ERIC KANDEL: FROM MIND TO BRAIN AND BACK AGAIN

SCIENTIFIC AMERICAN
MIND
THOUGHT · IDEAS · BRAIN SCIENCE
October/November 2007 www.sciammind.com

In Search of the God Spot
page 38

BRIGHTER BRAINS

Your IQ is higher than your parents'—which is higher than your grandparents'. Here's why.

PLUS:

Therapy 2.0

Smart Eating

Brain Stains

Skewed Vision

Page Intentionally Blank

SCIENTIFIC AMERICAN
MIND
THOUGHT · IDEAS · BRAIN SCIENCE

HOW TO CONTACT US

FOR GENERAL INQUIRIES OR TO SEND A LETTER TO THE EDITOR:
Scientific American Mind
415 Madison Avenue
New York NY 10017-1111
212-451-8200
editors@sciammind.com

Brain Changes

They seem normal enough. But how come Grandpa doesn't act retarded—and Sonny is clearly no budding Einstein?

Those questions pop up when intelligence researchers look at the startling trends in IQ scores. Massive point gains occurred from one generation to the next throughout the 20th century—a phenomenon dubbed the "Flynn effect," after psychologist James R. Flynn. The IQ gains were troubling: either today's children are far brighter than their parents, or the tests are not good measures of intelligence. To express it another way, if we put the score of today's average American at 100, then the Americans of 1900 had a mean IQ of 50 to 70, signaling an obviously implausible plague of mental retardation among our progenitors. Something must have happened, but what? Now Flynn himself offers answers in his article, "Solving the IQ Puzzle," starting on page 24.

The brain is famously adaptable, altering in response to conditions in a person's environment and to his or her life experiences. "Brain Stains," by psychologists Kelly Lambert and Scott O. Lilienfeld, reveals the dark side of that mutability. Patients who have undergone traumatic and misdirected "therapies" can suffer mentally and emotionally damaging consequences that may persist for years. Turn to page 46 for their disturbing and important account.

Of course, the power of *good* therapy is in the lasting benefits that it bestows. As psychologists Hal Arkowitz and Lilienfeld write in this issue's Facts and Fictions in Mental Health, empirically supported options such as cognitive-behavior therapy can create the kinds of positive brain changes associated with the use of antidepressant medications. Talk therapy may offer other advantages over drugs as well. The column appears on page 80.

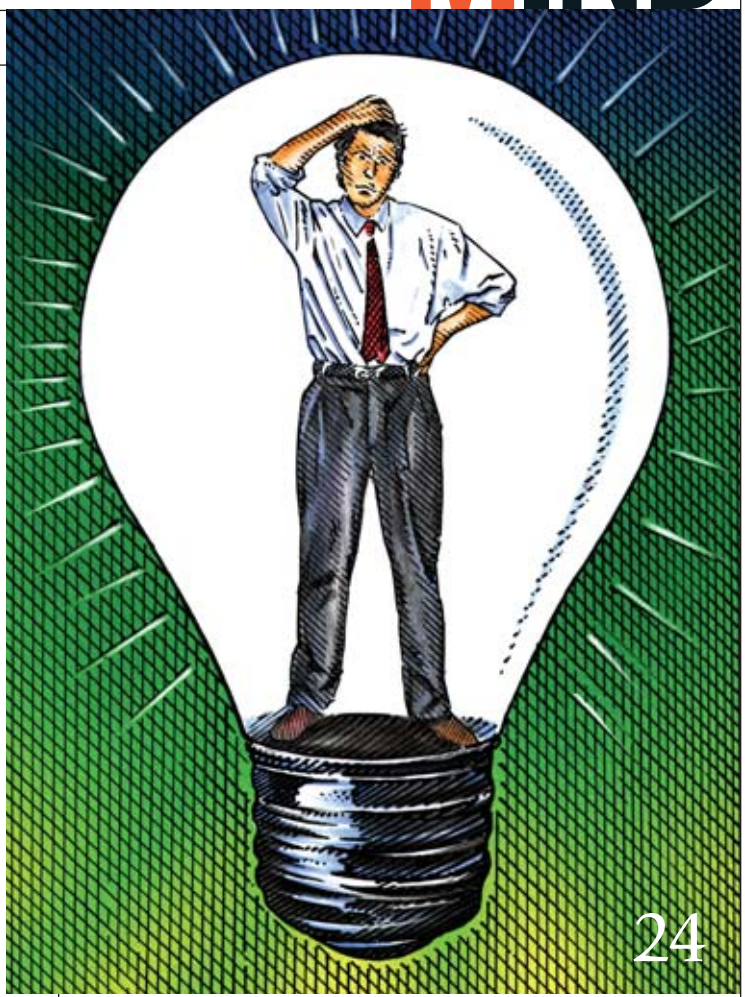
While we are on the subject of columns, I want to point you to the revamped Calendar (page 22) and Mind Reviews (page 84). We hope you find the pages more appealing and easier to use—part of our ongoing efforts to fine-tune your *Mind*.

