes in the orexin cells.

What would happen if this experiment were done in a sleeping mouse? In control animals, a couple of hundred blue flashes awakened the rodents after about one minute. When the same light was delivered to animals carrying the ChR2 gene, they woke up in half the time. That is, ghostly blue light that illuminates the catacombs of the brain and causes a tiny subset of neurons with a known identity to produce electrical spikes wakes up the animal. With additional controls, the Stanford group proved that the release of orexin from the lateral hypothalamus was what drove this behavior. This exemplary study established a compelling causal link between electrical activity in a subset of the brain's neurons and sleep-to-wake transitions.



A two-second sequence of flashes (*blue bars*) of blue light triggers electrical spikes in a nerve cell with ChR2 photoreceptors, except when a simultaneous flash of yellow (*orange bars*) inhibits the cell's activity.

A string of such beautiful, interventionist mice experiments over the past several years has revealed specific circuit elements involved in a variety of normal and pathological behaviors: depression, behavioral conditioning, Parkinson's disease and cortical oscillations critical for attention, among others. They have even helped restore sight to mice blinded by degenerating retinas. ChR2 experiments have been carried out successfully in monkeys; experimental human trials for some psychiatric illnesses are being actively considered.

The import of optogenetics for consciousness is that it allows testing of a specific hypothesis about the neural basis of consciousness. For instance, to what extent is feedback from higher cortical regions to lower regions essential? Find out by training an animal in a task that depends on conscious sensation, then inactivate those circuit elements with light and observe the animal's behavior.

Francis Crick, co-discoverer of the double helical structure of DNA, and I had hypothesized that the claustrum, a mysterious thin structure located below much of cortex, is critical for binding information across sensory modalities and making it accessible to consciousness. The challenge is to find an appropriate behavior that requires mice to combine information dynamically across modalities—say, touch and smell. Then excite or inhibit claustrum neurons while the animals execute the task to study the extent the structure is necessary for this behavior.

A judicious mix of recombinant DNA technology, protein and viral design, genomics, optical fibers, lasers and microinstrumentation will enable scientists to explore strange new theories that close the gap between the objective brain and the subjective mind, to boldly go where no one has gone before. **M**

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

(Further Reading)

- **Millisecond-Timescale, Genetically Targeted Optical Control of Neural Activity.** E. S. Boyden, F. Zhang, E. Bamberg, G. Nagel and K. Deisseroth in *Nature Neuroscience,* Vol. 8, pages 1263–1268; September 2005.
- **Multimodal Fast Optical Interrogation of Neural Circuitry.** F. Zhang, L. Wang, M. Brauner, J. F. Liewald, K. Kay, N. Watzke, P. G. Wood, E. Bamberg, G. Nagel, A. Gottschalk and K. Deisseroth in *Nature,* Vol. 446, pages 633–641; April 5, 2007.
- **Neural Substrates of Awakening Probed with Optogenetic Control of Hypocretin Neurons.** A. Adamantidis, F. Zhang, A. M. Aravanis, K. Deisseroth and L. de Lecea in *Nature,* Vol. 450, pages 420–424; November 15, 2007.

FROM "MULTIMODAL FAST OPTICAL INTERROGATION OF NEURAL CIRCUITRY," BY FENG ZHANG ET AL., IN *NATURE*, VOL. 446; APRIL 5, 2007

Aristotle's Error

Using aftereffects to probe visual function reveals how the eye and brain handle colors and contours

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

ALTHOUGH OUR PERCEPTION of the world seems effortless and instantaneous, it actually involves considerable image processing, as we have noted in many of our previous columns. Curiously enough, much of the current scientific understanding of that process is based on the study of visual illusions.

Analysis and resolution of an image into distinct features begin at the earliest stages of visual processing. This was discovered in cats and monkeys by a number of techniques, the most straightforward of which was to use tiny needles—microelectrodes—to pick up electrical signals from cells in the retina and the areas of the brain associated with vision (of which there are nearly 30). By presenting various visual targets to monitored animals, investigators learned that cells in early-processing brain areas are each sensitive mainly to changes in just one visual parameter, not to others. For instance, in the primary visual cortex (V1, also called area 17), the main feature extracted is the orientation of edges. In the area known as V4 in the temporal lobes, cells react to color (or, strictly speaking, to wavelengths of light, with different cells responding to different wavelengths). Cells in the area called MT are mainly interested in direction of movement.

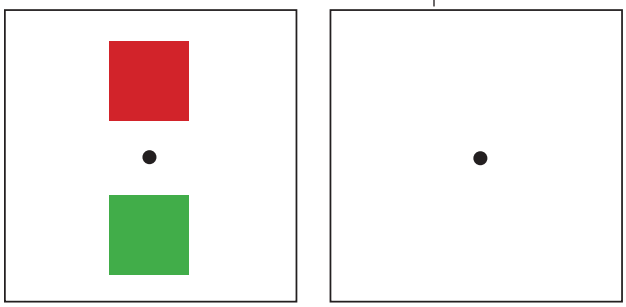
One characteristic of these cells that may seem surprising is that their activity when stimulated is not constant. A neuron that responds to red, for instance, will initially fire vigorously but taper off over time as it adapts, or "fatigues," from steady exposure. Although part of this adaptation may result from depletion of neurotransmitters, it also likely reflects the evolutionary logic that the goal of the cell is to signal change rather than a steady state (that is, if nothing changes, there is literally nothing for the cell to get excited about).

Staring at a waterfall can create an illusory aftereffect that the grass is flowing uphill.

ISTOCKPHOTO

How do we know that such cells also exist in humans? Simply put, we descended from apelike ancestors, and there is no reason why we would have lost those cells during evolution. But we can also infer the existence (and properties) of feature-detecting cells in humans from the results of psychological experiments in which the short-term viewing of one pattern very specifically alters the perception of a subsequently viewed pattern.

For example, if you watch a waterfall for a minute and then transfer your gaze to the grass on the ground below, the grass will seem to move uphill. This

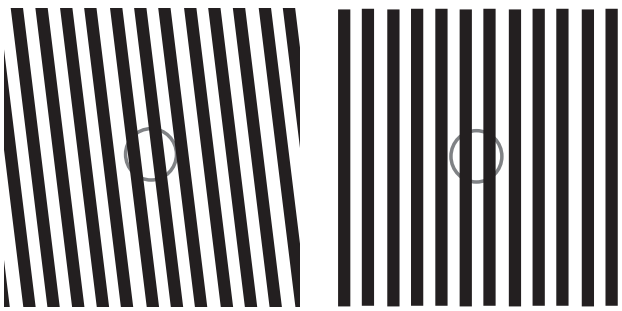


a *b*

illusion occurs because the brain normally interprets motion in a scene from the ratio of activity among cells responding to different directions of movement. (Similarly, the wide range of hues you see on the screen of your television set is based on the relative activity of tiny dots reflecting just three colors—red, green and blue.) By gazing at the waterfall, you fatigue the cells for downward movement; when you then look at a stationary image, the higher baseline of activity in the upward-motion cells results in a ratio that is interpreted as the grass going up. The illusion implies that the human brain must have such feature-detecting cells because of the general dictum that "if you can fatigue it, it must be there." (This is only a rule of thumb. One of us "adapted" to the dreadful climate and food in England, but there are no "weather cells" or "food-quality cells" in his brain.)

The waterfall effect (or motion aftereffect, as it is also known) was first noted by Aristotle. Unfortunately, as pointed out by 20th-century philosopher Bertrand Russell, Aristotle was a good observer but a poor experimenter, allowing his preconceived notions to influence his observations. He believed, erroneously, that the motion aftereffect was a form of visual inertia, a tendency to continue seeing things move in the same direction because of the inertia of some physical movement stimulated in the brain. He assumed, therefore, that the grass would seem to move downward as well—as if to continue to mimic the movement of the waterfall! If only he had spent a few minutes observing and comparing the apparent movements of the waterfall and the grass, he would not have made the mistake—but experiments were not his forte. (He also proclaimed that women have fewer teeth than men, never having bothered to count Mrs. Aristotle's teeth.)

The principle of motion adaptation isn't all that different from the one illustrated by the color aftereffect. Stare at the fixation spot in *a* between the two vertically aligned squares—the top one red, the bottom one green. After a minute, look at the blank gray screen in *b*. You should see a ghostly bluish-green square where the red used to fall in your visual field and a reddish square where the green used to be. The effect is especially powerful if you blink your eyes.



c *d*

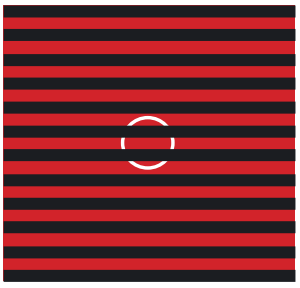
This color-adaptation aftereffect occurs mainly in the retina. The eye has three receptor pigments–for red, green and blue—each of which is optimally (but not exclusively) excited by one wavelength. Light that contains all wavelengths and thereby stimulates all three receptors equally yields a ratio that the brain interprets as white. If your red color receptors become fatigued from staring at a red square, then when you look at a field of white or light gray, the ratio of activation shifts in favor of greenish blue, which is what you see.

Orientation adaptation, discovered by Colin Blakemore, then at the University of Cambridge, is another striking example of this phenomenon, except that (like the waterfall effect) it occurs in the brain, not the eye. Stare at the anticlockwise-tilted lines in *c* for a minute (while moving fixation within the central disk) and then transfer your gaze to the vertical lines in *d*. You will be startled to find the vertical lines tilted in the opposite direction, clockwise. This perception allows the inference that orientation-specific cells do exist in the human brain: the adaptation to tilt "tilts" the balance of activity among the orientation-specific neurons, favoring those that are attuned to the opposite, clockwise direction.

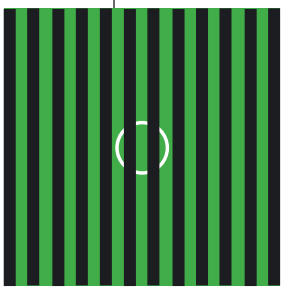
Even more exciting was Celeste McCollough's discovery during the early 1960s, while on sabbatical from Oberlin College, of "double duty" cells in humans. Her experiments showed that in addition to cells that respond specifically to a color or an orientation, there are cells that respond only to a line that is both tilted and colored appropriately (that is, a cell for "red line tilted 45 degrees clockwise" or for "green line tilted 10 degrees anticlockwise," and so on).

Look at *e* (horizontal black and red bars) for 10 seconds, moving your eyes around the central fixation (don't keep staring just at the fixation) and then at *f* (vertical green and black bars) for 10 seconds. Alternate between them about 10 times each. By doing so, you tire all the color receptors in your retina about

It is as though the brain were saying, "Every time I see horizontal stripes, there's **too much red in the world**."



e



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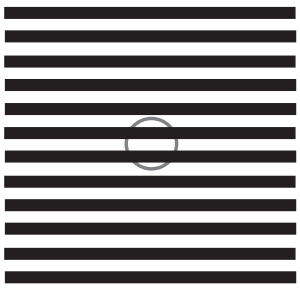
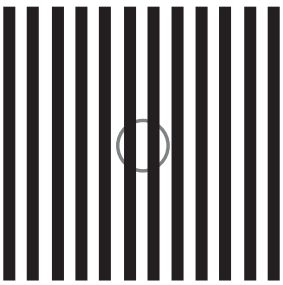


g



h

equally. If you then look at white paper, you see white—no colors. But an astonishing thing happens if you look at *g* and *h*, which consist of black and white horizontal or vertical bars. (Move your eyes back and forth betweeen them.) The white horizontal lines now look tinged green and the vertical ones red! The effect is even more striking if you look at the patchwork quilt (*i*).

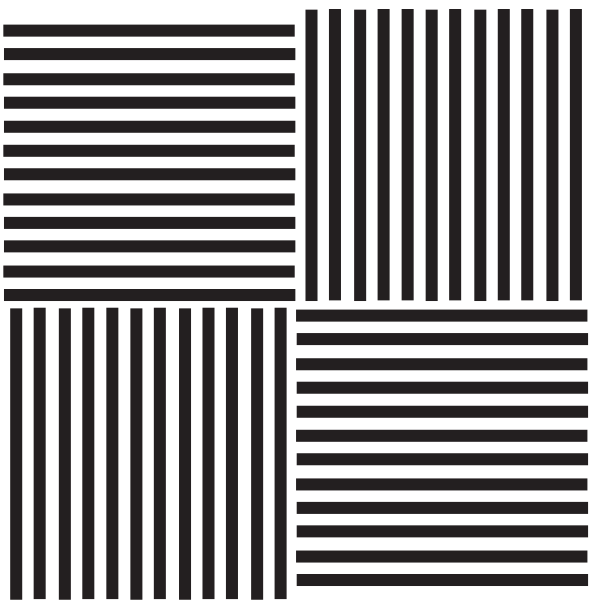
Why does this happen? The McCollough effect suggests that subsequent to the retinal processing, some cells in the brain's visual pathway extract two features along independent dimensions simultaneously. For simplicity, assume there are just four types of these cells: red-vertical, green-vertical, red-horizontal and green-horizontal. Because *e* fatigues only the red-horizontal cells, you are left with nonfatigued green-horizontal cells, which are then relatively active when you look at white horizontal stripes. Consequently, the white horizontal stripes look greenish; *f* has the reverse effect on the cells: because green-vertical cells have been selectively adapted, white vertical stripes now appear reddish. But none of these aftereffects occurs when you look at blank white paper because your eye movements ensure that all color receptors are equally stimulated on the retina, whereas cortical cells that have an orientation specificity are not stimulated.

Therefore, with a 10-minute experiment, we have shown the existence of neurons in the brain that require the joint presence of a specific color and orientation to fire. The adaptation effects that result from fatiguing them are called contingent aftereffects. The McCollough effect is an orientation-contingent color aftereffect.

A peculiar aspect of the McCollough effect is that once it has been generated in your brain, it can survive for a long period. Look again next week, and the stripes may very well continue to look red- or green-tinged. (The strength of the aftereffect normally ebbs gradually over time, unless you are submerged in darkness, in which case it endures undiminished!) It has therefore been suggested that contingent aftereffects have more in common with memory and learning than with purely visual adaptation. It is as though during the initial adaptation (or exposure) phase, the brain were saying, "Every time I see horizontal stripes, there's too much red in the world, so let's pay less attention to red. Whereas every time I see vertical stripes, I see too much green. So let me damp down the green when I am shown vertical white stripes and damp down red when I see horizontal white." (In the same way, your brain says, "Any time I set foot into the hot tub, it's hot, so let me recalibrate my temperature judgment accordingly. I'll expect it to be hot and won't withdraw my foot in surprise.")

It has been shown that certain drugs (including caffeine) can enhance the persistence of the McCollough effect. The phenomenon deserves further study as a way of approaching the neurochemistry of perceptual mechanisms. Visual aftereffects may thus give us insights not only into the neural channels that mediate perception but also into the neural—and possibly pharmacological—basis of memory and learning. M

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. They are on the board of advisers for *Scientific American Mind.*



i

(Further Reading)

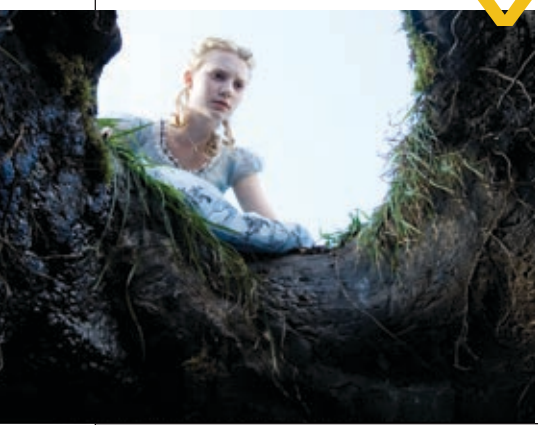
- **Color Adaptation of Edge-Detectors in the Human Visual System.** Celeste McCollough in *Science,* Vol. 149, pages 1115–1116; September 3, 1965.
- **Eye and Brain: The Psychology of Seeing.** Richard L. Gregory. Princeton University Press, 1997.

(calendar)

March

1 How does the human brain process fear? Neuroscientist Joseph E. LeDoux of New York University will reveal what we know about the biological underpinnings of fear and memory during a lecture hosted by the Oregon Health & Science University. The lecture is part of a series leading up to **Brain Awareness Week** (March 15–21), which inspires events worldwide. This year O.H.S.U. is hosting seven weeks of activities, including talks by leading brain researchers and science writers such as Jonah Lehrer (a contributing editor for *Scientific American Mind*), a workshop for teachers, a brain fair and a scientific meeting.
Portland, Ore.
http://tinyurl.com/yce7aly
To find Brain Week events near you:
www.sfn.org/BAW

5 A new film version of **Alice in Wonderland**, directed by Tim Burton, stars Johnny Depp and Helena Bonham Carter. Most people know that the familiar tale is based on books by Lewis Carroll, but few realize that Carroll himself suffered from an unusual neurological condition that alters how the brain perceives the size of objects. The author experienced bouts of micropsia and macropsia, in which small objects appear to be huge and vice versa. Carroll used this disorder as a source of creative inspiration—in fact, micropsia is commonly known as Alice in Wonderland syndrome in homage to Carroll's evocative prose.
Nationwide
http://disney.go.com/aliceinwonderland



WALT DISNEY PICTURES (*Alice*); SAM GROSS *Courtesy of WGBH* (*New York Stock Exchange*); JULIUS KIELAITIS /*Stockphoto* (*mountains*)

23 Beginning in 1979, neuropsychologist Nancy Wexler of Columbia University and her colleagues traveled to a small village in Venezuela where the inhabitants exhibited a startlingly high rate of neurodegeneration. Her team spent several years collecting tissue samples from large families there. Fourteen years later, on this day in 1993, her research team identified the single **gene that causes Huntington's disease**, an incurable degenerative disorder that affects muscle coordination and cognitive function. This breakthrough discovery was one of the first successful attempts to identify a gene associated with a disease.

30 Ever wonder what goes through a Wall Street trader's head as he or she is buying and selling stocks? Now you can find out—and discover how your own decision-making process compares. The NOVA documentary ***Behavioral Economics*** delves into the psychology and neuroscience behind our economic decision making, decoding brain scans of Wall Street workers during a trade and supermarket shoppers deciding which items to purchase. Watch on your local PBS station or online after the airdate.
Nationwide
www.pbs.org/wgbh/nova

April

6–10 Are we wired for romance? Researchers at the **12th International Neuroscience Winter Conference** will explore, among other hot topics in neuroscience, the neurobiology of courtship, new gene therapy approaches in Parkinson's disease, the role of sleep in neuropsychiatric disorders and breakthroughs in brain repair. And in case the science isn't exciting enough, the neuroscientists attending the conference will be staying just a short drive away from some of Austria's major ski resorts.
Sölden, Austria
http://inwc.sambax.com

11 Parkinson's disease, a degenerative nerve disorder now known to result from the loss of dopamine-producing brain cells, was first described almost 200 years ago by English doctor **James Parkinson**, born on this day in 1755. In his famous piece, *An Essay on the Shaking Palsy,* Parkinson described a number of patients with key symptoms of the neurological condition, such as involuntary tremors and diminished muscle control, and several decades later the disease was named after him.

14–17 The deadliest and most common type of brain cancer, known as malignant glioma, has no cure—it kills half of the afflicted within a year of diagnosis. [For more on our growing understanding of glioma, see "New Weapons against Brain Cancer," by Greg Foltz, on page 50.] New technologies offer promise, however—a novel imaging technique that causes tumor cells to glow in a fluorescent hue, for example, is now allowing surgeons to find and remove the cancer cells more effectively. This fluorescence-guided surgery and other cutting-edge neuroimaging techniques will be discussed at this year's **IEEE International Symposium on Biomedical Imaging**, with the aim of improving treatments in years to come.
Rotterdam, the Netherlands
http://fens.mdc-berlin.de/calendar/?id=1192&action=read

Compiled by Allison Bond and Victoria Stern. Send items to editors@SciAmMind.com

The Power to PERSUADE

How masters of "supersuasion" can change your mind

By Kevin Dutton

"Nothing is so unbelievable that oratory cannot make it acceptable."

—Marcus Tullius Cicero

I don't know about you, but most of my attempts at persuasion end up going 'round in circles: impassioned, long-winded affairs that seem as if they're working. But aren't. This is why I've become fascinated with something I call "supersuasion," a brand-new kind of influence that disables our cognitive security systems in seconds. Animals do it [*see box on page 26*]. Babies do it [*see box on page 29*]. But for reasons that I've been exploring, most of us grownups seem to find it difficult. With one or two exceptions, of course.

My journey to understand the art of persuasion began a couple of years ago, with the simple idea that some of us are better at it than others. And that, just as with every other skill, there's a spectrum of talent along which each of us has our place. At one end are those who always say the wrong thing. At the other, the supersuaders, who always get it right. These black belts in influence hark back to the days of our ancestors; their powers of persuasion effortlessly recapitulating the immediate, instinctual response sets of our primeval, preconscious past. Their elite, flashbulb influence suffuses all before it. It is fast. It is simple. And it works. Immediately. Instantaneously. NOW.

You could call it the persuasion "hole in one."

Take, for example, the man I encountered on a flight (business class, thanks to a film company I was working for) from London to New York. The guy across from me had a problem with his food. After several minutes of prodding it around his plate, he summoned the chief steward to his side.

"This food," he enunciated, "sucks."

The chief steward nodded and was very understanding. "Oh, we're very sorry!" he replied. "It's such a pity! How will we ever make it up to you?"

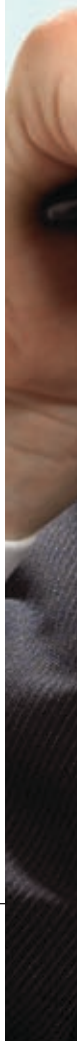
Not bad, I thought.

"Look," continued the man (he was, one suspected, quite used to continuing). "I know it's not your fault. But it just isn't good enough. And you know what? I'm so fed up with people being nice!"

But then came something that totally changed the game. That didn't just turn the tables. It kicked 'em over.

"IS THAT RIGHT, YOU F* * *ING D* * *? THEN WHY THE F* * * DON'T YOU SHUT UP, YOU F * * * ING A * * HOLE?" Instantly, the whole cabin fell silent. Who the hell…?

A guy in one of the front seats turned around. He looked at the fellow who was complaining about his food, winked at him, and inquired, "Is that any better? Cause if it ain't, I can keep going."



PHOTOILLUSTRATION BY AARON GOODMAN

The Persuasion Instinct

"You looking at my girl?" How many times has that particular question drawn an evening out to a close? Not so with elephants. During the mating season young male elephants, when they inadvertently encroach on females in estrus, give off what is known as an innocent scent, an olfactory signal to adult bull elephants that they are going to toe the line.

How many times have houseguests outstayed their welcome, because despite all your hints they somehow just didn't get that it was time to go? Not so with the thorny acacia tree of Central Africa. When insects start feeding on the thorny acacia too greedily, it produces a toxin that turns Michelin-starred leaves into pig swill. Not only that, it also gives off an odor, warning nearby acacias to put up the shutters themselves: an arboreal, chemical Twitter that there's a freeloader doing the rounds.

Examples such as these provide a pretty good flavor of how persuasion works in the animal kingdom. And it leaves what we humans do in the dust. There are no mixed messages, no beating around the bush (unless that bush happens to belong to a cassowary, in which case the phrase takes on a different, more ominous meaning) and no sitting down over coffee to talk about it. Instead, in the absence of consciousness and those ephemeral containers of meaning we call words, animals rely on what ethologists call key stimuli: environmental triggers (such as the innocent scent in elephants and the not so innocent scent in acacias) that initiate, when they are activated, instinctive behavioral responses.

DIETER HOELL age fotostock (elephant); CHRIS MATTISON FLPA/age fotostock (trees)

For a moment, nobody said anything. Everyone, quite literally, f-r-o-z-e. But then, as if some secret neural tripwire had been pulled, our disgruntled diner … smiled. And then he laughed. And then he *really* laughed. This, in turn, set the chief steward off. And that, of course, got us *all* started.

Problem solved with just a handful of simple words. And definitive proof, if ever any were needed, of what my old English teacher Mr. Johnson used to say: You can be as rude as you like, so long as you're polite about it.

Almost without effort, this connoisseur of curses (who also happened to be a famous musician) had used supersuasion to deflect an awkward situation and turn the tables another way. And he did so by uniting biology, psychology and neuroscience in a model of influence with five constituent factors—factors that may be handily arranged in the acronym "SPICE": *S*implicity, *P*erceived self-interest, *I*ncongruity, *C*onfidence and *E*mpathy.

Studies have taken these five elements apart one by one to show us how each one works in building toward supersuasion.

Simplicity

"Easy to swallow, easy to follow" is the brain's heuristic for influence. This is one reason why the world's great orators have always spoken in threes. Julius Caesar's "*veni, vidi, vici,*" for example. Or Abraham Lincoln in the Gettysburg Address: "we cannot dedicate, we cannot consecrate, we cannot hallow this ground."

This device, known as the tricolon, is among a number of rhetorical secrets first identified by the speakers of the ancient world, classical orators such as Cicero, Demosthenes and Socrates (who themselves form a tricolon). Its magic lies in its efficiency: a third word not only gives confirmation and completes a point, it is also economical, constituting the earliest stage at which a possible connection, implied by the first two words, may be substantiated. More than three, and you risk going on and on. Fewer than three, and your argument lands prematurely.

The bottom line couldn't be any clearer: the shorter, sharper, simpler the message—tricolon again—the more amenable we are to its content.

Imagine I were to hand you a recipe for Japanese rolls—and that it was printed in this typeface (Times New Roman, 12 point). Next, imagine I

FAST FACTS

Would You Like to Buy a Bridge?

1» **Some people are masters of "supersuasion," but the skill is not inborn; their techniques can be taught to anyone.**

2» **Humor is the key, especially if it catches your listeners off guard, leaving them laughing and open to suggestion.**

3» **Make people believe you have their best interests at heart, and you can persuade them to do almost anything.**

were to ask you to estimate how long it would take you to prepare the recipe. And then, how inclined you were to do so.

Question: Do you think you would rate the dish as being easier to cook if it were ***printed in this typeface*** (Brush, 12 point)? Or do you think that the typeface would make little difference to your judgment? Psychologists Hyunjin Song and Norbert Schwarz of the University of Michigan at Ann Arbor put exactly this question to a group of college students in 2008. And guess what? The fussier the typeface, the more difficult the students judged the recipe. And what's more, the less likely they were to attempt it. Even though the recipes were exactly the same in both cases, the students walked into a classic cognitive ambush: they confused the facility with which they took in information with the resources required to comply with it. Result? The group gave Brush the brush-off.

Perceived Self-Interest

Several million years ago, when social networking was even more important than Facebook and Twitter are today, the facility to be true to one's word, and to return favors accordingly, was synonymous with group cohesion. With individual cohesion, too: in the days before welfare and pest control, being ostracized was fatal.

But old evolutionary habits die hard—and the spectral remnants of exigencies past hover like neural phantoms on the dark, primeval stairwells of the brain [*see box on page 31*]. Take loyalty cards, for example. In 2006 psychologists Joseph Nunes and Xavier Dreze of the Wharton School of Marketing at the University of Pennsylvania presented the patrons of a car wash with two different types of voucher—each of which, when completed, entitled the beneficiary to a free visit. In both cases, eight stamps (corresponding to eight visits) were required to redeem the offer. But the vouchers differed from each other in one important feature. One consisted of eight blank circles, whereas the other consisted of 10, with the first two circles already voided out.

Which of the vouchers do you think proved the more effective? You got it—the one with the first two stamps thrown in ostensibly "for free." Of the customers given the 10-circle voucher, 34 percent filled the promotional requirements and returned to the garage the stipulated eight times to claim their free car wash, compared with just 19 percent of the customers who weren't on the empirical fast track. Even though the offer was exactly the same for both groups—customers had to visit the car wash on eight occasions to earn their freebie—those initial two tokens created a powerful illusion: not only of something for nothing (a gesture of corporate goodwill triggering reciprocity) but also of client commitment. On receiving the vouchers that apparently gave them a two-point lead, customers thought to themselves: "Hey, I'm a fifth of the way there already. I might as well keep going." And so they were far more likely to continue with the scheme than those who had started supposedly from scratch.

This voucher trick is all about the art of framing—the presentation of information in a way that maximizes positive outcomes. And framing isn't just confined to advertising. Politicians do it. Attorneys do it. We all do it.

The key, as a persuader, is to present things in such a way that they appear to be not in your *own*

It helps if people feel like they're being offered a good deal, especially if the good deal involves getting away with something.

ANDREW PATERSON *age fotostock*

Make people believe that they will get an exceptionally beneficial deal by doing what you want (even if they won't), and you go a long way toward persuading them.

The best jokes are the ones we don't see coming. Our brains do a double take, and that's when they are most open to suggestion.

Humor plays an important part in supersuasion, most especially humor that arises from incongruities that catch the listener off guard.

best interests—but in those of whom you're trying to influence. Take, for example, the story of King Louis XI of France, a staunch believer in astrology. When a courtier correctly predicted the death of a member of his imperial household, the king worried that having such a powerful seer in his court might pose a threat to his authority. He summoned the man, planning to have him thrown to his death from a window ledge. But first he addressed him gravely. "You claim to be able to interpret the heavens," King Louis said, "and to know the fate of others. So tell me: What fate will befall *you*, and how long do you have to live?"

The oracle thought carefully for a moment. Then he smiled.

"I shall meet my end," he replied, "just three days before Your Majesty meets his." A perfect, if apocryphal, example of the courtier using perceived self-interest on the *king's* part as a way to save his *own* life.

Incongruity

The persuasive power of humor is second to none. If someone can make you laugh while trying to change your mind, chances are they're on to a winner. Not long ago in London, I walked past a homeless man selling a copy of the magazine the *Big Issue*, the proceeds of which go toward helping those living on the street. "Free delivery within 10 feet!" he called out. I bought one on the spot.

Precisely why humor is so powerful an influencer is an interesting question. The answer lies in one of its key ingredients, incongruity. The best jokes are the ones we don't see coming, and *because* we don't see them coming, they violate expectation. Our brains do a double take. And in that fraction of a second, while their backs, so to speak, are turned, our brains are open to suggestion.

The neurology of incongruity—what happens inside the brain as it is doing a double take—is well documented. Single cell recordings in monkeys show that the amygdala, the emotion center of the brain, is more sensitive to unexpected than expected presentations of both positive and negative stimuli. In humans, intracranial EEG recordings reveal increased activation in both the amygdala and the temporoparietal junction, a structure involved in novelty detection, on exposure to unusual events. Such findings confirm that incongruity not only gains our attention (a crucial component of any effective persuasion—just ask the guy in business class who complained about his dinner) but that it also lobs a stun grenade between our ears. It disables cognitive functioning and compromises, for a brief but critical time window, our neural homeland security.

Yet incongruity isn't just about distraction. It's also about reframing—as a study by social psychologist David Strohmetz and his co-authors at Monmouth University demonstrated rather fiendishly in 2002. The study in question was conducted in a restaurant, and Strohmetz began by dividing diners up into three groups, according to how many candies the waiter handed out with the check.

To one group of diners the waiter gave one candy. To another, he gave two. And to the third—and this is where it gets interesting—he did the following. First he gave out one candy and then walked away … then turned back around, as if he had

AGE FOTOSTOCK

(The Author)

KEVIN DUTTON is a Research Fellow at the Faraday Institute of St. Edmund's College at the University of Cambridge. He is author of *Split-Second Persuasion: The Ancient Art and New Science of Changing Minds*, to be published later this year by Houghton Mifflin Harcourt. In the U.K., the title will be *Flipnosis: The Art of Split-Second Persuasion* (William Heineman, 2009).

Fetal Attraction

Let's say you found a wallet on the street. What would you do? Take it to the nearest police station? Mail it back to the owner? Keep it? The answer, it emerges, depends less on a question of individual morality and a great deal more on our collective evolutionary heritage.

In 2009 psychologist Richard Wiseman of the University of Hertfordshire in England left a bunch of wallets on the streets of Edinburgh, Scotland, each of which contained one of four photographs: a happy family, a cute puppy, an elderly couple and a smiling baby. Which ones, he wondered, would be most likely to find their way home? There was no doubting the outcome: 88 percent of the wallets containing the picture of the smiling baby were returned, beating all the others out of sight.

The result, according to Wiseman, is not surprising. "The baby kicks off a caring feeling in people," he says, a nurturing instinct toward vulnerable infants that has evolved to safeguard the survival of future generations.

In 2009 Melanie Glocker of the Institute of Neural and Behavioral Biology at the University of Muenster in Germany flashed pictures of newborns to a group of childless women while they underwent functional MRI. Using a special image-editing program, Glocker manipulated the pictures so that some of the infant faces incorporated higher "baby schema" values (large, round eyes; round, chubby face) whereas some had lower values (smaller eyes; narrower face). It wasn't just the program that was eye-opening. Results revealed that the faces with higher baby schema values precipitated an increase in activity not just in the amygdala (the brain's emotional control tower) but also in the nucleus accumbens, a key structure of the mesocorticolimbic system that mediates reward.

Similar findings to Glocker's have also been demonstrated acoustically. Kerstin Sander of the Leibnitz Institute for Neurobiology in Germany compared amygdala responses to infants and adults crying and discovered something extraordinary: a 900 percent increase for babies. Additional research has taken things one stage further and revealed that although preverbal infant vocalizations do indeed increase amygdala activation, it is sudden and unexpected changes in crying pitch that convey the most emotion—further support for the role of incongruity in supersuasion.

changed his mind, and added another. So one group got one candy. And two groups got two. But the two who got two were given them in different ways. (I hope you're paying attention—there's a test later.)

Did the number of candies and the manner in which they were allocated bear any relation to tip size? You bet it did. Compared with a control group of diners who got no candies at all (charming), those who got one tipped, on average, 3.3 percent higher. Similarly, those who got two candies tipped 14.1 percent higher. But the biggest increase was shown by those who received first one candy, then another—a biblical escalation of philanthropic zeal 23 percent greater than their uncandied brethren.

That unexpected change of heart completely reframed the situation. It instigated a whole new way of appraising the interaction. He's giving us special treatment, the diners thought to themselves. Let's give him something back.

Confidence

Confidence, misplaced or otherwise, is catching. It's a privileged, though sometimes precarious, condition, fiercely independent of reality, that's transmitted sub-radar from one individual to another via language, belief and appearance. It's why con men enjoy their appellation, and why McDonald's and Nike bring out ads that declare "Just Do It" and "I'm Loving It," as opposed to ads that say "I'm Thinking about It" or "I Kind of Like It." Influence without confidence is about as useful as an inflatable dartboard.

Context is everything: a fancy label and a high price tag can fool people into thinking that a wine tastes better than glasses from seemingly cheaper bottles.

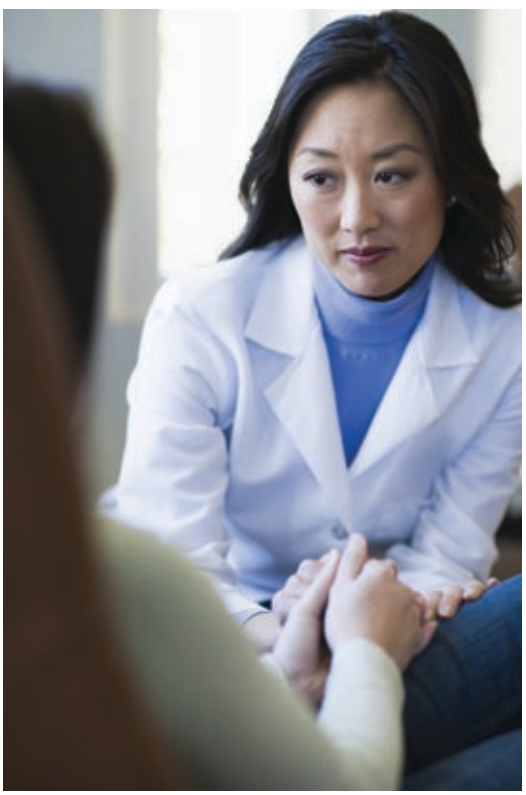
LYDIE GIGERICHOVA *age fotostock (top)*; GLOW CUISINE *age fotostock (bottom)*

Exhibiting empathy helps to convince people that you have their best interests at heart, a surefire way to get them on your side.

Our reliance on confidence to help divine correctness—our deployment, that is, of a confidence heuristic—has been demonstrated in the lab. In 2008 Hilke Plassman, now associate professor of marketing at INSEAD Business School near Paris, sneakily switched the price tags on bottles of Cabernet Sauvignon. For some it was valued at $10, for others at $90.

Would the difference in price be reflected in a difference in taste? It sure would.

Volunteers rated the $90 bottle considerably more drinkable than the $10 bottle—even though both bottles, unbeknownst to them, contained exactly the same wine. And that wasn't all. Subsequently, during a functional MRI scan Plassman found that this simple sleight of mind was actually reflected anatomically, in neural activity deep within the brain. Not only did the "cheaper" wine taste cheaper and the "dearer" one, well, dearer; the supposedly more expensive wine generated increased activation in the medial orbitofrontal cortex, the part of the brain that responds to pleasurable experiences.



Being a good listener is not only persuasive, it can be self-protective: physicians who seem empathetic are less likely to be sued for malpractice.

AGE FOTOSTOCK

Similar results have also been found with experts. In 2001 cognitive psychologist Frédéric Brochet, then at the oenology research and teaching unit at the University of Bordeaux in France, took a midrange Bordeaux and served it in two different bottles. One was a labeled as a splendid *grand cru*, the other as a *vin du table*.

Would the wine buffs smell a rat? Not a chance.

Despite the fact that, just as in the Plassman study, they were actually being served the same vintage, the experts appraised the different bottles differently. The *grand cru* was described as "agreeable, woody, complex, balanced and rounded," whereas the *vin du table* was evaluated less salubriously—as "weak, short, light, flat and faulty."

Confidence is a wormhole into truth. In ambiguous, dynamic or fluid situations, not only does it have the right air—it also has the air of being right.

Empathy

In the summer of 1941 Sergeant James Allen Ward was awarded a Victoria Cross for bravery for clambering onto the wing of his Wellington bomber and, while flying 13,000 feet above the North Sea, extinguishing a fire in the starboard engine. He was secured, at the time, by just a single rope tied around his waist.

Some time later Winston Churchill summoned the shy and swashbuckling New Zealander to Number 10 Downing Street to congratulate him on his exploits. They got off to a shaky start. The fearless, daredevil airman, tongue-tied in the presence of the prime minister, was completely unable to field even the simplest of questions put to him. Churchill tried something different.

"You must feel very humble and awkward in my presence," he began.

"Yes, sir," replied Ward. "I do."

"Then you can imagine," Churchill said, "how humble and awkward I feel in yours."

A brilliant double stroke of empathy—feeling the discomfort of his visitor and recasting it as though begging for the visitor to feel his—showed Churchill at his most disarming and persuasive. A warm, empathetic style will often convince people of your best intentions and bring them onboard.

Empathy has been shown to be important in the doctor-patient relationship, in which physicians

Programs of Persuasion

Psychologist Robert Cialdini of Arizona State University has spent his entire career observing influence techniques not just in the lab but also in the real world. Cialdini has published his conclusions in a book, *Influence: Science and Practice,* fifth edition (Allyn & Bacon, 2008), where he identifies six core principles of social influence—all of which, he argues, have evolutionary underpinnings reaching far back into our ancestral history.

These core principles are as follows:

1. **Reciprocity**—we feel obligated to return favors.
2. **Liking**—we have a tendency to say yes to people whom we like.
3. **Scarcity**—we place more value on things that are in short supply.
4. **Social proof**—we look at what others are doing when we're not sure what to do ourselves.
5. **Authority**—we listen to experts and those in positions of power.
6. **Commitment and consistency**—we like to be true to our word and finish what we've started.

When in doubt, people naturally look to figures of authority and experience for guidance.

All of these principles tap (somewhat self-evidently given their evolutionary origins), one way or another, into issues of primeval survival—issues that in the 21st century are perhaps recapitulated a little more often than we think. What will happen if I don't fill up with gas? we mutter to ourselves in a fuel crisis (scarcity). Or at dinner: everyone else is using that funny-shaped spoon with the hook, so it's got to be right. Right? (Social proof.)

Because of this evolutionary lineage and of the strategies' explicit connection to ostensibly individual reward systems, they are all subsumed within the supersuasion model under the broader, more generic principle of perceived self-interest.

have to convince patients that they care about them and have their best interests at heart. This tactic not only makes for good medicine, it also has been shown to protect doctors from malpractice lawsuits. In 2002 Nalini Ambady, now a professor of psychology at Tufts University, divided physicians into two groups: those who'd been dragged through the court and those who hadn't. She made audiotapes of the doctors and their patients in session and then played the tapes to a group of students. The students were asked to determine which doctors had been sued.

But there was a catch. For each of the recordings the output was "content-filtered." All the students could hear was prosody: muffled, low-frequency garble, as if they were listening underwater.

How, linguistically, would the doctors measure up? Could the students, on the basis of intonation alone, somehow distinguish one group from another? The results were unequivocal: they could tell them a mile off. The doctors who had been sued sounded way more self-important. They had a dominant, hostile, less empathic conversational style—whereas those who had not been sued sounded warmer.

Forgive and forget? Live and let live? Only, it seems, if I like you.

The position of incongruity at the center of the SPICE model reflects its centrality to the idea of supersuasion. From calming someone down to raising someone's spirits, from closing the deal to trying to bum a quarter from strangers on the street, defiance of expectation, script reversal, antithesis—call it what you will—lies at the very heart of supersuasion. Not only does incongruity enhance the aesthetic prowess of simplicity, it also knocks out the brain's surveillance mechanisms and thereby enables the rest of the SPICE task force to secretly slip in under the radar and hotwire our neural pleasure centers.

Humor Is Key

Of course, incongruity is also the essence of humor—one of the most effective tools in disarming your interlocutor and becoming a supersuader.

Take a lesson from the following:

Jim stumbled out of a saloon right into the arms of Father McGuire.

"Inebriated again!" the priest scolded him. "Shame on you! When are you going to straighten out your life?"

"Father," Jim asked. "What causes arthritis?"

"I'll tell you what causes it," snapped the priest. "Drinking cheap whiskey, gambling and carousing around with loose women! How long have you had arthritis?"

"I don't," slurred Jim. "But the Bishop does."

Supersuasion doesn't just bring the house down. It clears up the rubble and carts it off in a dump truck. M

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A Sensory Fix for Problems in School

Certain learning disabilities are linked to problems of perception, when the brain misinterprets sensory input. Targeted exercises can help correct these difficulties

By Burkhart Fischer

To succeed in school, children must master the "three R's"—reading, writing and arithmetic—but not all students readily grasp these basic skills. Among English-speaking children, an estimated 2 to 15 percent have trouble reading or spelling, problems broadly classified as dyslexia. From 1 to 7 percent struggle to do math, a disability known as dyscalculia. Statistics vary; dyslexia appears to be more common, for example, among English speakers than among speakers of highly phonetic languages, such as German or Italian. Nevertheless, it is fair to say that at least one child in most elementary school classes in the U.S. suffers from dyslexia or dyscalculia.