Mariette DiChristina
Executive Editor
editors@sciammind.com

COVER IMAGE BY JOHN WILKES STUDIO

SCIENTIFIC AMERICAN MIND
Volume 18, Number 5, October/November 2007

FEATURES


24


64

DEPARTMENTS

Please Recycle This Magazine. Remove Inserts or Samples Before Recycling

Scientific American Mind (ISSN 1555-2284), Volume 18, Number 5, October/November 2007, published bimonthly by Scientific American, Inc., 415 Madison Avenue, New York, NY 10017-1111.

Periodicals postage paid at New York, NY, and additional mailing offices. Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40012504. Canadian BN No. 127387652RT; QST No. Q1015332537. Publication Mail Agreement #40012504. Canada Post: Return undeliverables to 2835 Kew Dr., Windsor, ON N8T 3B7. Subscription rates: one year (six issues), $19.95; elsewhere, $30 USD. Postmaster: Send address changes to Scientific American Mind, 415 Madison Avenue, New York, NY 10017-1111. To purchase additional quantities: U.S., $10.95 each; elsewhere, $13.95 each. Send payment to Scientific American, Dept. SAMIND07, 415 Madison Avenue, New York, NY 10017-1111. **For subscription inquiries, call (800) 333-1199. To purchase back issues, call (800) 975-0788.** Printed in U.S.A.

SCIENTIFIC AMERICAN
MIND
THOUGHT • IDEAS • BRAIN SCIENCE

VICE PRESIDENT AND PUBLISHER: Bruce Brandfon
SALES DEVELOPMENT MANAGER: David Tirpack
SALES REPRESENTATIVES: Jeffrey Crennan, Stephen Dudley, Stan Schmidt

ASSOCIATE PUBLISHER, STRATEGIC PLANNING: Laura Salant
PROMOTION MANAGER: Diane Schube
RESEARCH MANAGER: Aida Dadurian
PROMOTION DESIGN MANAGER: Nancy Mongelli

GENERAL MANAGER: Michael Florek
BUSINESS MANAGER: Marie Maher
MANAGER, ADVERTISING ACCOUNTING AND COORDINATION: Constance Holmes

ASSOCIATE PUBLISHER, CIRCULATION: Simon Aronin
CIRCULATION DIRECTOR: Christian Dorbandt
RENEWALS MANAGER: Karen Singer
FULFILLMENT AND DISTRIBUTION MANAGER: Rosa Davis

MANAGING DIRECTOR AND VICE PRESIDENT, ONLINE: Mina C. Lux
DIRECTOR, WEB TECHNOLOGIES, ONLINE: Vincent Ma
SALES REPRESENTATIVE, ONLINE: Gary Bronson

DIRECTOR, ANCILLARY PRODUCTS: Diane McGarvey
PERMISSIONS MANAGER: Linda Hertz

CHAIRMAN: Brian Napack
VICE PRESIDENT AND MANAGING DIRECTOR, INTERNATIONAL: Dean Sanderson
VICE PRESIDENT: Frances Newburg
CHAIRMAN EMERITUS: John J. Hanley

HOW TO CONTACT US

FOR ADVERTISING INQUIRIES:

Scientific American Mind
415 Madison Avenue
New York NY 10017-1111
212-451-8893
FAX: 212-754-1138

FOR SUBSCRIPTION INQUIRIES:

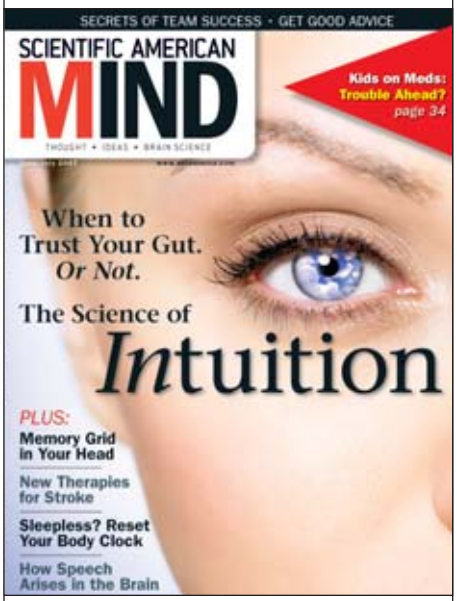
U.S. and Canada: 800-333-1199
Outside North America:
Scientific American Mind
Box 3187, Harlan IA 51537
515-248-7684
www.sciammind.com

TO ORDER REPRINTS:

Reprint Department
Scientific American Mind
415 Madison Avenue
New York NY 10017-1111
212-451-8877
FAX: 212-451-8252
reprints@sciam.com

FOR PERMISSION TO COPY OR REUSE MATERIAL FROM SA MIND:

Permissions Department
Scientific American Mind
415 Madison Avenue
New York NY 10017-1111
212-451-8546
www.sciam.com/permissions
Please allow three to six weeks for processing.



FEAR OF DYING

David G. Myers's article, "The Powers and Perils of Intuition," dealt in part with statistics; for example, women fear breast cancer more than heart disease but are more likely to die of heart disease than of breast cancer, and we fear planes more than cars, although more people die in cars than in planes. I think the author missed something central about how the brain assesses risk.

The brain does not make a fear assessment based on the likelihood of a particular event occurring; rather it does so based on the likelihood of dying if you should find yourself in a particular event. For example, when it comes to planes and cars, the brain isn't concerned with how likely it is that you will be in one or the other. Instead it is saying, "If I am in a plane crash, I will certainly die. If I am in a car crash, however, there is some decent chance that I will live because people survive car crashes all the time. Therefore, planes are scarier than cars." Along the same lines, cancer is famously lethal. Heart disease, on the other hand, feels survivable—plenty of people get heart disease and then change their diets or exercise or get bypass surgery and survive.

You can see why such thinking would be a good evolutionary mechanism: avoid the things that are most lethal regardless of how often they occur. And these fears are not set in stone. Pretend that through some scientific breakthrough, breast cancer becomes a manageable disease—a disease that you will have but that will not kill you. In that case, breast cancer would drop off the fear list even if the statistical incidence of breast cancer remained the same as it is now. It is not about how often but how lethal.

Matt Prager
Brooklyn, N.Y.

MYERS REPLIES: *Research does confirm a corollary of Prager's interesting conjecture: people make gut judgments about the likelihood of bad things happening based on their availability in our memories (a phenomenon called the availability heuristic).*

Catastrophic events such as plane crashes and terrorist violence are vivid, easily recalled incidents. We are therefore inclined to have exaggerated fears of such events—which often kill people in bunches—and to underplay our vulnerability to more mundane risks, such as smoking, driving and other threats that claim lives one by one or in the distant future. The human mind, Oliver Wendell Holmes, Jr., noted, is disposed to reason dramatically, not quantitatively.

MIRRORS FOR STROKE

We read with interest "Therapeutic Reflection," by Ferdinand Binkofski and Giovanni Buccino, about the rehabilitation of motor function after stroke. The authors describe a treatment in which patients watch a videotape of movements being carried out properly.

We fail to understand why they did not mention our prior work on a method that clearly predates theirs. We reported at the Society for Neuroscience meeting nearly a decade ago and in the journal *Lancet* in 1999 the striking recovery of function using visual feedback. In our therapy, patients try to move their paralyzed limb while watching the reflection of the unaffected limb in a mirror positioned so

that both limbs appear to be moving normally. Indeed, in a 1995 article in *Nature* we were the first to suggest the concept of using visual feedback as a powerful new tool for the rehabilitation of hemiparesis, or partial paralysis, after stroke, based on our earlier work using mirrors to mobilize phantom limbs for pain relief. As early as 1994, one of us (Ramachandran) suggested using visual feedback—employing mirrors—for stroke rehabilitation in the *International Review of Neurobiology,* Vol. 37, pages 291–333 (Academic Press).