These learning disabilities defy easy explanation. Neither is the result of faulty eyesight or hearing, both of which can also delay language acquisition but are easily corrected using glasses or hearing aids. Instead children with dyslexia and dyscalculia have working sensory organs, apparently normal sensory and motor development and, sometimes, above-average intelligence.

After more than 15 years of research, investigators now believe these conditions frequently involve so-called partial functional deficits, often of the senses: in affected children, the eyes and ears accurately register sights and sounds, letters, numbers, spoken syllables—but that information is misinterpreted as it is processed in the brain. Curiously, girls apparently suffer from fewer partial functional deficits and seem less affected by disorders of sensory perception in general, although we do not yet know why this should be the case.

At the Optomotor Laboratory at the University of Freiburg in Germany, where I am the founder and director, we test children for sensory-processing errors, looking closely at what expertise the brain needs to develop before it can coordinate activities as sophisticated as understanding speech, reading or calculating. We have devised targeted exercises to hone these underlying mental skills. Our training can indeed help children to construe auditory and visual information correctly, and in so doing, it boosts their ability to read, listen, spell and do math.

From 1 to 7 percent of schoolchildren struggle to perform simple calculations, a disability known as dyscalculia. Fortunately, these students can often improve in math by practicing critical skills such as subitizing—recognizing quantity on sight without actually counting.

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The headgear-based apparatus at the right and the handheld devices below are just some of the tools that can help train kids to improve their control over perceptual skills essential for reading and other learning.

HANNA FUCHS *Gehirn & Geist*

Building Eye-Brain Coordination

Seeing depends on our eyes only at the very start of a complicated sequence of processing steps. Along the way, various adjustments take place. For example, consider the fact that only a tiny area of the retina—several layers of light-detecting cells at the back of the eye—is capable of distinguishing visual details. To work around this physical limitation, the brain directs the eyes to make rapid movements called saccades, which enables us to shift our focus from one place to another. Without these jumps, we would never register more than a thin slice of our field of view. Reading, in particular, requires highly precise saccade control. When we read, our eyes skip from word to word between three to five times per second. The brain must be able to choreograph these movements such that our eyes scan words and syllables in the correct sequence without jumping ahead. For this kind of eye-brain coordination to take place, the areas of the brain responsible for language processing and for eye movements must be in perfect sync.

In 2000 our team at the Optomotor Lab explored the possibility that some children who have difficulty reading might also have poor saccade control. Working together with physicist Klaus Hartnegg, also at Freiburg, and physician Monica Biscaldi-Schäfer of the University Medical Center Freiburg, we asked 620 people between the ages of seven and 17 to perform two tasks measuring eye movement control.

First, the participants glanced away from an initial focus—a point of laser light—toward a second point of light when it appeared, and then, almost immediately, they had to look away from the new stimulus. This second "antisaccade" task is harder than it sounds because the natural reflex is to continue looking at the new light; without excellent control, it is hard to override that instinct. In this part of the test, however, any eye movement toward the second light counted as an error.

The results confirmed our ideas: subjects who read poorly also had significantly less control over their saccades than did nondyslexic children and

FAST FACTS

Training the Senses

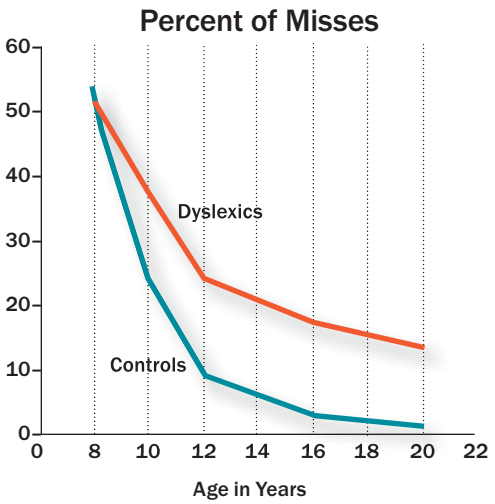
1» Learning disabilities such as dyslexia and dyscalculia may arise in part from faulty sensory processing.

2» Testing can identify specific sensory deficits: many dyslexics have trouble interpreting sounds; dyscalculics often show a diminished capacity to recognize quantity on sight, a skill called subitizing.

3» Targeted training can improve sensory processing, which in turn has a positive effect on reading, spelling and arithmetic skills.

adolescents. We concluded that trouble in controlling visual attention must at least partially contribute to some cases of dyslexia. After analyzing 3,224 children and young adults between the ages of seven and 17—a total that included the subjects in the study above—we further concluded that the brain seems to learn how to control visual attention over time. Seven- and eight-year-old participants, both with and without dyslexia, erroneously looked at the second light in our test some 80 percent of the time over the course of 200 trials; children at this age, dyslexic or not, cannot normally read with the speed or fluency of an adult (and these particular children had all just started to learn to read).

At age 20, however, when most people are fluent readers, nondyslexic individuals erred 20 percent of the time, on average, and quickly redirected any errant glances, whereas dyslexic test subjects continued to look the wrong way on the antisaccade task about 40 percent of the time and failed to correct those errors 14 percent of the time. The results show a dramatic improvement for both sets of individuals over the course of normal development, but whereas the control subjects advanced very rapidly toward reliable saccade control between the ages of seven and 18, the dyslexic subjects increasingly lagged behind [*see illustration above*].



Dyslexic individuals are more likely to make mistakes in a task that involves regulating small eye movements, which suggests that a lack of control over visual attention may contribute to some cases of dyslexia.

Trouble in controlling visual attention appears to contribute at least partially to some cases of dyslexia.

Fortunately, several studies, including our own, have demonstrated that training can have an impact on saccade control—and reading ability. We formulated a variety of exercises for dyslexic subjects, aged seven to 17 years old, to perform daily at home using a specialized computer device borrowed from the lab [*see illustration on opposite page*].

In one exercise, they used only their eyes to follow a symbol that rapidly changed direction on the device's small screen. When the symbol disappeared, the participants had to indicate, using arrow keys, the last direction in which the symbol headed. The speed at which the symbol tacked around the screen—which determined the difficulty of the exercise—slowly increased, as did the subjects' skill level. After three to six weeks, our recruits were significantly better at directing saccades. Of particular significance, after training, children in the program made half as many errors in reading as they did before.

The Spoken Word

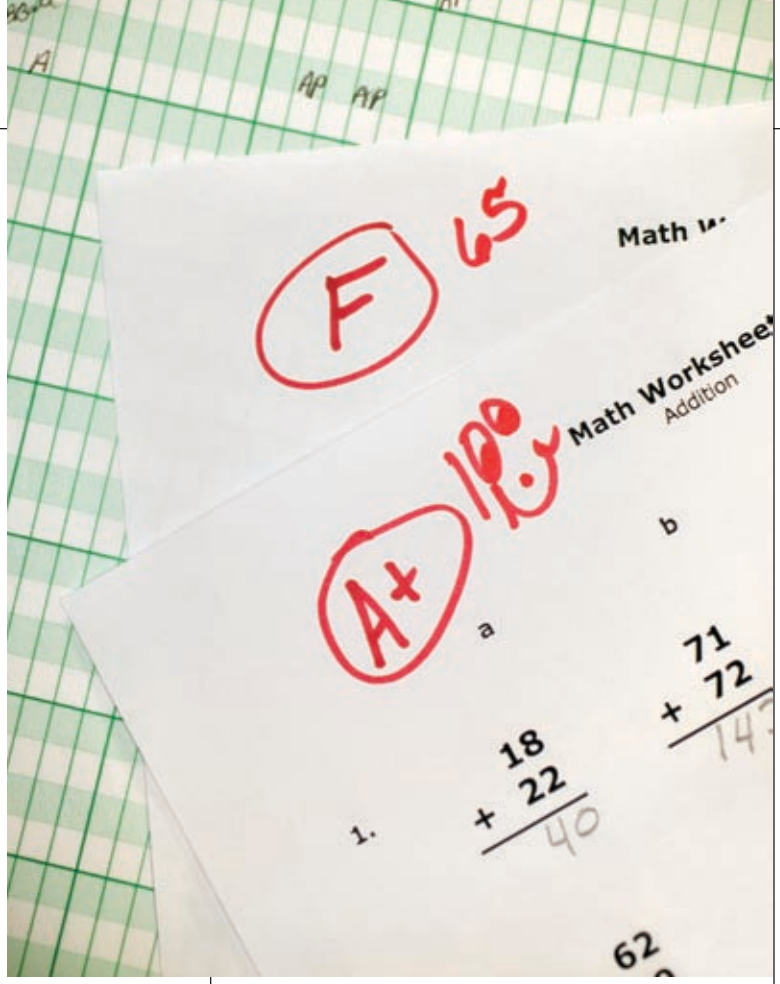
The success of saccade training is encouraging, but there is more to dyslexia than poor gaze control. Many researchers believe that dyslexic children also have difficulty understanding the spoken word. In particular, some dyslexics appear to lack full phonological awareness, which is the ability to distinguish among speech sounds, such as the initial sounds b and g, or among similar syllables. Psychologist Wolfgang Schneider of the University of Würzburg in Germany has demonstrated that drills aimed at building phonological awareness can bolster children's reading and writing skills in general—and they specifically help children who may speak a language at home that is different from what is spoken at school. Among other activities, these exercises require children to find words that rhyme, to divide words into syllables and to break syllables into individual sounds.

Unfortunately, not all children benefit equally from these exercises. To develop phonological

(The Author)

BURKHART FISCHER is emeritus professor of neurophysiological biophysics and founder of the Optomotor Laboratory at the University of Freiburg in Germany.

SCIENTIFIC AMERICAN MIND, COURTESY OF BURKHART FISCHER



Research shows that even short, three-week training courses can improve arithmetic ability among dyscalculic children. Participants in one study made 60 percent fewer errors on a math test as compared with their score before training.

awareness, individuals must first be able to interpret speech; the sounds used in the training exercises are actual words and syllables. Some children, however, have trouble making sense of sounds long before they reach the brain's language center. Acoustic input undergoes many processing steps, and any errors along the way can cripple comprehension. In 2004, again in collaboration with Hartnegg, we developed a series of tests to probe which mental abilities are critical for understanding the spoken word.

Initially we focused on measuring our subjects' capacities for discerning volume and pitch. In the pitch test, for instance, children listened to two sounds at different frequencies; the spread between the two grew progressively smaller until the children could no longer say which was higher. We also tested how well our participants could recognize gaps. When we enunciate words, certain syllables or sounds are interrupted when, for example, the tongue briefly touches the teeth or our breath momentarily pauses. If a listener fails to perceive these breaks, he or she will hear a different syllable from what was intended.

Among the 682 children and adolescents we analyzed, we found a strong association between dyslexia and auditory-processing deficits such as discerning pitches, soft versus loud sounds, or gaps between syllables. Indeed, children with reading problems scored lower on all the tests we administered. As before, our subjects became increasingly competent up to about age 20, and so we concluded that the brain must learn to hear subtle differences among sounds over time. As with the saccade training, we devised a regimen to exercise auditory perception that included drills for distinguishing sounds by pitch and sound intensity, as well as perceiving phonetic gaps between sounds. The trainees practiced each task for 10 consecutive days, over the course of several weeks. One study of 509 students showed that this program markedly improved their ability to distinguish pitches. The drills also had a positive effect on spelling: participants made approximately 40 percent fewer spelling errors than before. By comparison, subjects who did not undergo training reduced their error rate by only 10 percent.

In 2001 neuropsychologist Teija Kujala and her team at the University of Helsinki in Finland revealed that perceptual training brings about permanent changes in the brain. They studied the effect of audiovisual training, which made use of various tones but no language-related sounds, on children who had reading problems. After seven weeks of practicing 14 different exercises, the students not only made fewer reading errors but also showed changed patterns of brain activity, as measured by electroencephalography. In particular, scientists observed more intense neuronal firing in the auditory cortex, a part of the brain dedicated to perceiving sounds, in response to anomalies in an expected sequence of pitches.

How Many?

Basic perceptual processes also play an important role in dyscalculia. Take, for instance, subitizing, or our knack of perceiving quantity just by looking, not by actually counting. This facility aids children as they establish a concept of number—namely, the idea that a numeral stands for a particular amount. Most four-year-olds can readily recognize quantities between one and four. But we hypothesized that children suffering from dyscalculia might be less able to subitize. Hartnegg, Optomotor Lab researcher Christine Gebhardt and I tested this idea in a study of 375 children and adolescents. We flashed at random anywhere from one to nine small circles on a computer screen. The circles appeared so fleetingly that it was impossible for our participants to count them; instead they needed to be able to identify the amount on sight and press the correct number on the keypad. We were particularly interested in response times.

Our results, published in 2008, revealed that individuals with dyscalculia were, as expected, less

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adept at subitizing and took considerably longer to come up with the correct number of circles. Fortunately, just as with acoustic and visual training, a person can enhance his or her ability to subitize by practicing his or her powers of estimation, looking at collections of dots or figures and guessing how many. Another study from our lab, also published in 2008, revealed that a three-week training course could improve subitizing—and arithmetic ability—among dyscalculic children. Participants who performed the exercises made 60 percent fewer errors on a math test as compared with their score before training. In contrast, a group of children who did not participate in the training showed no improvement. Our research further indicated that children extend their capacity to subitize throughout school. As is the case with hearing and seeing, subitizing—and presumably other perceptual processes as well—is continually refined into adulthood.

It is difficult for parents, teachers and physicians to discern whether a child's perceptual development lags behind that of his peers.

Regrettably, it is difficult for parents, teachers and physicians to discern whether a child's perceptual development lags behind that of his peers. To estimate the prevalence of perceptual problems, we extrapolated from our studies, determining the percentage of children among those with dyslexia or dyscalculia who scored below the control subjects on our battery of tests. Among the eight-year-olds with dyslexia or dyscalculia, 64 percent lagged behind in at least one perceptual function. And because these children develop certain perceptual capabilities at a slower rate than unaffected children do, this proportion increased with maturity: at age 16 some 85 percent of the children with reading and math difficulties displayed perceptual shortcomings as compared with the control group. Of course, if visual- and acoustic-processing faults were solely to blame for dyslexia or dyscalculia, the rate would have been 100 percent. Nevertheless, these faults clearly aggravate many cases of learning disabilities and deserve further investigation.

Researchers are planning to study preschoolers in the near future. Targeted training might then be used to mitigate the effects of visual- and acoustic-processing faults before children start to read. It also remains to be seen whether training can help very able pupils, who, as initial studies reveal, sometimes exhibit perceptual problems. For instance, they are frequently more reactive on tests of gaze control; instead of reacting too slowly, their eyes may react too quickly, which can also make reading difficult. Sensory-processing deficits appear to have the largest effect on special-needs students. In 2008, in collaboration with Sylvia Denecke-Fassrainer of the Kollegium der Kirchbergschule in Herborn, Germany, I conducted a study at a school for special-needs students. We found that none of the 49 subjects, ranging in age between nine and 16 years old, performed at an age-appropriate level on the tests described in this article. Subsequent training improved academic skills in these children but less so than normally occurs in students without special needs.

Our findings have implications for the entire educational system. If 75 percent of all students diagnosed with dyslexia and dyscalculia probably also have sensory-processing problems—and if we assume that special training can strengthen at least one academic talent in approximately two thirds of cases—then we could dramatically help half of all dyslexic and dyscalculic students. Unfortunately, physicians look for disorders only in sensory organs; teachers know how to spot deficits in "higher" skills. Sensory processing falls into a gray area. Screening high-risk groups using the tests and exercises discussed in this article, however, is not only feasible, it would pay enormous social dividends in the long run. M

(Further Reading)

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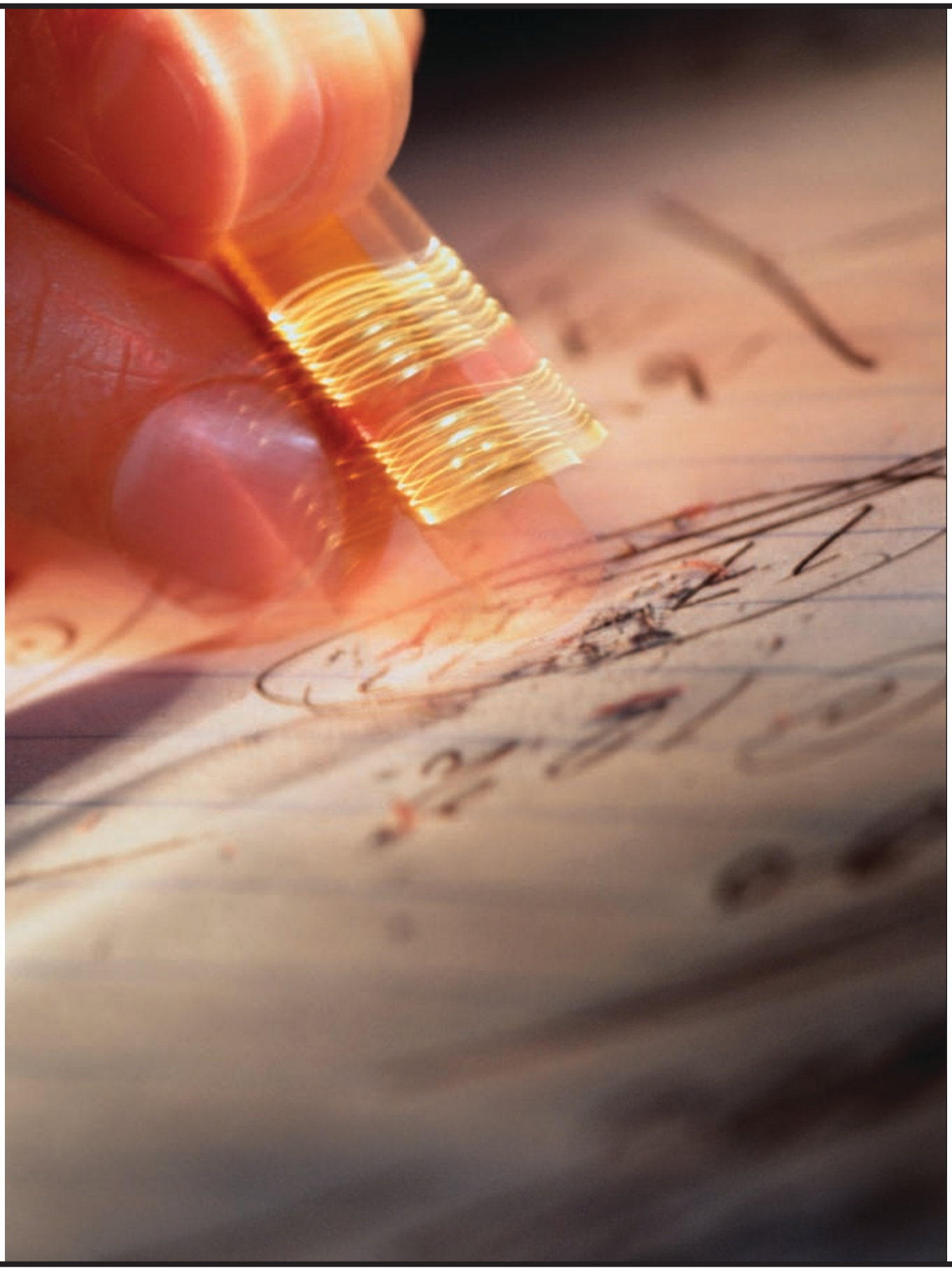


ZIGY KALUZNY-CHARLES THATCHER *Getty Images*

The Pluses of Getting It Wrong

New research makes the case for difficult tests in schools and suggests an unusual technique that anyone can use to learn

By Henry L. Roediger III and Bridgid Finn

For years many educators have championed "errorless learning," advising teachers (and students) to create study conditions that do not permit errors. For example, a classroom teacher might drill students repeatedly on the same multiplication problem, with very little delay between the first and second presentations of the problem, ensuring that the student gets the answer correct each time.

The idea is that students who make errors will remember the mistakes and will not learn the correct information (or will learn it more slowly, if at all). Recent research shows that this worry is misplaced. Pupils actually learn better if conditions are arranged so that they *have* to make errors. Specifically, people remember things better and longer if they are given tests so challenging that they are bound to fail. This phenomenon has obvious applications for education, but the technique could be useful for anyone who is trying to absorb new material of any kind.

Test First, Study Later

Evidence for the effect comes from a new study by psychologists Nate Kornell, Matthew Hays and Robert Bjork, then at the University of California, Los Angeles, which showed that trying and failing to retrieve the answer do help in learning. As the researchers report in the July 2009 issue of the *Journal of Experimental Psychology: Learning, Memory and Cognition*, students who make an unsuccessful attempt to answer a test question before receiving the correct answer remember the material better than if they simply study the information.

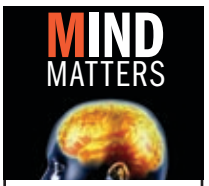
In one of the experiments, students were required to learn pairs of "weak associates"—loosely related words, such as star-night or factory-plant. The associations are weak because students who are given the first word and asked to generate an associate have only a 5 percent probability of coming up with the target word. Students who took a pretest were given the first word of each pair (star-???) and told to try to produce the second member that they would have to later remember. They had eight seconds to do so. Of course, almost by definition,

FAST FACTS

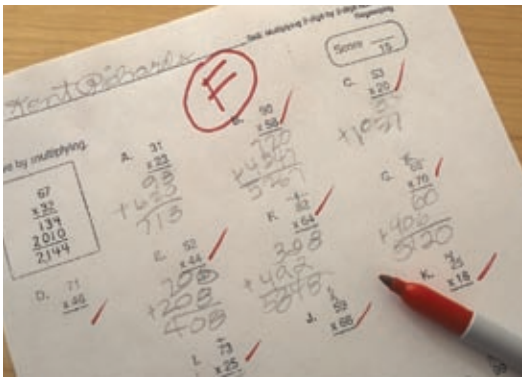
Testing before Learning

1» **Students who take tests on material before studying it remember the information better and longer than those who study without pretesting.**

2» **Anyone can use this learning technique to enhance recall of new information.**



Each week in Mind Matters, www.ScientificAmerican.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. Mind Matters is edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, where he edits the Sunday Ideas section.



Failing a test may not be all bad. If students learn the correct answers soon after they get the questions wrong, they will retain the information better in the long run.

with probability against them, they nearly always failed to think of the correct answer—they might say "bright" or "sun" in the case of star-???. After their attempt, they were given the target pair (star-night) and allowed to study the pair for five seconds. Another group of students got 13 seconds to study each pair. Thus, in both conditions, students had a total of 13 seconds of study time for each pair.

The team found that students remembered the pairs much better when they first tried to guess the answer before it was shown to them. In a way, this pretesting effect is counterintuitive: studying a pair for 13 seconds is less effective than studying the pair for five seconds if those five seconds of study follow eight seconds of trying to guess the answer. But the pretesting effect produced about 10 percent better recall when the students were tested both immediately after study and after a delay averaging 38 hours.

Memory Boost

Using word pairs is a favorite tactic of psychologists, but it may seem a far cry from a real classroom test. In a paper from the *Journal of Experimental Psychology: Applied,* psychologists Lindsey E. Richland, Kornell and Liche Sean Kao investigated the same phenomenon, but they used more educationally relevant material: an essay on vision from Oliver Sacks's book *An Anthropologist on Mars* (Vintage, 1996), commonly used in college classrooms. Some students were asked to read the essay and prepare for a test on it. Others were given a pretest: they were asked questions about a passage before reading it, such as, "What is total color blindness caused by brain damage called?"

Asking these kinds of questions before reading the passage obviously focuses students' attention on the critical concepts. The psychologists used several methods to control this "direction of attention" issue. Students who read the essay without a pretest were given additional time to study, or else the students' attention was focused on the critical passages in one of several ways: by italicizing the critical section or by making the key term that would be tested bold, or by a combination of strategies. In all the experiments, however, the researchers found an advantage in having students first guess the answers. The effect was about the same magnitude, around 10 percent, as in the previous set of experiments.

The authors took care to show that the beneficial effect from pretesting did not result from simply having seen the test questions before reading the essay but rather from attempting to answer the questions. In one of the experiments they describe in the paper, they studied a third group of students in addition to the pretested group and the extended study group. Prior to testing, this new group was asked to study the test questions carefully, try to memorize the questions and then write them down on a sheet of paper—ostensibly so they could test other students on the reading material at a later time. These question-memorizing students also performed better on the final test than the group who studied the essay without seeing the test questions, but they did not do as well as the students who attempted to answer the test questions before reading the essay.

In other words, the learning boost from pretesting seems to truly come from the attempt to answer a question and the subsequent failure to call up the information. The researchers even suggest that perhaps the enhanced retention in the memorization group was a result of the students' mental attempts to answer the questions, even though they were not instructed to do so.

Useful Techniques

This new work could be seen as an extension of the "testing effect," a well-established psychological phenomenon whereby testing students on previously learned material causes them to retain the material better than continued study does. For example, a 2006 study by one of us (Roediger) and Jeffrey D. Karpicke of Washington University in St. Louis showed that taking a memory test enhances later retention. In two experiments, students first studied prose passages. Then one group took one or three

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(The Authors)

HENRY L. ROEDIGER III is James S. McDonnell Distinguished University Professor at Washington University in St. Louis. BRIDGID FINN earned her Ph.D. in cognitive psychology at Columbia University. She is now working as a postdoctoral research fellow at Washington University.

People studying any material can benefit from asking themselves questions about the information they have not yet learned.

immediate free-recall tests, without feedback, whereas another group restudied the material the same number of times as the students who received tests. On tests later, at two days and at one week, there was a substantial difference between the groups—students who had been tested remembered around 60 percent of the material, whereas students who restudied remembered only about 40 percent of the material. The benefits of testing as a learning strategy are clear, and now the new papers from Kornell and his colleagues add to this idea the fact that testing *before* learning can improve later recall as well.

Although researchers do not yet know the neural mechanisms responsible for the testing effect, the implications of this work are obvious—rather than aiming at "errorless learning," teachers should challenge their students to try to answer questions about a subject before they study the material (a tactic bound to produce many errors). And even if this strategy is not employed in the classroom, students could use it on their own to improve their learning. Look at the questions in the back of each textbook chapter and try to answer them before reading the chapter. If there are no questions, convert the section headings to questions. For instance, if the heading is "Pavlovian conditioning," ask yourself, "What is Pavlovian conditioning?" Then read the chapter and answer the questions while reading it. When the chapter is finished, go back to the questions and try answering them again. For any you miss, restudy that section of the chapter. Then wait a few days and try to answer the questions again (restudying when you need to). Keep this practice up for an entire course, and you will have learned the material in a durable manner—you will be able to retrieve it long after you have left the course.

Of course, these are general-purpose strategies that work for any type of material, not just textbooks. By challenging ourselves to retrieve or generate answers, we can improve our recall. Keep that in mind next time you turn to Google for an answer. You might want to give yourself a little more time to come up with the answer on your own. And remember, even if you get the questions wrong as you self-test yourself during study, the process is still useful, indeed much more useful than just studying alone. Getting the answer wrong is a great way to learn—as long as you receive the correct answer shortly afterward. M

(Further Reading)

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- **Unsuccessful Retrieval Attempts Enhance Subsequent Learning.** Nate Kornell, Matthew Hays and Robert Bjork in *Journal of Experimental Psychology: Learning, Memory and Cognition,* Vol. 35, No. 4, pages 989–998; July 2009.
- **The Pretesting Effect: Do Unsuccessful Retrieval Attempts Enhance Learning?** Lindsey E. Richland, Nate Kornell and Liche Sean Kao in *Journal of Experimental Psychology: Applied,* Vol. 15, No. 3, pages 243–257; September 2009.

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Busting Big Myths in Popular Psychology

By Scott O. Lilienfeld, Steven Jay Lynn, John Ruscio and Barry L. Beyerstein

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Pop psych lore is a bewildering mix of fact and fallacy. Here we shatter some widely held misconceptions about the mind and human behavior

Popular psychology has become a fixture in our society, and its aphorisms, truths and half-truths permeate our everyday existence. A casual stroll through our neighborhood bookstore reveals dozens of self-help, relationship, recovery and addiction books that serve up heaping portions of advice for steering us along life's rocky road. About 3,500 self-help books are published every year, and numerous new Internet sites on mental health sprout up every month.

Much of this information is accurate and useful. Yet scores of popular psychology books and articles are rife with what we term "psychomythology," the collective body of misinformation about human nature. Without a trustworthy field guide for sorting psychological fact from fiction, the public may find itself at the mercy of self-help gurus, television talk-show hosts and self-proclaimed mental health experts, many of whom dispense dubious psychological information and guidance.

In our new book, *50 Great Myths of Popular Psychology:*

Parts of this article are adapted from *50 Great Myths of Popular Psychology: Shattering Widespread Misconceptions about Human Behavior,* by Scott O. Lilienfeld, Steven Jay Lynn, John Ruscio and Barry L. Beyerstein.

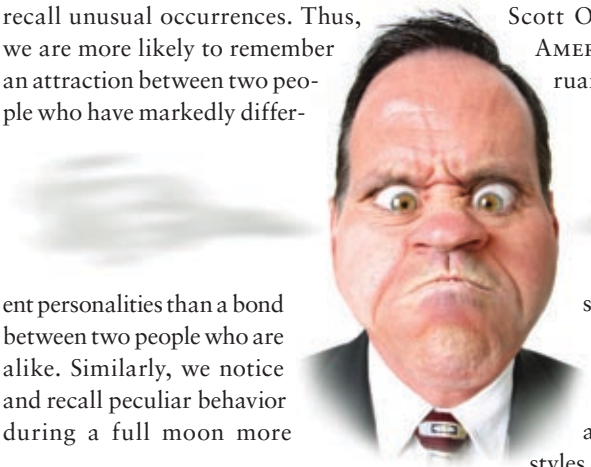
Shattering Widespread Misconceptions about Human Nature (Wiley-Blackwell, 2010), we bust 50 widespread myths of popular psychology, along with about 250 "mini myths," explore the ramifications of these fallacies in popular culture and everyday life, and trace their psychological and sociological origins.

For example, we demonstrate that the following widely held beliefs are largely or entirely false:

- Most people use only 10 percent of their brainpower.
- In romantic relationships, opposites tend to attract.
- Our memories are faithful recordings of events similar to those on a videotape or DVD.
- People with schizophrenia have multiple personalities.
- Only depressed people commit suicide.
- People tend to behave oddly during a full moon.
- All successful psychotherapy forces people to confront the "root causes" of their problems from childhood.

These notions have various origins. Some, such as the idea that we use only 10 percent of our brainpower, seem to arise in part from misinterpretations of psychological research that are trumpeted in pop psych books, articles and blogs—in this case, from a warped interpretation of decades-old and now discredited claims that scientists did not know what 90 percent of the brain did. Other mistaken beliefs probably result from selective attention and memory. For instance, all of us tend to notice and recall unusual occurrences. Thus, we are more likely to remember an attraction between two people who have markedly different personalities than a bond between two people who are alike. Similarly, we notice and recall peculiar behavior during a full moon more readily than we do ordinary actions.

Some see anger as a monster we must tame by "letting off steam." Yet expressing anger actually amplifies aggression.



Still other myths probably derive from the powerful allure of our everyday experience. For instance, our memories seem subjectively real to us, often leading us to accept their veracity without question. In fact, hundreds of studies show that our memories are subject to distortions over time [see also "Do the 'Eyes' Have It?" by Hal Arkowitz and Scott O. Lilienfeld; SCIENTIFIC AMERICAN MIND, January/February 2010].

In this article, we debunk six popular psychology myths. We deflate some of the widely expressed enthusiasm for expressing anger, different learning styles and a positive attitude as a treatment for cancer. We also discredit the belief that all alcoholics must aim for abstinence, that old age is usually characterized by sadness and mental deterioration, and that we all deal with death in an unvarying sequence of five stages.

FAST FACTS

Conventional Wisdom?

1» Scores of popular psychology books and articles are rife with what we term "psychomythology," the collected body of misinformation about human nature.

2» The authors' new book busts 50 widespread psychology myths, along with about 250 "mini myths," including "Most people use only 10 percent of their brainpower" and "People tend to behave oddly during a full moon."

3» In this article, the authors debunk six fallacies. They deflate enthusiasm for expressing anger, different learning styles and a positive attitude as a salve for cancer. They also discredit the belief that all alcoholics must aim for abstinence, that older people are unhappy and that grief emerges in five set stages.

Myth #1: Blowing Our Tops Defuses Anger

People often opine that releasing anger is healthier than bottling it up. In one survey, 66 percent of university undergraduates agreed that expressing pent-

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up anger is a good way of tamping down aggression. This belief dates back at least to Aristotle, who observed that viewing tragic plays affords the opportunity for catharsis, a cleansing of anger and other negative emotions.

Popular media also assure us that anger is a monster we must tame by "letting off steam," "blowing our top" and "getting things off our chest." In the 2003 movie *Anger Management,* the meek hero (played by Adam Sandler) is falsely accused of "air rage" on a flight, causing a judge to order him to attend an anger management group run by psychiatrist Buddy Rydell (played by Jack Nicholson). At Rydell's suggestion, Sandler's character tosses dodgeballs at schoolchildren and throws golf clubs to purge his anger.

Rydell's advice echoes the counsel of many self-help authors. One suggested that rather than "holding in poisonous anger," it is better to "punch a pillow or a punching bag. And while you do it, yell and curse and moan and holler." Some popular therapies encourage clients to scream, hit pillows or throw balls against walls when they get angry. Practitioners of Arthur Janov's "primal therapy," popularly called primal scream therapy, believe that psychologically disturbed adults must bellow at the top of their lungs or somehow otherwise release the emotional pain stemming either from the trauma of birth or from childhood neglect or suffering.

Yet more than 40 years of research reveals that expressing anger actually amplifies aggression. In one study, people who pounded nails after someone insulted them became more critical of that person than did their counterparts who did not pound nails. Other research shows that playing aggressive sports, such as football, actually boosts self-reported hostility. And a review of 35 studies by psychologist Craig Anderson of Iowa State University and psychologist Brad Bushman of the University of Michigan at Ann Arbor suggests that playing violent video games such as Manhunt, in which participants rate assassinations on a five-point scale, heightens aggression in the laboratory and in everyday social situations.

Psychologist Jill Littrell of Georgia State University concludes from a published review of the literature that expressing anger is helpful only when accompanied by constructive problem solving or communication designed to reduce frustration or address the immediate source of the anger. So if we are upset with our partner for repeatedly ignoring our feelings, shouting at him or her is unlikely to make us feel better, let alone improve the situation. But calmly and assertively expressing our resentment ("I realize you probably aren't being insensitive on purpose, but when you act that way, I don't feel close to you") can often take the sting out of anger.

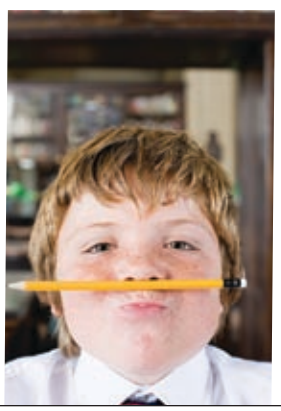
Why is this myth so popular? People probably attribute the fact that they feel better after expressing anger to catharsis, rather than to the anger subsiding on its own, which it almost always does. Odds are, they would have felt better if they had merely waited out their anger.

Myth #2: Different Strokes for Different Pupils

In the story "Parents of Nasal Learners Demand Odor-Based Curriculum," writers at the satirical newspaper *The Onion* poked fun at the idea that a teaching style exists to unlock every underperforming student's latent potential. An expert quoted in the story observed that "nasal learners often have difficulty concentrating and dislike doing homework.... If your child fits this description, I would strongly urge you to get him or her tested for a possible nasal orientation."

Plug the words "learning styles" into an Internet search engine, and you'll find scores of Web sites purporting to diagnose your preferred learning style in a matter of minutes. These sites are premised on a widely accepted claim: students learn best when teaching styles are matched to their learning styles. The popularity of this view is understandable. Rather than implying that some

Students' learning styles are difficult to reliably identify, largely because they differ greatly across situations.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students are better or worse learners overall, it suggests that all students can learn well, perhaps equally well, given just the right teaching style.

This idea has become a truism in much of recent educational theory and practice. It has been extolled in many popular books and in workshops that attract hundreds of teachers and principals. In some schools, teachers have even started giving children T-shirts emblazoned with one of the letters V, A and K, which stand for three widely accepted learning styles: visual, auditory and kinesthetic.

Yet studies show that students' learning styles are difficult to reliably identify, largely because they often differ greatly across situations. A child might display one style in art class, say, and a different one when trying to learn math.

Moreover, from the 1970s onward, most investigations have failed to show that matching teaching styles to learning styles works: for example, it does not improve students' grades in most cases. Instead certain general teaching approaches—such as setting high expectations for students and providing them with the motivation and skills to attain them—usually yield better results than other strategies, regardless of students' learning styles.

To the extent that the "matching" approach encourages educators to teach to students' intellectual strengths rather than their weaknesses, it may actually backfire. In the long run, students need to learn to compensate for their shortcomings, not avoid them. [For more on better learning techniques, see the Special Report beginning on page 32.]

Myth #3: Positive Thinking Cures Cancer

In the book *9 Steps for Reversing or Preventing Cancer and Other Diseases* (Career Press, 2004), Shivani Goodman argues that her cancer was the product of negative thought patterns—in this case, her subconscious rejection of being a woman. Once she identified her toxic attitudes, Goodman claims, she changed them into healing approaches that created "radiant health." Numerous self-help books similarly imply that a positive attitude can stop cancer in its tracks or at least slow its progression.

Most women who have survived cancer seem to agree. According to surveys, 40 to 65 percent of survivors believe their cancers were caused by stress, and between 60 and 94 percent think they became cancer-free because of their positive attitude.

The weight of the evidence, however, fails to support the notion that optimism is a salve for cancer. Most studies find no connection between cancer risk and either stress or emotions. In fact, in several investigations, researchers observed a *lower* risk of breast cancer among women who experienced relatively *high* stress in their jobs, compared with women who experienced relatively low job stress. Scientists have also consistently failed to turn up an association between positive attitude and cancer survival.

For such reasons, journalist and social critic Barbara Ehrenreich adopts a decidedly skeptical stance on the power of mind-set over healing in her book *Bright-Sided: How the Relentless Promotion of Positive Thinking Has Undermined America* (Metropolitan Books, 2009). Further, Ehrenreich rails against the "cancer culture" that pressures people with cancer to believe that being upbeat and cheerful will heal them or at least ennoble them as human beings. Instead Ehrenreich urges people with breast cancer to adopt an attitude of

Between 60 and 94 percent of cancer survivors think they became cancer-free because of their positive attitude.

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"vigilant realism" and not to bury themselves under a cosmetic veil of cheer.

The impotence of a positive outlook in the face of physical ailments calls into question the medical value of support groups and the emotional assistance they provide. Early preliminary studies seemed to suggest that participating in such groups helps to prolong life. But more recent and scientifically solid research, reviewed by University of Pennsylvania psychologist James Coyne and his colleagues, showed that psychological interventions (including support groups) do not extend the lives of cancer patients, although they can enhance their quality of life.

People with cancer can relieve their physical and emotional burdens by seeking quality medical and psychological care, connecting with friends and family, and finding meaning and purpose in every moment. They can also take comfort in the now well-established finding that their attitudes, emotions and stressful experiences are not to blame for their illness.

Myth #4: One Drink, One Drunk

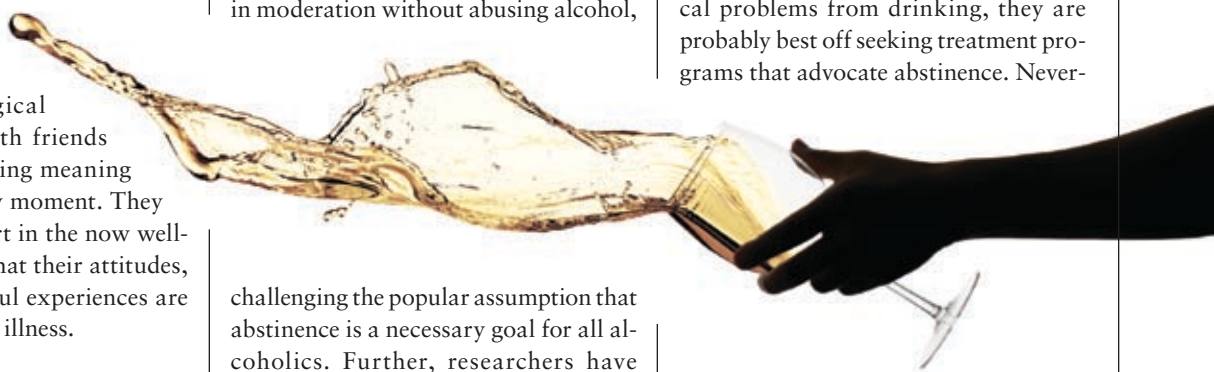
Can ex-alcoholics eventually drink in moderation without succumbing to their old addiction? One survey of more than 3,000 people reveals that only 29 percent of Americans think they can. This perception dovetails with the Alcoholics Anonymous (AA) slogan, "One drink, one drunk." AA's familiar 12-step program encourages members to admit that they are powerless over alcohol. Treatment programs premised on the 12 steps boast recovery rates as high as 85 percent. But here's the rub: as many as two thirds of drinkers drop out within three months of joining AA, and AA helps only about a fifth of people

A survey of 40,000 adults showed that 18 percent of one-time alcoholics could drink without abusing alcohol.

abstain completely from alcohol.

Claims that some people with a history of alcoholism can safely engage in "controlled drinking" have generated a firestorm of controversy. Yet a 2001–2002 National Institute on Alcohol Abuse and Alcoholism survey of more than 40,000 adults revealed that 18 percent of one-time alcoholics could drink in moderation without abusing alcohol, challenging the popular assumption that abstinence is a necessary goal for all alcoholics. Further, researchers have found that behavioral self-control training programs, in which moderate drinking is the goal, are at least as effective as those that use the 12-step method. In these restraint-centered programs, therapists train people to monitor their drinking, set limits for their alcohol consumption, control their rate of drinking and reward their progress. These programs also teach coping skills that help participants "wait out" the urge to drink and to avoid situations that tempt them to drink.

Such tactics do not work for everyone. Studies suggest that if individuals are severely dependent on alcohol, have a long history of unhealthy drinking, and experience physical and psychological problems from drinking, they are probably best off seeking treatment programs that advocate abstinence. Nevertheless, controlled drinking is probably a feasible goal for some ex-alcoholics. Indeed, problem drinkers may seek help earlier if they know that complete abstinence from alcohol is *not* the only alternative. Indeed, controlled drinking may be especially worth considering for patients for whom abstinence-oriented programs have repeatedly failed to work.



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(The Authors)

SCOTT O. LILIENFELD is professor of psychology at Emory University. He studies personality disorders, psychiatric diagnosis, evidence-based psychological practice, and questionable psychotherapeutic and diagnostic techniques. STEVEN JAY LYNN is professor of psychology at Binghamton University, where he conducts research on hypnosis, memory, fantasy and psychotherapy. JOHN RUSCIO is associate professor of psychology at the College of New Jersey, where he investigates statistical methods and the distinction between psychological science and pseudoscience. BARRY L. BEYERSTEIN passed away in 2007; as professor of psychology at Simon Fraser University, he studied myths about the brain and the use of critical thinking for evaluating psychological claims.

Myth #5: Older and Sadder

Think of someone who is depressed, cantankerous, lonely, sexually inactive and forgetful. Did an elderly person come to mind? In one survey, 65 percent of psychology students agreed that "most older people are lonely and isolated," and in another survey, 64 percent of medical students agreed that "major depression is more prevalent among the elderly than among younger persons."

Exposure to dubious media depictions of the aged begins early in life. In a study of Disney children's films, investigators found that 42 percent of elderly characters are portrayed in a less than positive light and as forgetful or crotchety. Such unflattering renderings also pervade films aimed at adolescents. In a study of popular teen movies, most elderly characters exhibited some negative characteristics, and a fifth fulfilled only off-putting stereotypes.

Contradicting these representations, one research team surveyed adults between the ages of 21 and 40 or older than 60 about their own happiness as well as about their assessment of the happiness of the average person at their current age, aged 30 and aged 70. Young adults predicted that people would become less happy as they got older. Yet older adults were actually happier than younger respondents. Population-based surveys reveal that rates of depression are highest in those between the ages of 25 and 45 and that the happiest group overall is men aged 65 and older. Happiness increases through the late 60s and perhaps even 70s. In one study of 28,000 Americans, a third of 88-year-olds reported being "very happy," and the happiest individuals surveyed were the oldest. Indeed, the odds of being happy increased 5 percent with every decade. Interestingly, research by Stanford University psychologist Laura Carstensen demonstrates that compared with younger people, older people are more likely to recall positive than negative information, perhaps accounting partly for their often surprisingly rosy outlook on life.

Older people are not generally lacking in sexual desire either. In a national survey, more than three quarters of men aged 75 to 85 and half of their female counterparts reported interest in sex. Moreover, 73 percent of people between the ages of 57 and 64 were sexually active, as were 53 percent of those 64 to 74 years old. Among 75- to 85-year-olds, 26 percent said they were sexually active.

Finally, cognitive abilities do not fade dramatically with age. We do experience some memory loss as the years pass, especially minor forgetfulness and difficulty retrieving words while speaking. Our ability to manipulate numbers, objects and images may also decline some in our later years. But even at age 80, in the absence of serious illness affecting the brain, general intelligence and verbal abilities are not much worse than they were decades earlier. Furthermore, research on creative accomplishments indicates that in some disciplines, such as history or fiction writing, many people produce their best work in their 50s or even decades later. Thus, to tweak an old saying, "You *can* teach an old dog new tricks … and a lot more."

Happiness increases through at least the late 60s. In one study, a third of 88-year-olds reported being "very happy."

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Myth # 6: A Universal Course for Dealing with Death

Legions of mental and medical health professionals who work with the elderly memorize this acronym: DABDA. It stands for the five stages of coping with death popularized by Swiss-born psychiatrist Elisabeth Kübler-Ross in

the late 1960s: *d*enial, *a*nger, *b*argaining, *d*epression and *a*cceptance. These stages describe a sequence of transitions that all people supposedly pass through on finding out they are about to die. According to Kübler-Ross, when we learn of our impending demise, we first tell ourselves it is not happening (denial), then become angry at the realization that it actually is (anger), next search in vain for a way to postpone the death, perhaps until we can accomplish a desired goal (bargaining), later become sad as the awareness that we are dying sets in (depression), and finally come to grips with our inevitable demise and accept it with equanimity (acceptance).

Many medical, nursing and social work students in North America and Britain learn about Kübler-Ross's stages as part of their professional training. These stages also pervade our culture and now extend beyond death in the popular mind-set to the psychological processing of grief from any significant disappointment. In the sitcom *Frasier,* the main character passes through all five stages of grief after losing his job as a radio talk-show psychologist. And in *The Simpsons,* Homer experiences the same sequence of emotions in a matter of seconds after a doctor informs him (erroneously) that he is dying.

Despite its popularity, Kübler-Ross's theory is surprisingly devoid of scientific support. Studies reveal that many dying patients skip one or more Kübler-Ross stages or even pass through the stages in reverse order. For example, some people initially accept their own deaths but enter denial later. Nor does research bear out the validity for these stages for grief. Not all people experience depression or marked distress after the loss of loved ones, including partners or family members to whom they were deeply attached, according to research by Columbia University psychologist George Bonanno and his colleagues. Moreover, in a 2007 study of 233 Connecticut residents who had recently lost a spouse, acceptance, not denial, was the predominant initial reaction following loss.

The process of dying does not follow the same path for all of us, any more than does the process of living.

FRANK TANCREDI *Getty Images*

Kübler-Ross stages may be appealing because they offer a sense of predictability over an event that is out of our control. The idea that the frightening experience of death can be boiled down to a set series of defined stages that culminate in tranquility is reassuring. In truth, however, the process of dying does not follow the same path for all of us, no more than does the process of living.

We can all be fooled by psychomythology, because so many of its falsehoods dovetail with our intuitions, hunches and experiences. Thus, scrutinizing popular psychology claims can provide a new window onto our mental worlds and enable us to make better life decisions. As paleontologist and science writer Stephen Jay Gould reminded us, debunking a myth necessarily unveils an underlying truth, thereby allowing us to attune our expectations more squarely with reality. In this way, taking on psychomythology, example by example, can transform us into better informed and educated citizens. M

(Further Reading)

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New Hope
for Battling Brain Cancer

Studies suggest that stem cells sustain deadly tumors in the brain—and that aiming at these insidious culprits could lead to a cure

By Gregory Foltz

In May 2006 Dwayne Berg woke up on a gurney in a Seattle emergency room, an IV in his arm and a team of doctors and nurses working him up. The last thing the 42-year-old financial executive could remember was running on a treadmill at his gym, part of his regular fitness regimen. He had suffered a seizure and tumbled off the machine, and although he had not hurt himself in the fall, doctors had asked for an MRI scan of his brain to see if they could find a cause for the seizure.

They did, and the news was not good: the scan showed a large mass in the left frontal lobe that turned out to be a malignant glioma, a brain cancer that is almost invariably fatal. Berg underwent standard treatment: an operation to remove the tumor, followed by chemotherapy and radiation to eradicate any cancer cells that might remain.

Today Berg is back to his fitness regimen, without any sign that the tumor has returned. But almost certainly it will, and when it does, current treatments offer little chance of cure.

More than 25,000 Americans are diagnosed with a malignant glioma every year, according to the Central Brain Tumor Registry of the United States. About 60 to 70 percent of these cancers occur in the deadliest form, glioblastoma, the

GUSTOIMAGES/SPL/PHOTO RESEARCHERS, INC.

Tumor stem cells can explain why cancer

type that took the life of Massachusetts Senator Edward Kennedy in August 2009, 15 months after he was diagnosed. Like Berg, Kennedy's first sign of trouble was a seizure, and of course Kennedy also received the best treatments medicine has to offer. Berg had a less aggressive form called oligodendroglioma. Other common types include astrocytomas and oligoastrocytomas, names derived from normal brain cells called oligodendrocytes and astrocytes that resemble cells in these tumors.

Progress in developing new treatments for brain cancers has been agonizingly slow. Over the past 30 years medicine has found cures for some leukemias and lymphomas and markedly reduced the death rates for breast, prostate and colon cancer through early detection and treatment. Yet only three new drugs that treat brain cancer have been approved by the U.S. Food and Drug Administration in the past 35 years, and these prolong the lives of patients by only a few months. Despite decades of research, the life expectancy of a person diagnosed with glioblastoma remains 12 to 14 months, roughly the same as it was a century ago.

But that picture may soon brighten. New research focusing on a tiny population of tumor-regenerating stem cells within brain tumors has fundamentally changed our understanding of how brain tumors develop. The discovery and characterization of these cells brings new hope that these deadly cancers can be successfully treated, possibly with drugs that are already on pharmacy shelves.

Missing Link

The goal of current brain cancer treatments is to rid the body of as many tumor cells as possible. When feasible, the first step is to surgically remove all accessible tumor tissue. Such "debulking" operations often require cutting near critical areas of the brain that, if damaged, could leave the patient severely disabled. In Berg's case, the tumor was close to his brain's speech center, Broca's area. Berg was kept awake during his operation so that I and the rest of his surgical team could talk to him and determine if we were encroaching on this area. Our strategy worked, but swelling caused by the surgery still left Berg unable to talk for two weeks, after which his speech returned slowly over several months.

Surgery is typically followed by chemotherapy and radiation, which target rapidly dividing, cancerous cells. These treatments will slow tumor growth and in some cases will shrink or eliminate the mass by triggering cell death. But most cancers recur, sometimes years later, often having acquired resistance to treatment.

Cancer recurrence after treatment has long been a mystery. Traditionally, scientists thought tumors consisted of a largely homogeneous group of rapidly proliferating cells. As a result, standard cancer therapies were designed to target and kill those cells. But recently researchers have realized that this dogma may be dramatically wrong—and in a way that explains the mystery of recurrence.

The story began in the mid-1990s, when molecular geneticist John Dick of the University of Toronto and his colleagues made an astounding observation: only a tiny fraction of the leukemia cells in a patient's blood were capable of seeding a new leukemia when they were transplanted into another animal. The rest would proliferate in a test tube but could not regenerate the vast population of leukemic cells. The regenerative minority became known as cancer stem cells.

Cancer stem cells have since been found in a variety of solid tumors, including those of the skin (melanoma), breast, ovaries, pancreas, liver, prostate, colon, and head and neck. Like the normal stem cells that help to maintain healthy tissues, the cancerous stem cells can replicate themselves and never die out. Moreover, like normal stem cells, cancer stem cells can mature into differ-

FAST FACTS

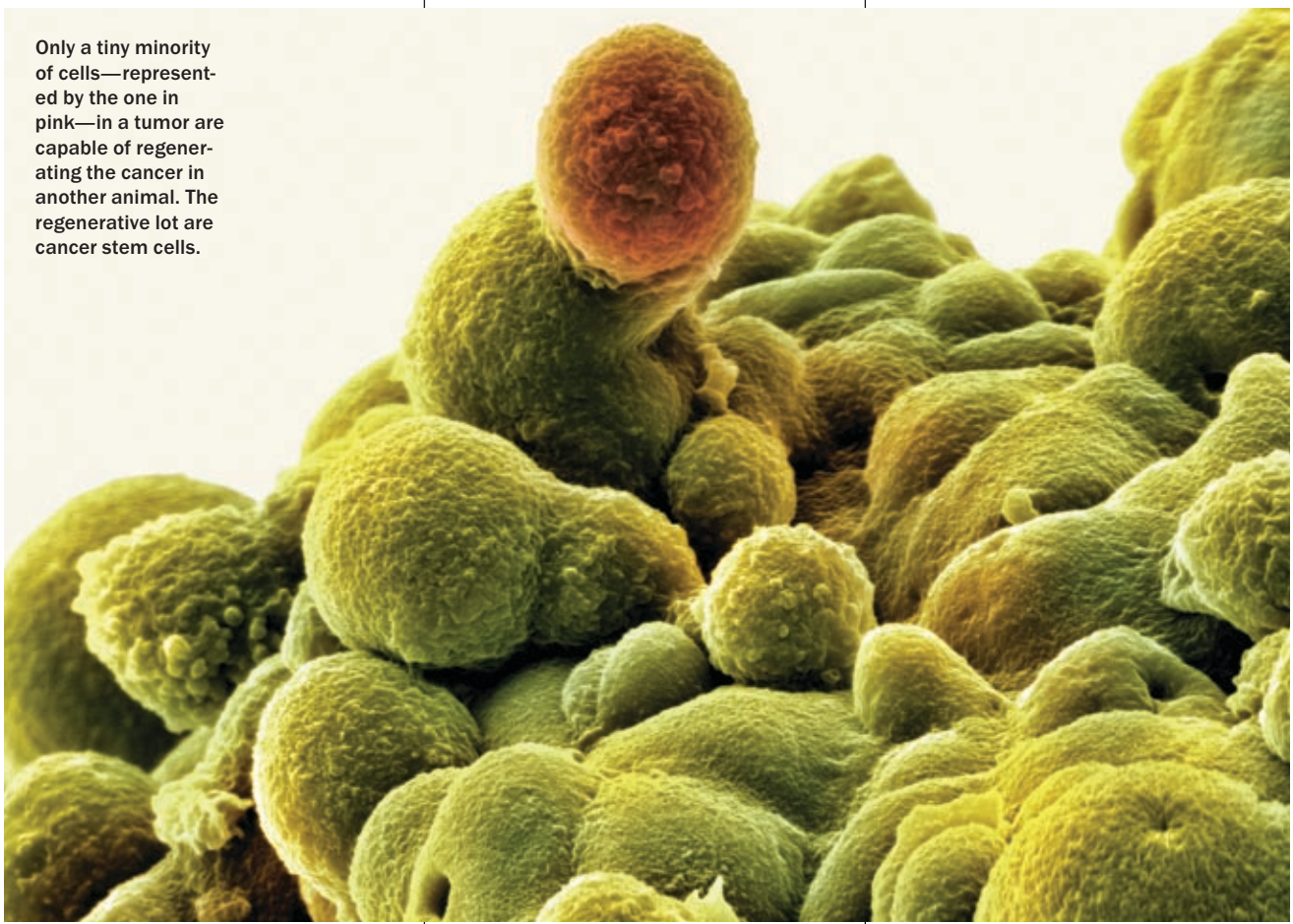
Tumor Attack

1» **More than 25,000 Americans are diagnosed with a malignant glioma every year. About 60 to 70 percent of these cancers occur in the deadliest form, glioblastoma, the type that took the life of Massachusetts Senator Edward Kennedy in August of 2009, 15 months after he was diagnosed.**

2» **Although medical science has made significant progress in treating several other cancers, the U.S. Food and Drug Administration has approved only three new drugs that treat brain cancer in the past 35 years, and these prolong lives by only a few months. The life expectancy of a person diagnosed with glioblastoma remains 12 to 14 months, roughly the same as it was a century ago.**

3» **The discovery and characterization of a tiny population of tumor-regenerating stem cells within brain tumors brings new hope that these deadly cancers can be successfully treated, possibly with drugs that are already on pharmacy shelves.**

therapies fail: they hit the **wrong cells.**



Only a tiny minority of cells—represented by the one in pink—in a tumor are capable of regenerating the cancer in another animal. The regenerative lot are cancer stem cells.

DAVID MCCARTHY SPL/Photo Researchers, Inc.

ent types of cells—in this case, the cell types found in a tumor rather than in healthy tissue. In one theory, cancer stem cells are considered to be stem cells "gone bad." According to this idea, genetic damage in normal stem cells (or in progenitor cells, which are slightly more developed than stem cells) leaves them with some of their standard reproductive traits but causes them to generate malignant instead of healthy progeny.

Many researchers now believe that cancer stem cells form the lifeblood of a cancer, sustaining the mass and giving rise to millions of new malignant cells. In addition, these stem cells share traits with normal ones that make them highly resistant to standard cancer therapies. Thus, cancer stem cells explain why standard cancer treatments so often fail: those therapies target the wrong cells.

Growth in the Brain

But for years after the discovery of cancer stem cells, few scientists thought that they played a role in brain cancer. Most cancers, such as those of the breast, lung and colon, involve active tissues in which cell proliferation is common, so biologists easily warmed to the idea that stem cells would be present to replenish those tissues. In contrast, the brain was thought to be different: it was supposedly static—devoid of growing, dividing cells, much less stem cells.

There was evidence, however, that the animal brain was not static. In the early 1980s neuroscientists Steven Goldman (now at the University of Rochester) and Fernando Nottebohm of the Rockefeller University found cells in the adult canary brain that could form new brain cells, migrate through the brain and mature into specific cell types. They speculated that these cells could be involved in learning (which appears to be true, at least in some cases).

Other researchers subsequently identified similar cells in adult rodent brains and in adult monkey brains. Then, in a 1998 publication, neuroscientist Fred Gage of the Salk Institute for Biological Studies in La Jolla, Calif., and his colleagues revealed that they had discovered comparable cells in the brains of adult humans, demonstrating for the first time that the adult human brain can

generate new tissue throughout life.

Finally, in 2003, neurosurgeon Peter Dirks of the University of Toronto and his colleagues reported spotting cancer stem cells in human brain tumors. The researchers examined human brain tumor tissue for cells bearing a protein on their surface called CD133, which is found on normal neural stem cells. Not only were cells sporting this marker present in the tumors, but those cells could replicate, proliferate and differentiate (develop into mature tissue types) much as normal stem cells do. In addition, the stem cells that copied themselves the most frequently came from patients with aggressive brain tumors.

Since that discovery, scientists have learned more about the properties of brain tumor stem cells. They make up only about 3 percent of the cells in a brain tumor and behave quite unlike other tumor cells: they do not proliferate rapidly and are relatively quiescent. But when small numbers of these cells are transplanted into a mouse brain, they can construct a tumor that is almost an exact copy of the original. Indeed, Dirks and his colleagues demonstrated in 2004 that creating a brain tumor in a mouse requires just 100 brain cancer stem cells, compared with the *one million* regular cancer cells ordinarily required.

The discovery of stem cells in brain tumors could explain several mysteries about gliomas, such as where they appear in the brain, how they spread and why they are so difficult to treat. Most gliomas, for example, tend to arise from areas where neural stem cells reside—in particular, an area at the base of the brain called the subventricular zone of the lateral ventricles. Gliomas also often spread by traveling along the white matter tracts (bundles of nerve fibers) that connect different areas of the brain; these are the same pathways that stem cells and their offspring follow. And the ability of these brain tumor stem cells to migrate and spread throughout the brain helps to explain why surgery alone cannot cure malignant gliomas: many cells simply elude the scalpel.

Moreover, other properties of cancer stem cells can clarify why malignant gliomas do not respond to standard chemotherapy and radiation. First of all, tu-

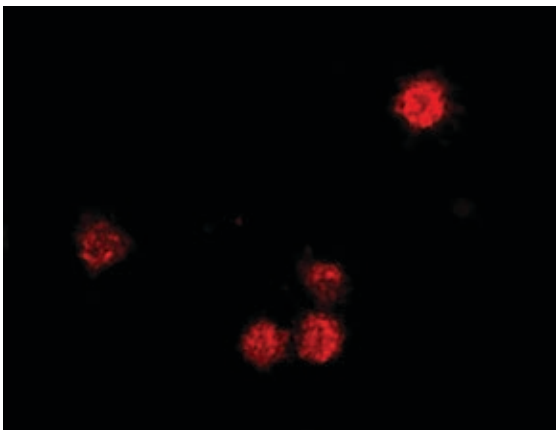
Molecules on brain tumor stem cells may

Chemotherapy and radiation target dividing cancer cells such as this one. But tumor stem cells do not multiply rapidly, making them far less sensitive to these standard therapies.

STEVE GSCHMEISSNER *SPL/Photo Researchers, Inc.*

mor stem cells divide much less often than most cancer cells. Thus, they are less vulnerable to many chemotherapy agents, which directly sabotage cell division by targeting its molecular machinery and thereby triggering cell death, and to radiation, which also preferentially kills fast-dividing cells by damaging their DNA.

Second, data suggest that glioma cells bearing the CD133 biomarker actively resist the effects of chemotherapy and radiation. Neurosurgeon John S. Yu and his colleagues at Cedars-Sinai Medical Center in Los Angeles, for example, showed in a 2006 paper that CD133-bearing cells turn on a gene for a protein that pumps chemotherapy drugs out of the cell. These cells also produce proteins that help to repair chemotherapy-induced DNA damage and that prevent cell suicide. Meanwhile a group led by neurologist Jeremy Rich, then at Duke University, reported in 2006 that when exposed to radiation, glioma cells carrying CD133 can activate a specific system that fixes radiation-induced DNA damage and can therefore initiate repair more effectively than the vast bulk of glioma cells. Thus, although standard radiation and chemotherapy treatments kill the proliferating cells that make up most of the tumor, they leave behind, unscathed, a remnant capable of regenerating the deadly mass.



Brain tumor stem cells bear a protein on their surface called CD133 (*red*) that other stem cells lack and that scientists can use to pick out these cells.

point to which drugs will kill the tumor.

Aiming at the Enemy

Nevertheless, the discovery of brain tumor stem cells offers hope to victims of brain cancer, because it suggests that treatment strategies that specifically target those cells could kill the cancer and prevent it from recurring. One of the first challenges is to find better ways to isolate brain cancer stem cells. The molecular flags on the cells—which include characteristic DNA, RNA and proteins—found as yet are not foolproof identifiers. Not all glioma cells that sport CD133 are brain cancer stem cells, and not all brain cancer stem cells carry this marker. Thus, attempts to isolate these cellular time bombs may miss some of them.

Distinguishing brain cancer stem cells from normal stem cells is important for designing therapies that eradicate the former while sparing the latter, which are crucial for regeneration, for repair and (in the brain) maybe for learning. For example, doctors might employ monoclonal antibodies—Y-shaped proteins that help to destroy invading bacteria and viruses—that target surface biomarkers unique to brain cancer stem cells. Such molecular tags might also reveal whether a brain cancer is more or less aggressive and which drugs are most likely to eradicate it. After treatment, tests that look for the presence of certain biomarkers in the blood or spinal fluid may also make it possible to detect a recurring tumor before it has had time to grow.

Researchers are also trying to understand the molecular changes that transform normal cells into a brain cancer. Their efforts could lead to drugs that prevent the cancers from developing, shrink them or stop them from spreading. To become cancerous, a cell must sustain genetic damage that alters proteins in one or more of the molecular pathways that control a cell's growth and behavior. Often a disrupted pathway interacts with other processes, leading to additional failures—and those interactions may change as the tumor grows or responds to treatment. A new approach called systems biology can help make sense of such complexity. Systems biology combines technology that can quickly analyze the activity of thousands of genes in tumor tissue with supercomputers that can identify patterns among abnormal genes, proteins and molecular pathways and then link those patterns to clinical information such as treatment and tumor type.

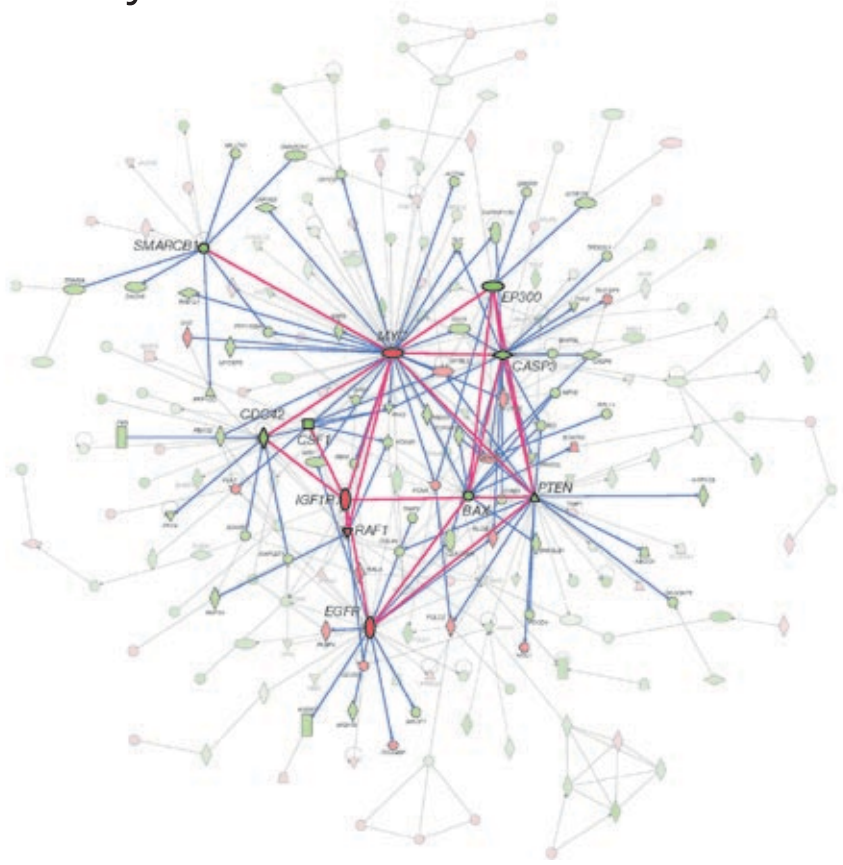
In 2009 neuro-oncologist Markus Bredel, who directs the Brain Tumor Institute Research Program at Northwestern University, and his colleagues used a systems biology approach to unearth a network of genes that appears to play an important role in malignant glioma. In an analysis of gliomas from 501 patients, they identified the most common genes and genetic abnormalities among the cancerous cells, along with their patterns

(The Author)

GREGORY FOLTZ is a neurosurgeon and director of the Ben and Catherine Ivy Center for Advanced Brain Tumor Treatment at the Swedish Neuroscience Institute in Seattle. His research interests include genomics and neuro-oncology, with a focus on the development of novel treatments for malignant brain tumors.

FROM "ANALYSIS OF GENE EXPRESSION AND CHEMORESISTANCE OF CD133+ CANCER STEM CELLS IN GLIOBLASTOMA," BY GENTAO LIU ET AL., IN *MOLECULAR CANCER*, VOL. 5; DECEMBER 2, 2006

Deadly Connections



By analyzing tissue from excised brain tumors, researchers have uncovered a complex network of 214 genes that seem to play a role in brain cancer. Within this pattern of connections are so-called hub genes (*hot pink*) that appear particularly central to the disease process and therefore are likely to be good targets for anticancer medications.

of expression. Many of the most active genes, they discovered, are involved in a complex system of interacting signaling pathways that tells a cell when to grow and when to stop. Certain patterns of gene activity in these interacting networks, they further learned, were associated with better or worse patient survival. They also identified what they called "hub" genes that seemed to be key elements in these networks, providing possible targets for future medications. A larger effort to dissect the molecular anatomy of brain cancer is under way at the Allen Institute for Brain Science in Seattle, where researchers will be creating a 3-D genetic map of these tumors [*see box on opposite page*].

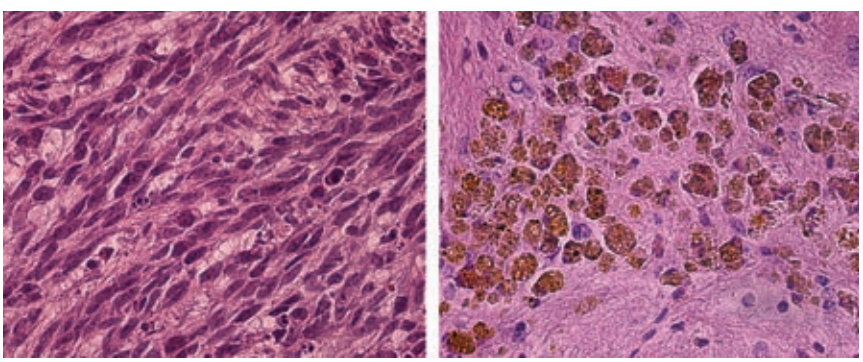
Other researchers are finding drugs that temper the toxicity of brain tumor stem cells by coaxing them into a less hazardous form. In a 2006 paper, for example, cell biologist Angelo Vescovi of the University of Milan-Bicocca in Italy and his colleagues studied the effect that a growth factor called bone morphogenetic protein (BMP) had on glioblastoma cells. In the normal brain, BMP directs cells to differentiate, mature and specialize. In their study, Viscovi's team showed that BMP had a similar effect on human glioblastoma stem cells, causing them to abandon their stem cell–like behavior and become less aggressive. In test tube experiments, BMP shrank the number of stem cells within a tumor. It also prevented the cancer cells from growing into a tumor when they were later implanted in a mouse brain. And administering BMP after a glioblastoma had been transplanted into the brain of a mouse could block the growth of the tumor and save the mouse's life.

Taking a separate tack, some investigators are targeting the vascular hideouts in which brain tumor stem cells thrive. Like neural stem cells, brain cancer stem cells appear to prefer to occupy areas with a rich blood supply. (The subventricular zone near the bottom of the brain is one such location.) To survive in less vascular regions of the brain, brain cancer stem cells release growth factors that stimulate blood vessel growth.

Some brain tumor patients are already treated with anticancer drugs that block these growth factors to inhibit this growth. One drug, bevacizumab (Avastin), which has been used to treat other cancers for many years, has now been approved for glioblastoma. Unfortunately, although tumors often appear to shrink in response to Avastin, they inevitably grow back.

Off-the-Shelf Treatments?

Intriguing new findings hint that drugs used to treat certain common psy-

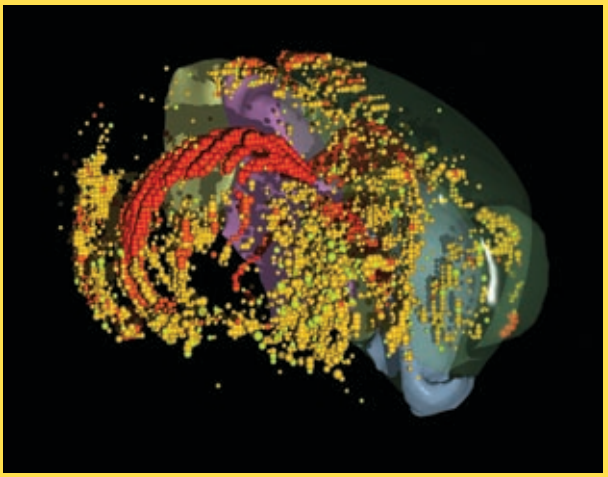


Exposing brain cancer stem cells (*left*) to a growth factor called bone morphogenetic protein causes them to assume a more mature—and less dangerous—form (*right*).

FROM "A NETWORK MODEL OF A COOPERATIVE GENETIC LANDSCAPE IN BRAIN TUMORS," BY M. BREDEL ET AL., IN *JAMA*, VOL. 302, NO. 3; JULY 15, 2009 (*gene network*); A. L. VESCOVI *Stem Cell Research Institute, Milan, Italy (micrographs)*

Mapping Brain Cancer

In a further effort to identify the genes that are key to brain cancer growth, researchers in Seattle will soon be creating a detailed map of these tumors indicating how genetic activity varies throughout each tumor mass. In this effort, called the Ivy Glioblastoma Atlas Project, doctors at Seattle's Swedish Medical Center are collecting tumor samples from 64 patients undergoing surgery to remove the deadliest form of brain tumor, glioblastoma. Investigators at the Allen Institute for Brain Science will slice the tumors into microscopically thin strips. Then, using a process called in situ hybridization, they will map onto each strip the activity of 1,000 key genes known to play a role in glioblastoma. Scientists will use these data to construct a three-dimensional digital atlas of the tumors showing which genes are being used to make proteins in their various regions. Such a map should highlight the most active molecular machinery in fast-growing areas of these masses. Active genes in those sections, as opposed to those expressed primarily in slower-growing parts, are likely to be good targets for new drugs. —*G.F.*



This image from the mouse brain atlas, a project of the Allen Institute for Brain Science in Seattle, depicts the activity of a single gene in three dimensions across the rodent cerebrum. (The colors indicate the level of the gene's activity, with red denoting high levels.) Allen Institute scientists are now creating similar 3-D maps of gene expression in the human brain and within human brain tumors.

COURTESY OF THE ALLEN INSTITUTE FOR BRAIN SCIENCE

chiatric disorders may also be effective against brain tumors—again, by targeting brain tumor stem cells. In a study published in 2009 Dirks and his colleagues created cultures of glioma neural stem cells on which they tested the efficacy of various medications. In a trial-and-error screen of 450 approved drugs, the researchers found that 23 drugs used to treat mental illnesses such as depression, anxiety and schizophrenia killed the glioma stem cells.

These drugs all block or alter the transmission or reception of neurotransmitters (substances that pass information between neurons), and that mechanism probably underlies their toxicity to brain tumors. During brain development, normal neural stem cells need certain chemical signals from their surroundings to transform into mature nervous system cells. Similarly, brain tumor stem cells depend on chemical input to survive and grow. Thus, such neuromodulatory drugs may interfere with the molecular messages that brain tumor stem cells need to multiply and mature.

Testing of these neuromodulatory drugs is still in the very early stages. Currently a major effort is under way to identify which of these compounds appear most promising by screening them against tumor cells in laboratory studies. Once the most promising drugs are identified, however, clinical trials should start reasonably quickly because many of these drugs have already been tested for safety and approved by the FDA for other purposes.

Could an antidepressant treat brain cancer? Dwayne Berg would certainly like to know. Developing a new drug typically takes decades, time that Berg and other brain cancer patients do not have. The promise of combating their disease with available medications is immediately appealing. Other new treatments that target brain cancer stem cells, too, remain unproved. Clinical trials for many of them are just getting under way. But for the first time in a long while, our new understanding of brain cancer is giving patients and doctors some degree of hope. M

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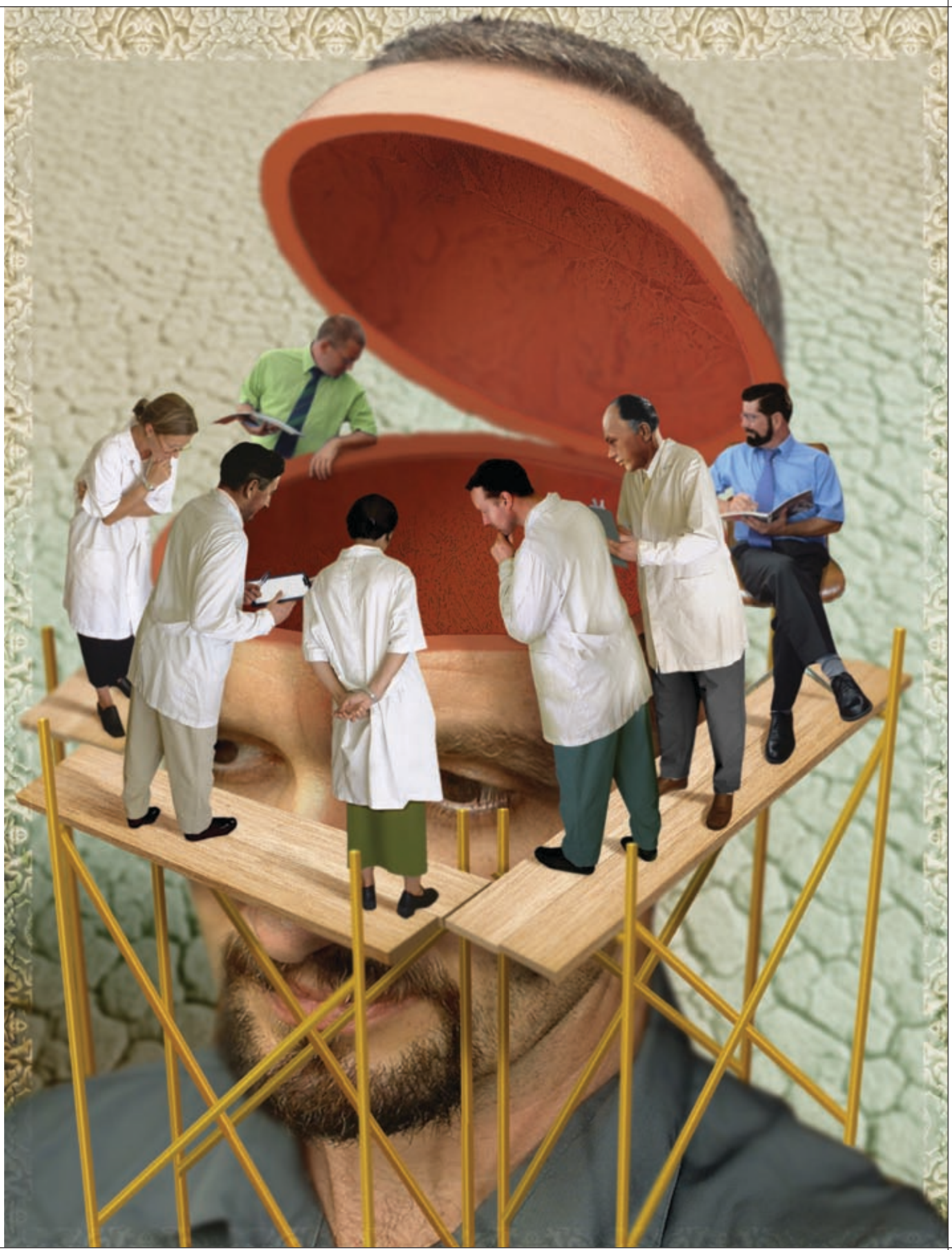

JON BERKELEY age fotostock

Are You Mentally Healthy?

Here's a new screening tool that might set your mind at ease—or get you chatting with a therapist

By Robert Epstein

More than one in four Americans suffer from a diagnosable psychiatric disorder at any given time, according to estimates from the National Institute of Mental Health (NIMH). Over our lifetime nearly one half of us suffer from such disorders. Unfortunately, nearly two thirds of our behavioral and emotional problems are never diagnosed or treated, even though in many cases effective treatment is available. More than 80 percent of people with major depression, for example, benefit substantially from a combination of medication and counseling.

When I served as editor in chief of *Psychology Today*, readers often asked me to direct them to screening tests for mental health problems. I looked for such tests on the Internet, which seemed the ideal tool for helping people find answers to questions about their mental health: Is this down feeling I'm experiencing normal? Why do I shout at my wife and kids all the time? Is my drinking out of control? Should I be seeing a therapist? I found the Internet riddled with thousands of homemade tests, but none had been scientifically validated. Worse, many of them served as marketing vehicles for videos, books or services—sending the test taker straight to a sales pitch. No broad, reliable, consumer-friendly test seemed to exist.

FAST FACTS

Mental Scorecard

1» **More than one in four Americans suffer from a diagnosable psychiatric disorder at any given time, according to estimates from the National Institute of Mental Health. Unfortunately, nearly two thirds of our behavioral and emotional problems are never diagnosed or treated.**

2» **A user-friendly test, the Epstein Mental Health Inventory (EMHI), screens people for 18 common psychiatric problems, based on criteria from the *Diagnostic and Statistical Manual* of the American Psychiatric Association, the guidebook most therapists use for making diagnoses. The test does not diagnose illness but urges those at risk to see a qualified mental health professional.**

3» **In a recent study of 3,403 individuals who took the EMHI, scores on the test predicted seven important factors related to psychological well-being.**

How to Find a Therapist

In the U.S., more than 50 different types of credentials and licenses give someone the right to practice therapy. The major professions offering therapy are psychology, psychiatry, counseling, social work, pastoral counseling, and marriage and family therapy. Some therapists have master's degrees; others have M.D.s, Psy.D.s, Ph.D.s or M.S.W.s. So, how do you find one of these professionals to help you? Here are some tips:

- If you belong to an HMO, call the organization's main number and ask to speak with a therapist. (Depending on your health plan, you may need to visit your primary care doctor first to get a referral.)
- Ask your primary care doctor, or a family member or friend whose judgment you trust, for a referral.
- Use the Internet. Web sites such as Find-a-Therapist.com, GoodTherapy.org, NetworkTherapy.com, PsychologyToday.com and TherapistLocator.net direct users to therapists in their area. Some of these directories include "expanded" listings (for which therapists pay) that have photographs and give you a feel for what each therapist is like.
- If you are in a rural area, try remote counseling. Recent studies suggest that therapy-at-a-distance—available by phone or e-mail or through live video chats—can be just as effective as in-office treatment, and it is generally much cheaper. To find a distance therapist, check Web sites such as Metanoia.org or AskTheInternetTherapist.com.
- Make sure you are dealing with a qualified, licensed practitioner, but do not worry too much about your therapist's exact degree or title; good therapists come in many different varieties. Instead stay focused on your progress. If it's going well, stay put. If not, move on. In most states, your therapist has a legal obligation to help you find another counselor.

So I created a test, now called the Epstein Mental Health Inventory (EMHI), based on the *Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition* (*DSM-IV*), the guidebook most therapists use for making diagnoses. The test covers 18 common psychiatric problems in the U.S., such as major depression, phobias, bipolar disorder and substance abuse, a selection I made using prevalence data from the NIMH, among other sources. For each disorder, the test screens for three of the *DSM-IV* criteria, which I restated in plain language.

The EMHI does not make diagnoses. Its goal is to direct individuals who might be at risk for a disorder to qualified professionals who can make diagnoses and, more important, help people feel and function better. Given how few people actually seek treatment, any legitimate way to get people to consult with a therapist would, I reasoned, have value.

Laura Muzzatti, a student at the University of California, San Diego, and I presented an evaluation of the EMHI last year. Using a sample of 3,403 people who took the test after it was posted online in 2007, we found that test scores predicted seven important factors related to mental health. These included how happy people said they are; how highly they rated their personal and professional success; whether they were employed; whether they had ever been in therapy; whether they had ever been hospitalized for behavioral or emotional problems; and whether they were currently in therapy. The scores did not differ by race, but females scored about 17 percent higher than males; that is, they seemed to have more mental health problems, a result consistent with those of other studies.

Consumers and some clinics are now using the EMHI every day. You can, too. Visit http://DoYouNeedTherapy.com for the complete test. Or take the abbreviated version, which covers 10 disorders, immediately below. Place a check next to all the statements that apply to you.

Impulse-Control Disorders

___ I am sometimes unable to control my anger.
___ I often act impulsively, and this causes me great difficulty at times.
___ I am preoccupied with gambling, and I seem to have trouble controlling my gambling behavior.

Substance Abuse

___ Over the past year I have had to drink more alcohol or take more drugs to satisfy my needs.

YELLOWDOG *age fotostock*

(The Author)

ROBERT EPSTEIN is a contributing editor for *Scientific American Mind* and former editor in chief of *Psychology Today*. He holds a Ph.D. in psychology from Harvard University and is a longtime researcher and professor. He is currently working on a book called *Making Love: How People Learn to Love, and How You Can Too*. To learn more about his work, visit http://DrEpstein.com.

Most treatable mental health problems, such as depression, are never diagnosed.

__ Over the past year I have tried but have been unable to decrease the amount of alcohol I drink, drugs I use or cigarettes I smoke.
__ Over the past year I have had to use larger and larger amounts of alcohol or drugs to get satisfaction or to cope with my problems.

Major Depression
__ For at least the past two weeks, I have found it difficult to get any pleasure from daily activities that I used to enjoy.
__ For at least the past two weeks, I have been thinking frequently about wanting to die.
__ For at least the past two weeks, I have felt depressed most of every day.

Specific Phobias
__ I suffer from an extreme fear of some object or situation, and I believe this fear may be excessive or unreasonable.
__ I am extremely afraid of some object or situation, and my fear interferes with my ability to function normally in my work or home life.
__ I am extremely afraid of an object or a particular situation, and when exposed to that object or situation I experience great fear or panic.

Social Phobias
__ I am afraid to be around other people in certain situations, and I realize that my fears may be unreasonable or excessive.
__ In certain social situations, I feel extremely anxious.
__ I am highly fearful of one or more situations in which I need to interact with other people.

Eating Disorders
__ I regularly eat a great deal and then vomit or use laxatives or other extreme means to prevent weight gain.
__ I am preoccupied with my weight or the shape of my body, and as a result I eat or exercise in ways that some people might consider unusual.
__ I am unwilling or unable to eat or to digest enough food to maintain a healthy body weight.

Post-Traumatic Stress Disorder
__ I often find myself having disturbing recollections related to a traumatic event I experienced in the past.
__ I often have disturbing dreams about a terrible experience I had in the past.
__ I sometimes find myself reliving the horror of a traumatic event I experienced in the past.

Generalized Anxiety Disorder
__ For at least the past six months, I have experienced worry and excessive nervousness that I find difficult to control.
__ For at least the past six months, I have been extremely anxious and worried about a number of different events and activities.
__ For at least the past six months, I have felt unusually restless, fatigued, irritable, tense or distractible.

Bipolar Disorder
__ Over the past year my mood has sometimes shifted without any apparent reason.
__ My mood shifts rapidly from depressed to highly elevated without any apparent reason.
__ Over the past year my mood has shifted more than once from depressed to highly elevated.

Obsessive-Compulsive Disorder
__ I repeat certain behaviors or thoughts excessively, and I can't seem to stop doing so.
__ Certain thoughts occur to me over and over again and cause me great anxiety, and I think that these thoughts might be irrational or excessive.
__ I do certain things or think certain things over and over again to calm myself or to prevent something terrible from happening.

Scoring

If you left all the items blank, congratulations! Your mental health is probably first rate (although bear in mind that this is not the complete test). If you checked off one item in one or more categories, you might not need therapy, but if you have any concerns about the way you are feeling or functioning, consider seeking help from a qualified mental health professional.

If you marked two or three items in one or more categories, a visit with a mental health professional would probably be a good idea. Most treatable mental health problems, such as depression, are never even diagnosed, which means many people are suffering unnecessarily. You can find a qualified therapist through a physician or with the help of a variety of powerful new Internet directories [*see box on opposite page*]. M

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MIND MATTERS

Each week in Mind Matters, www.Scientific-American.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. Mind Matters is edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, where he edits the Sunday Ideas section.

The Brain and the **Written Word**

A cognitive neuroscientist explains his quest to understand how reading works in the mind—and how the brain is changed by education and culture

Interview by Gareth Cook

PATRICK IMBERT, © COLLÈGE DE FRANCE

Stanislas Dehaene holds the chair of experimental cognitive psychology at the Collège de France, and he is also director of the INSERM-CEA Cognitive Neuroimaging Unit at NeuroSpin, the most advanced neuroimaging research center in France. Dehaene is best known for his research into the cerebral basis of numbers, popularized in his book The Number Sense: How the Mind Creates Mathematics *(Oxford University Press, 1999). In his new book,* Reading in the Brain: The Science and Evolution of a Human Invention *(Viking Adult, 2009), he describes his quest to understand an astounding feat that most of us take for granted: translating marks on a page (or a screen) into language. Mind Matters editor Gareth Cook recently talked with Dehaene about how the art of reading reveals the fundamental relationship between our cultural inventions and our evolved brain.*

SCIENTIFIC AMERICAN MIND: How did you become interested in the neuroscience of reading?

STANISLAS DEHAENE: One of my longtime interests concerns how the human brain is changed by education and culture. Learning to read seems to be one of the more important changes that we impose on our children's brains. The impact that it has on us is tantalizing. Reading raises very fundamental issues of how the brain and culture interact.

As I started to do experimental research in this domain, using the different tools at my disposal—from behavior of patients, functional magnetic resonance imaging [fMRI], changes in electrical activity measured by electroencephalography [EEG] and even intracranial electrodes embedded under the skull—I was struck that we always found the same areas involved in the reading process. I began to wonder how it was even possible that our brain could adapt to reading, given that the brain obviously did not evolve for that purpose. The search for an answer resulted in this book. In the end, reading forces us to propose a very different relationship between culture and the brain.

MIND: How does this new relationship differ from more traditional views of culture and the brain?

DEHAENE: A classical, though often implicit, view in social science is that the human brain, unlike that of other animals, is a learning machine that can adapt to essentially any novel cultural task, however complex. If this idea is correct, we humans would be liberated from our past instincts and free to invent entirely new cultural forms.

What I am proposing is that the human brain is a much more constrained organ than we think and that it places strong limits on the range of possible cultural forms. Essentially the brain did not evolve for culture, but culture evolved to be learnable by the brain. Through its cultural inventions, humanity constantly searched for specific niches in the brain, wherever there is a space of plasticity that can be exploited to "recycle" a brain area and put it to a novel use. Reading, mathematics, tool use, music, religious systems—all might be viewed as instances of cortical recycling.

Of course, this view of culture as a constrained "LEGO game" is not novel. It is deeply related to the structuralist view of anthropology, as exemplified by the late Claude Lévi-Strauss, which posits that any cultural phenomenon can be understood in terms of certain structures that are ubiquitous around the world. What I am proposing is that the universal structures that recur across cultures—mythology, marriage traditions, language—are, in fact, ultimately traceable to specific brain systems.

In the case of reading, the shapes of our writing systems have evolved toward a progressive simplification while remaining compatible with the visual-coding scheme that is present in all primate brains. A fascinating discovery, made by American neuroscientist Marc Changizi of the Rensselaer Polytechnic Institute, is that all the world's writing systems use the same set of basic shapes. Recordings of neurons in macaques show that several of these shapes are already a part of the visual system in all primates, because they are also useful for coding natural visual scenes. The monkey brain already contains neurons that preferentially respond to an "alphabet" of these naturally occurring shapes, including T, L and Y. We merely "recycle" these shapes (and the corresponding part of the cortex) and turn them into a cultural code for language. [For more on Changizi's work, see "Origins," by Melinda Wenner; Reviews, Scientific American Mind, July/August 2009.]

MIND: In your new book, you describe a part of the brain as the "letterbox." Can you please explain what you mean by that?

DEHAENE: The letterbox, also called the "visual word-form area" in the scientific literature, is the nickname I have given to a brain region that systematically responds whenever we read words. It is in the left hemisphere, on the inferior face, and belongs to a broader set of visual areas that help us recognize our environment. This particular region specializes in written characters and words. What is fascinating is that it is at the same location in all of us—whether we read Chinese, Hebrew or English, whether we've learned with whole-language or phonics methods, a single brain region seems to take on the function of recognizing the visual word.

MIND: But reading is a relatively recent invention, so what was the letterbox doing before we had written language?

BEGSTEIGER *age fotostock*

The printed word activates the same region in everyone's brain, regardless of their native language.

Kids learn to read best letter by letter, rather than in whole words, because the brain is already equipped to recognize the basic natural shapes on which all writing systems are based.

BIDDIBOO Getty Images

DEHAENE: An excellent question—we don't really know. The whole region in which this area is inserted is involved in invariant visual recognition—it helps us recognize objects, faces and scenes (regardless of the lighting or other superficial variations).

We are starting to do brain-imaging experiments in people who are illiterate, and we find that this region, before it responds to words, has a preference for pictures of objects and faces. We are also finding that this region is especially attuned to small features present in the contours of natural shapes, such as the Y shape in the branches of trees. My hypothesis is that our letters emerged from a recycling of those shapes at the cultural level. The brain didn't have enough time to evolve "for" reading—so writing systems evolved "for" the brain.

MIND: How might our brain's abilities and limits shape other activities such as mathematics?

DEHAENE: I dedicated a whole book, *The Number Sense,* to our native intuitions of numbers and how they shape our mathematics. Basically, we inherit from our evolution only a rudimentary sense of number. We share it with other animals, and even infants already possess it in the first few months of life. But it is only approximate and nonsymbolic—it does not allow us to precisely distinguish 13 from 14 objects. Nevertheless, it gave humanity the concept of number, and we then learned to extend it with cultural symbols such as digits and counting words, thus achieving a more precise way of doing arithmetic.

We can still find traces of this evolutionarily old system whenever we approximate, sometimes quite irrationally—for instance, when we let go of $1,000 on an apartment sale (because it seems a small percentage of the total) while bargaining hard to obtain a carpet at $40 instead of $50!

Higher mathematics must be constrained in a similar manner by our evolutionary tool kit. Complex numbers, for instance, were deemed "imaginary" and impossible to understand until a mathematician found that they could be described intuitively on a plane—an easy-to-grasp concept for the brain.

MIND: What does this research tell us about how reading should be taught? And does it tell us anything, more generally, about how best to educate?

DEHAENE: Both my books, *The Number Sense* and *Reading in the Brain,* point to the fact that young children are more competent than we think. Learning is not the furnishing of the mind's white paper, as John Locke said. Even for an activity as novel as reading, we do not learn from scratch but by minimally changing our existing brain circuits, capitalizing on their preexisting structure. Thus, teachers and teaching methods should pay more attention to the existing structure of the child's mind and brain.

In the case of reading, very concretely, as I explain in the book, we now have plenty of evidence that the whole-language approach—in which children are taught entire words rather than graphemes (letters) and phonemes (fundamental sounds such as "th")—has nothing to do with how our visual

(The Author)

GARETH COOK is a Pulitzer Prize–winning journalist at the *Boston Globe*. He edits Mind Matters, an online commentary blog at www.ScientificAmerican.com/Mind-and-Brain.

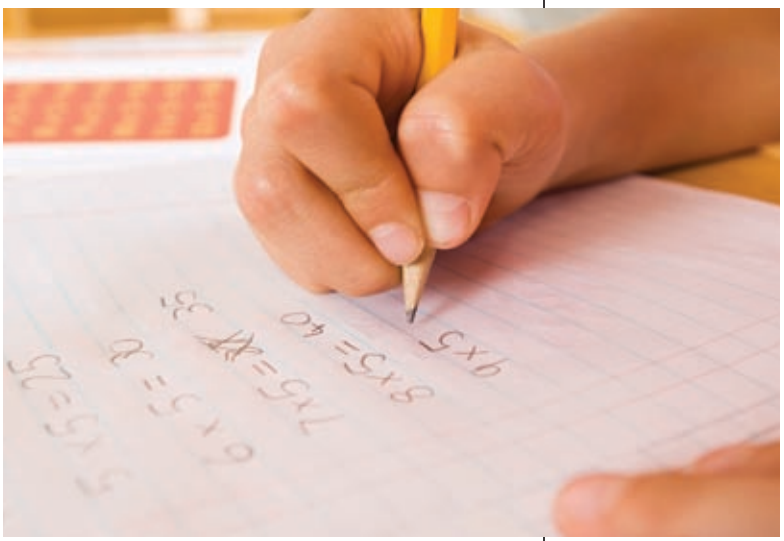
system recognizes written words. Our brain never relies on the overall contours of words; rather it decomposes all of a word's letters in parallel, subliminally and at a high speed, thus giving us an illusion of whole-word reading. Experiments even suggest that the whole-language method may orient learning toward the wrong brain region, one in the right hemisphere that is symmetrical to the left hemisphere visual word-form area—the letterbox.

We need to inform our teaching with the best brain science—and we also need to develop evidence-based education research, using classroom experiments to verify that our deductions about teaching methods actually work in practice. Theory, experiments on brain circuitry for reading, and education research all currently point to the superiority of grapheme-phoneme teaching methods. [For more on learning, see the Special Report beginning on page 32.]

MIND: What is happening in the brain of dyslexics? Are they reading differently or simply more slowly?
DEHAENE: The dyslexic brain shows disorganized circuitry in the left temporal lobe. In most dyslexic children, the phonological circuitry of the left hemisphere seems subtly disorganized, and this seems to cause a failure to learn to properly interconnect visual letter recognition with speech sounds. As a result, their visual word-form area does not develop fully, or it does not develop at the normal speed. They continue to read serially, letter by letter or chunk by chunk, at an age where parallel reading is well established in normal readers.

We should never forget, however, that there is great variation in dyslexia—so some children probably suffer from other difficulties, for instance, related to the spatial organization of the word. Some children appear to mix left and right or to be unable to focus on the letters sequentially from left to right without error, and this might be an additional cause of dyslexia, though somewhat less frequent than the phonological problem.

MIND: And if the brain of a dyslexic is organized differently, does that suggest it might have other abilities—or is dyslexia purely an impairment?
DEHAENE: The answer is not fully known, but I was intrigued by recent research indicating that dyslexic children and adults can perform better on tasks of symmetry detection—they have a greater ability to notice the presence of symmetrical patterns. The evidence even suggests that this skill was helpful in a group of astrophysicists to detect the symmetrical spectrum of black holes!



JUPITERIMAGES

Like the letters of an alphabet, mathematical symbols are a cultural invention that extends the brain's innate capabilities.

My theory is that mirror recognition is one of the functions that we have to partially "unlearn" when we learn to read—it is a universal feature of the primate brain that is, unfortunately, inappropriate in our alphabet where letters such as p, q, d and b abound. By somehow managing to maintain this ability, dyslexics might be at some advantage in visual, spatial or even mathematical tasks.

More generally, we are touching here on the very interesting issue of whether the cultural "recycling" of brain areas makes us lose some abilities that were once useful in our evolution. The brain is a finite system, so although there are overwhelming benefits of education, there might also be some losses. We are currently doing experiments with Amazon Indians, in part to test what their native abilities are and whether, in some domains such as geometry and spatial navigation, they might not be better than us.

MIND: Having done all this research, do you find yourself reading differently now or experiencing it differently?
DEHAENE: Not really. Reading has become so automatic as to be inconspicuous: as an expert reader, you concentrate on the message and no longer realize the miracles that are worked out by your brain. I am always in awe, however, when I watch young children decipher their first words—the pride on their face is a living testimony to the wonders of reading. **M**

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Living with Schizophrenia

A diagnosis of schizophrenia is not always grounds for despair

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); COURTESY OF HAL ARKOWITZ (*Arkowitz*); BOB THOMAS *Getty Images* (*couple*)

A DECADE AGO psychologist Ronald Levant, then at Nova Southeastern University, was telling some of his colleagues at a conference about patients with schizophrenia whom he had seen recover. One of them asked rhetorically, "Recovery from schizophrenia? Have you lost your mind, too?"

Until recently, virtually all experts agreed that schizophrenia is always, or almost always, marked by a steady downhill progression. But is this bleak forecast warranted? Certainly schizophrenia is a severe condition. Its victims, who make up about 1 percent of the population, experience a loss of contact with reality that puts them at a heightened risk of suicide, unemployment, relationship problems, physical ailments and even early death. Those who abuse substances are also at risk for committing violent acts against others. Contrary to popular belief, people with schizophrenia do not have multiple personalities, nor are they all essentially alike—or victims of poor parenting [*see box on opposite page*].

Nevertheless, research has shown that with proper treatment, many people with schizophrenia can experience significant, albeit rarely complete, recovery from their illness. Many can, for example, live relatively normal lives outside a hospital, holding down a job and socializing periodically with family and friends. As psychiatrist Thomas McGlashan of Yale University concluded in a prescient 1988 publication, "The certainty of negative prognosis in schizophrenia is a myth."

From Desperation to Hope

Around 1900 the great German psychiatrist Emil Kraepelin wrote that schizophrenia, then called dementia praecox (meaning "early dementia"), was characterized by an inexorable downward slide. In 1912 another doctor, A. Warren Stearns, wrote of the "apparent hopelessness of the disease." Some treatments of the day, which included vasectomy and inducement of intense fever using infected blood, reflected this sense of desperation. An attitude of gloom pervaded the field of schizophrenia research for decades, with many scholars insisting that improvement was exceedingly rare, if not unheard of.

Yet experts have lately come to understand that the prognosis for patients with schizophrenia is not uniformly dire. Careful studies tracking patients over time—most of whom receive at least some treatment—suggest that about 20 to 30 percent of people recover substantially over years or decades. Although mild symptoms such as social withdrawal or confused thinking may persist, these individuals can hold down jobs and function independently without being institutionalized.

In one study published in 2005 psychologist Martin Harrow of the University of Illinois College of Medicine and his colleagues followed patients over 15 years and found that about 40 percent experienced at least periods of considerable recovery, as measured by the absence of significant symptoms as well as the capacity to work, engage in social activities and live outside a hospital for a

Studies show that 20 to 30 percent of people with schizophrenia recover substantially **over years or decades**.

Schizophrenia **Fictions**

Although most people have heard of schizophrenia, many misunderstand the disorder. Here we dispel three widespread misconceptions about this troubling mental illness.

Myth #1: People with schizophrenia have multiple personalities.
Fact: This belief reflects a confusion between schizophrenia and dissociative identity disorder—once called multiple-personality disorder—a controversial diagnosis that is supposedly marked by the coexistence of multiple personalities or personality states within individuals. People with schizophrenia possess only one personality, but that personality has been shattered, with severe impairments in thinking, emotion and motivation.

Myth #2: All people with schizophrenia are essentially alike.
Fact: People with schizophrenia experience a bewildering variety of symptoms. Some suffer primarily from "positive" symptoms, such as delusions, which are fixed false beliefs—the idea, say, that government agents are following them—and hallucinations, such as hearing voices. In contrast, others mainly have "negative" symptoms, such as social withdrawal and diminished emotional and verbal expression. Still another set of patients experiences cognitive deficits—problems with paying attention, remembering and planning. Many patients' deficits span all three categories.

Myth #3: Schizophrenia is caused by family attitudes and behaviors.
Fact: In 1948 German psychoanalyst Frieda Fromm-Reichmann introduced the notion of the schizophrenia-inducing mother—one who was hostile and hypercritical—an idea that persisted for decades. Yet research has consistently failed to directly link parenting to the onset of schizophrenia, although numerous investigations suggest that intense familial criticism may hasten its relapse.

year or more. Although most patients do not go into long remissions and may even decline over time, some 20 to 30 percent of this majority experience only moderate symptoms that interfere with—but do not devastate—their ability to perform in the workplace or maintain friendships.

Improved Treatments

Contributing to this less fatalistic view of schizophrenia are the effective treatments that have become available over the past two decades. Such atypical antipsychotic medications as Clozaril (clozapine), Risperdal (risperidone) and Zyprexa (olanzapine), most of which were introduced in the 1990s, appear to ameliorate schizophrenia symptoms by affecting the function of neurotransmitters such as dopamine and serotonin, which relay chemical messages between neurons.

In addition, certain psychological interventions developed over the past few decades can often attenuate symptoms such as delusions and hallucinations. For example, cognitive-behavior therapy aims to remedy the paranoid ideas or other maladaptive thinking associated with the disorder by helping patients challenge these beliefs. Family therapies focus on educating family members about the disorder and on reducing the criticism and hostility they direct toward patients. Though not panaceas by any means, these and several other remedies have helped many patients with schizophrenia to delay relapse and, in some cases, operate more effectively in everyday life.

Who is most likely to improve? Researchers have linked a number of factors to better outcomes in patients. These include functioning successfully in their lives before the disease emerged; experiencing severe symptoms suddenly, all at once, rather than little by little; being older when the disease appeared; being female; having a higher IQ; and lacking a family history of the disorder. All these traits and features, however, allow at best modest forecasts of schizophrenia's prognosis.

Clearly, we have made considerable progress in our understanding of schizophrenia's course and are more optimistic than we have ever been about the future of those afflicted. Nevertheless, we need even more effective remedies if our aim is to bring patients back to the productive, happy lives they enjoyed before their illness struck—and shattered their sense of self. M

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

Send suggestions for column topics to editors@SciAmMind.com

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GETTY IMAGES

Extraordinary Perception

We think of people with autism as having a deficit in cognitive processing—but their distractibility could also result from having enhanced perceptual capabilities

BY WRAY HERBERT

Most people do not pay much attention to the intricate details of highway intersections, but such minutiae may be noticed and remembered by people with autism or Asperger's syndrome.

MATT MENDELSON (*Herbert*); ALAN SCHEIN PHOTOGRAPHY *Corbis* (*road signs*)

WHEN Pulitzer Prize–winning music critic Tim Page was in second grade, he and his classmates went on a field trip to Boston. He later wrote about the experience as a class assignment, and what follows is an excerpt:

"Well, we went to Boston, Massachusetts, through the town of Warrenville, Connecticut, on Route 44A. It was very pretty, and there was a church that reminded me of pictures of Russia from our book that is published by Time-Life. We arrived in Boston at 9:17. At 11 we went on a big tour of Boston on Gray Line 43, made by the Superior Bus Company like School Bus Six, which goes down Hunting Lodge Road where Maria lives and then on to Separatist Road and then to South Eagleville before it comes to our school. We saw lots of good things like the Boston Massacre site. The tour ended at 1:05. Before I knew, it we were going home. We went through Warrenville again, but it was too dark to see much. A few days later it was Easter. We got a cuckoo clock."

Page received an unsatisfactory grade on his essay. What's more, his irate teacher scrawled in red across the top of the essay: "See me!" As he recalls in his new memoir *Parallel Play* (Doubleday, 2009), such incidents were not uncommon in his childhood, and he knew why he was being scolded: "I had noticed the wrong things."

A Question of Focus

The subtitle of Page's memoir is *Growing Up with Undiagnosed Asperger's*, and indeed Page didn't learn until age 45 that he suffers from what is called autism spectrum disorder, or ASD. ASD is usually defined by impairments in social interaction

Many people with autism and Asperger's syndrome tend to **fixate on irrelevant information** in their world.

> The people with autism were completing their work and moving on, **using their untapped capacity**.

and communication, but many people with autism and Asperger's syndrome (in which symptoms are milder) also tend to fixate on and remember seemingly irrelevant information in their world. Their attention seems to be awry, or to use Page's words, they notice the wrong things.

But why? What's going on in the autistic mind that makes the details of bus routes infinitely fascinating? Why are people like Page so easily distracted from the main act? Psychologists at University College London think that it might be a mistake to consider such distractibility as simply a deficit. To the contrary, Anna Remington and John Swettenham and their colleagues speculate that people with ASD might have a *greater* than normal capacity for perception, so that what appears as irrelevant distraction is really a cognitive bonus. They decided to test the idea in the lab.

Selective Attention

Remington and Swettenham studied a group of people with autism spectrum disorder, most of whom had Asperger's, along with normal controls. They asked all the subjects to look at a computer screen, which displayed various combinations of letters and dots forming a ring (*above*). The subjects were instructed to very rapidly determine if the letters N or X were present in the ring and then hit the corresponding key on the keyboard. Some of the circles—those with more letters—were more difficult to process than others. There were also other letters floating outside the circle, but the subjects were specifically instructed to ignore those letters. Those floating letters were the laboratory equivalent of an irrelevant distraction in the real world.

The psychologists were measuring perceptual capacity—that is why they varied the complexity of the task. As expected, everyone was slower at the task when the ring contained more letters. The researchers were also measuring distractibility. When a letter outside the ring was one of the target letters (N or X), the subjects often took a longer time finding the N or X in the ring—indicating they were distracted by the presence of a target letter in the location that they were supposed to ignore.

In an experiment, a ring of dots and letters (*two examples above*) appeared on a screen, and subjects had to indicate as quickly as possible whether the ring contained an N or an X, while ignoring the extra letter off to the side. People with autism spectrum disorder were equally as fast and accurate as the controls, and they continued to notice the extraneous letter as the task became more complex (with more letters appearing in the ring), suggesting that they have better than normal perceptual abilities.

The psychologists reasoned that as long as the subjects' total perceptual capacity was not exhausted, they would also process the irrelevant, distracting letters within their visual field. Once they had surpassed their perceptual capacity—once the ring of letters was sufficiently complex—irrelevant processing would stop. So if ASD subjects in fact have greater processing capacity, then they should process more distracting information even as the main task becomes increasingly complex.

Seeing the Bigger Picture

And that is exactly what they found. As the researchers reported online in the journal *Psychological Science*, although there was no difference among subjects in either reaction time or accuracy on the main task, those with ASD processed the irrelevant letters while solving much more complex problems. Their reaction times indicated that they were still noticing when the extra letter was an N or X, while also finding the target letter in the ring with the same speed and accuracy as the normal controls. Put another way, they weren't ignoring the main task, nor were they distracted away from it. Instead they were completing their work and moving on, using their untapped capacity.

But here's the rub. Although this increased distractibility may be a talent rather than a deficit, the psychologists point out, it nonetheless can have detrimental consequences in real-life situations. Just ask Tim Page about his uncanny facility for bus routes. M

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

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

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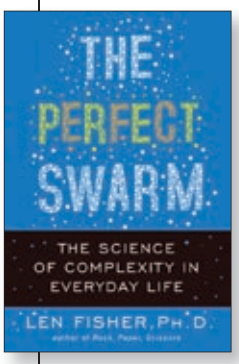
COURTESY OF ANNA REMINGTON. SOURCE: "SELECTIVE ATTENTION AND PERCEPTUAL LOAD IN AUTISM SPECTRUM DISORDER," BY ANNA REMINGTON, JOHN SWETTENHAM, RUTH CAMPBELL AND MIKE COLEMAN, IN *PSYCHOLOGICAL SCIENCE* (IN PRESS), PUBLISHED ONLINE OCTOBER 14, 2009

books

› HIVE MINDS

The Perfect Swarm: The Science of Complexity in Everyday Life

by Len Fisher. Basic Books, 2009 ($22.95)



Next time you get annoyed when you discover an army of ants marching through your kitchen pantry, think about this: these tiny insects could teach you how to make better decisions in your social, private and professional life. Sounds crazy? Not according to scientist and journalist Len Fisher. In his new book, *The Perfect Swarm,* he introduces us to the modern science of complexity—how intricate patterns grow out of simple rules. Research shows that such rules underlie the group behaviors of animals, such as bees and locusts, and Fisher explains how we can learn a thing or two from these basic laws.

At the heart of the book lies swarm intelligence, a phenomenon that results when large groups of individuals—be they robots or guppies—behave in the same way, and their collective actions (presumably unbeknownst to the individuals) become intelligent. Ant colonies provide a good example, Fisher says. In search of food, individual ants initially roam an area at random. Yet those animals that happen to be on the fastest route to a food source will return to the nest first. The pheromones they lay down on their trail then allow other ants to use that same route. By the time the remaining pioneers return to the nest, more animals will have already laid down more pheromones on the fastest route, which quickly becomes the predominant one.

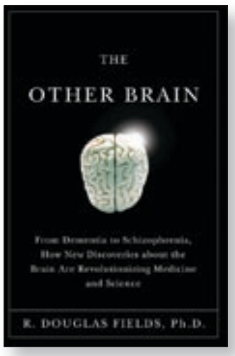
When the delivery company UPS wanted to optimize its daily driving routes, it followed the ants' lead, Fisher says, prompting drivers to learn from one another "in a way similar to ant colony routing." Using this tactic, a simple pattern emerged—trips were fastest and least accident-prone when they contained as many right turns as possible. According to Fisher, following that rule led to three million gallons of fuel savings for the company in 2006 alone and would result in tremendous savings for every one of us.

Unfortunately, not all of Fisher's examples are equally interesting, often amounting to little more than common sense. For example, simulations show that when crowds of people try to move through a narrow exit, the exit gets plugged. At other times, the advice Fisher distills from research findings seems impractical in real-life situations. But despite these shortcomings *The Perfect Swarm* is entertaining and makes an engaging read for anyone interested in learning about the rules that govern our complex lives. —*Nicole Branan*

› KEY BRAIN PLAYERS

The Other Brain: From Dementia to Schizophrenia, How New Discoveries about the Brain Are Revolutionizing Medicine and Science

by R. Douglas Fields. Simon & Schuster, 2009 ($27)

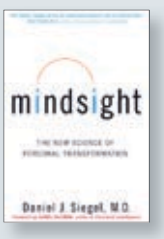


Few scientists can boast that they have held Albert Einstein's brain in their hands, but Marian Diamond, a biologist at the University of California, Berkeley, is one of the lucky ones. In the 1980s she analyzed preserved pieces of Einstein's cortex and compared them with the same brain regions in other adults. Einstein's neurons were indistinguishable from those in other brains. The only thing extraordinary about his brain came as a shock: it was a veritable explosion of nonneuronal cells called glia, which scientists had never associated with intellect. Einstein had twice as many glia as is normal—an observation that suggests that they may have been responsible for his genius.

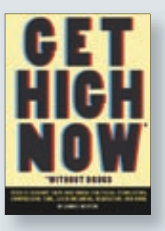
This anecdote is one of many relayed in R. Douglas Fields's new book *The Other Brain,* whose title refers to the fact that glia—Latin for "glue," because scientists had assumed the cells simply held neurons together and nourished them—have historically been an afterthought in scientists' minds. Now Fields, a neuroscientist and senior investigator at the National Institutes of Health (and a member of *Scientific American Mind*'s board of advisers), is convinced that a glial revolution is under way. Thanks in part to his own research, glia are now being uncovered as critical players in brain development, learning, memory, aging and diseases, including schizophrenia, epilepsy and Alzheimer's disease.

According to Fields, glia are like a tortoise to the neuron's hare: they do not communicate via flashy, linear electrical impulses like nerves do but in-

Brain, Alter Thyself



Research shows that the brain is quite malleable, but how can we sculpt our minds to our liking? A smattering of new books provides some insight into how to harness the power of our brains. In ***Mindsight—The New Science of Personal Transformation*** (Bantam, 2010), clinical psychiatrist Daniel J. Siegel examines "mindsight"—the ability to observe our own mental activity and modify it effectively.



If you are more interested in a quick fix, James Nestor's ***Get High Now (Without Drugs)*** (Chronicle Books, 2009) might be for you. The tongue-in-cheek book and its accompanying Web site (www.gethighnow.com) are jam-packed with mind-bending exercises that induce such tricks as lucid dreaming and optical and auditory illusions.

In ***Craving for Ecstasy and Natural Highs—A Positive Approach to Mood Alteration*** (Sage Publications, 2009), psychologist Harvey Milkman and chemist Stanley Sunderwirth explore why our relentless quest for pleasure sometimes leads us to dangerous addictions and show us healthy ways to achieve happiness.

—*Nicole Branan*

dvds

Thinking in Pictures

Temple Grandin

HBO Films

Airings throughout March

DVD available for purchase at www.hbo.com/dvd

Claire Danes as Temple Grandin

Temple Grandin doesn't like to be touched by other people. When she's feeling overstimulated, she crawls into a contraption she built that she calls her "squeeze machine." The machine is designed to mimic the calming effect of a cow's holding pen by giving her a mechanical hug. Grandin, who suffers from autism, a disorder characterized by the abnormal development of social and communication skills, stunned the crowd with this anecdote at a national autism conference in 1981. HBO Films's *Temple Grandin* tells the story of this young woman, who went on to serve on the Autism Society of America's board of directors, write best-selling books, and travel the country as an advocate both for animals and for people with autism.

Claire Danes plays a robotic, easily agitated Grandin, who finds peace as a teenager surrounded by animals on her aunt's Arizona ranch. She struggles, and throughout her life often fails, to understand people and to behave acceptably in public. In high school, she's expelled after tossing a book at the head of a teasing classmate. On the first day of college, she throws herself into a screaming panic that frightens her dorm mates.

Despite these challenges, Grandin thrives on the incredible observations granted by her condition. "I'm not like other people," she admits. "I think in pictures, and I connect them." Clever imagery helps to make her ideas accessible—for instance, layered on top of a scene of circling cattle, graphics illustrate the geometric equations she uses to design more humane livestock-handling facilities.

The film is based on two of Grandin's books and brings welcome visions to her words. "I have a gift," Grandin says. "I can see details other people are blind to." This film gives us a glimpse of what we are missing. —*Corey Binns*

stead send messages slowly using chemicals that can diffuse broadly throughout the brain, allowing them to influence many regions in complex ways. Fields explains that glia actually control much of what neurons do and, furthermore, that neurons are involved in fewer brain processes than scientists initially thought. "The rapid 'within an eyeblink' functions of our nervous system are actually a narrow slice of cognition," Fields writes. Slower processes—such as emotions, learning and aging—"operate over time scales where glia excel."

Tackling 300-plus pages about glia may sound like a daunting task, but Fields makes the experience an adventure. *The Other Brain* reads almost like a mystery: readers start by thinking of glia as witnesses to the various happenings of the brain but then slowly come to realize, through Fields's colorful anecdotes and descriptions, that they are actually the brain's primary movers and shakers. Glia have been "hidden in the blind spot of preconceived ideas," he writes. And now, as scientists learn more about them, "we are glimpsing a far greater universe of brain function than we had ever imagined."

—*Melinda Wenner*

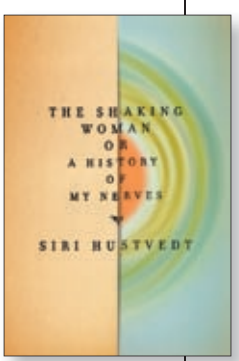
› MYSTERIOUS NERVES

The Shaking Woman or a History of My Nerves

by Siri Hustvedt.
Henry Holt, 2010 ($23)

Something strange happened to American novelist Siri Hustvedt when she was delivering a eulogy in honor of her late father a few years ago. As Hustvedt began to speak, wild spasms suddenly gripped her body, making her arms thrash and her knees knock. Bizarrely, even as she flailed uncontrollably, her voice remained calm and confident.

In the neurological memoir *The Shaking Woman or a History of My Nerves,* Hustvedt takes us on her personal journey as she tries to unravel reasons for her tremors (which mostly occur while speaking in public) and to explain the mysterious disconnect between her body and mind. Hustvedt's deeply personal narrative reads at once like a detective novel, a medical history and a scientific critique. Through her own medical mystery, she keeps the reader engaged in the science by drawing connections to fascinating case stories from the medical literature.



Plagued by bouts of shaking, Hustvedt wonders if she could be suffering from repressed grief, performance anxiety or, worse, epilepsy. "Am I looking for a narrative, a confabulation," she writes, "to interpret a debility that is no more and no less than synaptic wiring and firing?" Filled with apprehension, she decides to see a psychiatrist and a neurologist and to get her brain scanned.

As an intimate witness to Hustvedt's joys and sorrows at this point, the reader may end up wishing that the shaking will mean something on a personal level; that it's more than just a physiological hiccup. But in the end, the doctors have no clear answers for Hustvedt, just as she has none for her readers. We are left wondering about the relation between the mental and the physical, between brain science and modern psychology. With the ballooning availability of psychiatric medications to deal with neurological disorders, these connections and questions seem more important than ever. —*Frederik Joelving*

askthe**Brains**

When people have their feelings hurt, what is actually happening inside the body to cause the physical pain in the chest?
—Josh Ceddia, Melbourne, Australia

Robert Emery and **Jim Coan,** professors of psychology at the University of Virginia, reply:

TERMS SUCH AS "heartache" and "gut wrenching" are more than mere metaphors: they describe the experience of both physical and emotional pain. When we feel heartache, for example, we are experiencing a blend of emotional stress and the stress-induced sensations in our chest—muscle tightness, increased heart rate, abnormal stomach activity and shortness of breath. In fact, emotional pain involves the same brain regions as physical pain, suggesting the two are inextricably connected.

But how do emotions trigger physical sensations? Scientists do not know, but recently pain researchers uncovered a possible pathway from mind to body. According to a 2009 study from the University of Arizona and the University of Maryland, activity in a brain region that regulates emotional reactions called the anterior cingulate cortex helps to explain how an emotional insult can trigger a biological cascade. During a particularly stressful experience, the anterior cingulate cortex may respond by increasing the activity of the vagus nerve—the nerve that starts in the brain stem and connects to the neck, chest and abdomen. When the vagus nerve is overstimulated, it can cause pain and nausea.

Heartache is not the only way emotional and physical pain intersect in our brain. Recent studies show that even experiencing emotional pain on behalf of another person—that is, empathy—can influence our pain perception. And this empathy effect is not restricted to humans. In 2006 a paper published in *Science* revealed that when a mouse observes its cage mate in agony, its sensitivity to physical pain increases. And when it comes into close contact with a friendly, unharmed mouse, its sensitivity to pain diminishes.

Soon after, one of us (Coan) published a functional MRI study in humans that supported the finding in mice, showing that simple acts of social kindness, such as holding hands, can blunt the brain's response to threats of physical pain and thus lessen the experience of pain. Coan implicated several brain regions involved in both anticipating pain and regulating negative emotions, including the right anterior insula (which helps to regulate motor control and cognitive functioning), the superior frontal gyrus (which is involved in self-awareness and sensory processing) and the hypothalamus (which links the nervous system to the endocrine system).

Although the biological pathways underlying these connections between physical and mental pain are not well understood, studies such as these are revealing how intricate the connection is and how very real the pain of heartache can be.

Why is talking along with gestures so much easier than trying to talk without gesturing?
—Lionel Halvorsen, Cornith, Tex.

Michael P. Kaschak, an associate professor of psychology at Florida State University, offers an explanation:

A PERSON in a fit of rage may have trouble verbalizing thoughts and feelings, but his or her tightly clenched fists will get the message across just fine.

Gesturing is a ubiquitous accompaniment to speech. It conveys information that may be difficult to articulate otherwise. Speaking without gesturing is less intuitive and requires more thought. Without the ability to gesture, information that a simple movement could have easily conveyed needs to be translated into a more complex string of words. For instance, pointing to keys on the table and saying, "The keys are there," is much faster and simpler than uttering, "Your keys are right behind you on the countertop, next to the book."

The link between speech and gesture appears to have a neurological basis. In 2007 Jeremy Skipper, a developmental psychobiologist at Cornell University, used fMRI to show that when comprehending speech, Broca's area (the part of the cortex associated with both speech production and language and gesture comprehension) appears to "talk" to other brain regions less when the speech is accompanied by gesture. When gesture is present, Broca's area has an easier time processing the content of speech and therefore may not need to draw on other brain regions to understand what is being expressed. Such observations illustrate the close link between speech and gesture. M

Simple acts of social kindness, such as holding hands, can blunt the brain's response to threats of physical pain and thus lessen the experience of pain.

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

COURTESY OF ROBERT EMERY; COURTESY OF JIM COAN; COURTESY OF MICHAEL P. KASCHAK

Thanks to business aviation, we're bringing cancer patients closer to their cure.

"After her cancer treatment, she could not fly commercially. What a relief she could fly with Corporate Angel Network."


PHOTO BY GABE PALACIO

Through the generosity of corporations flying business aircraft, Corporate Angel Network arranges free travel for cancer patients using the empty seats on corporate jets.

This service is vitally important to cancer patients. Some simply can't afford the cost to fly commercially. Others can't handle the stress of navigating airports. Still others can't risk the exposure of crowded airports because of immune system deficiencies.

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Head Games

Match wits with the Mensa puzzlers

1 RHYME TIME

Find three rhyming words, each preceded by "a" or "an," that describe the clue words. Here's an example:

HORN	CONCORD	MASKING

The answer is a cape, a grape and a tape. What are the three rhyming words that describe each of the following trios?

a)	SAIL	ROLLED	TRENCH
b)	SUGAR	HIP	GRIND
c)	EQUUS	DORIS	HAIR
d)	INDIAN	PERPETUAL	DISCOUNT

2 BRIDAL BUDGET

Susanna was out with her bridesmaids on a shopping spree. At the first store she bought presents for the bridesmaids, spending one half of everything she had plus $4. At the second store she bought herself lace gloves, which cost half of what was left plus $2. At the third store Susanna found "something blue" and bought it for half of what she then had left plus $1. At that point she discovered that there was only $2 left, and they all went home. How much money did Susanna have when she started on the spree?

3 CRYPTOGRAM

Crack the code to reveal a message. (Hint: This cryptogram is not very complicated.)

GSRH RH MLG EVIB XLNKORXZGVW

4 TIMED TYPING

If two typists can type two pages in two minutes, how many typists are necessary to get 18 pages done in six minutes?

5 ZERO SUM GAME

Replace five of the digits below with zeros to make the sum equal 1,111.

```
  111
  333
  555
  777
+ 999
-----
1,111
```

6 WORD MAZE

Find the second line to this verse in the word maze. You can start with any letter and move in any direction, but the path cannot cross itself. Two letters are null; all other letters are used only once.

BE BOLD, BE BOLD, BUT NOT TOO BOLD

X E W O N
T S H D O
H O O E T
D L A R G
X O W O R

7 WORD SQUARE

A word square is a block of letters that form the same words when read in horizontal rows or vertical columns. For example, here is a three-letter word square beginning with "ten":

T	E	N
E	V	E
N	E	W

Complete this four-letter word square using only one letter in addition to those that are already present. (You may use any combination of the four letters already given.)

R	A	V	E
A			
V			
E			

8 RIDDLER

Find the six-letter word described in the poem below.

My first is in BOY but not in LAD,
My second in SORROW but not in SAD.
My third in HAPPY but not in JOY,
My fourth in PLAYTHING but not in TOY.
My fifth in NO and also NEVER,
My last in SHARP but not in CLEVER.
My whole you need for every day,
To work in the most efficient way.

Answers

1. a) A boat, an oat and a coat
b) A cone, a bone and a stone
c) A play, a day and a spray
d) An ocean, a motion and a promotion

2. $40.

3. "This is not very complicated."
(A = Z, B = Y, C = X, and so on.)

4. Six typists.

5.
```
  111
  333
  500
  077
+ 090
-----
1,111
```

6. Those who are do not grow old.

7. RAVE
AVER
VEER
ERRS

8. Brains.

The Partnership for a Drug-Free America®

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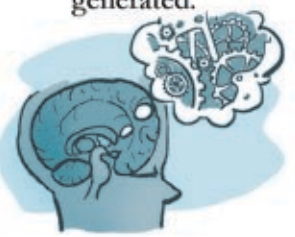
TIME TO THINK

By Dwayne Godwin and Jorge Cham

Ever wonder how your body keeps track of time?

The "master clock" in your brain is in the hypothalamus, where circadian rhythms are generated.



A cyclic reaction there between genes and proteins regulates melatonin in the pineal gland, which tells your body when to sleep.

The regularity of this cycle is very strong:

Even if you shut someone away from the outside world, their clock would still tell them when to sleep.

But we synchronize this clock to the outside world using sunlight, which activates certain chemical cues in your body.

This synchronization takes time, though, which is why people get jet lag.

But how do we PERCEIVE time?

For example,

time moves ... really slowly ... when you're doing ... something ... boring.

Yet it moves really fast when you're having fun.

Scientists believe some of the neural circuits for the *sensation* of time lie in certain cortical areas and in the basal ganglia.

Parkinson's disease and attention deficit disorder (ADD) affect this area, which may explain some of their symptoms.

Speaking of time, psychologists have found that chronic procrastinators are just as good at judging time as punctual people.

So you can't blame your brain for being late.

Aren't you supposed to be somewhere right now?

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

How Your Brain Works

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6. Cortex—Sensory, Motor, and Association Areas
7. Central Nervous System—Development
8. Central Nervous System—Cellular Organization
9. Pathways and Synapses
10. Neurotransmitters
11. Stroke
12. The Visual System—The Eye
13. The Visual System—The Cortex
14. The Auditory System
15. The Somatosensory System
16. Agnosias
17. The Motor System—Voluntary Movement
18. The Motor System—Coordinated Movement
19. Parkinson's Disease
20. Language
21. The Limbic System—Anatomy
22. The Limbic System—Biochemistry
23. Depression
24. The Reward System—Anatomy
25. The Reward System—Drugs
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29. Music and the Brain
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