Binkofski and Buccino used visual feedback from a video, whereas we used mirrors, but the principle is the same, and both procedures tap into the same neural system ("mirror neurons"), as suggested previously by us. The work of Binkofski and Buccino is to be applauded, but the general concept—the critical role of visual feedback—had already been established.

Vilayanur S. Ramachandran
Eric L. Altschuler
University of California, San Diego

JAILHOUSE BLUES

While reading "Rhythm and Blues," by Ulrich Kraft, I found myself applying the ideas he presented to what I consider one of the most interesting paradoxes of our society. During my undergraduate study in psychology at the University of Montana in 2001, I encountered the statistic that an estimated 70 percent of the adult male prison population suffers from antisocial personality disorder. Yet we take these people and put them in an intensely social situation wherein they have to rely every day on the goodwill of our society for everything they have.

Incarceration is also a situation in which they have no chance to learn or practice the social skills they are lacking and very little chance to be exposed to natural light. It would be interesting to see how the light therapy discussed in this article would affect this prison population.

Julie Kahl
Missoula, Mont.

MISSING THE POINT

Paul Raeburn's article "Kids on Meds: Trouble Ahead?" presented a balanced view on the issue of drugs versus no drugs for childhood mental illness. Yet like nearly all of the current debate in the media, it does not explore the core cause of low serotonin or glutamate in our children's brains. There are a host of pediatric disorders characterized by an imbalance in neurotransmitters that affect behavior, such as attention-deficit hyperactivity disorder (ADHD), autism and Asperger's, learning delay, and oppositional defiance disorder. We need to be asking *why* this is happening.

Several researchers, including Martha Herbert of Harvard University and Arthur Krigsman of New York University, are looking into metabolic dysfunction as a driver for these disorders. These biomedical researchers are finding that a combination of factors may create "brain-immuno-gut" disorders; for example, dysfunctional gastrointestinal health could lead to poor nutrient status and toxicity, altering the brain and causing autism, ADHD, learning delay, depression, anxiety and more.

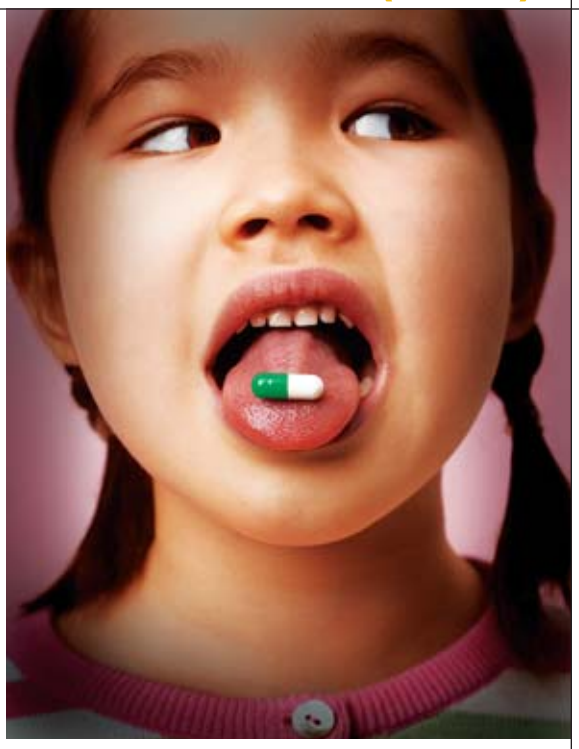
The deterioration in the health of our children attributed to pollutants, refined foods and overmedication is as big an issue as global warming is. Please consider researching and writing about this topic.

Leslie Embersits
Sydney, Australia

POLITICAL UNREST

I did a double take while reading "Right-Side Up," by Vilayanur S. Ramachandran and Diane Rogers-Ramachandran [Illusions], and it was not because of the interesting visual figures illustrating the article. My surprise was due to the authors' choice of the word "vapid" to describe George W. Bush's expression. Even as a Democrat, I find that word choice disappointing and out of place in your magazine. I would have expected more professionalism from Ramachandran, whom I respect for his insightful teaching about pain and brain disorders. I also hope that *Scientific American Mind* can avoid becoming a snide, liberal political magazine and return instead to embodying its tagline, covering "thought, ideas and brain science."

Sarah Whitman
Drexel University College of Medicine



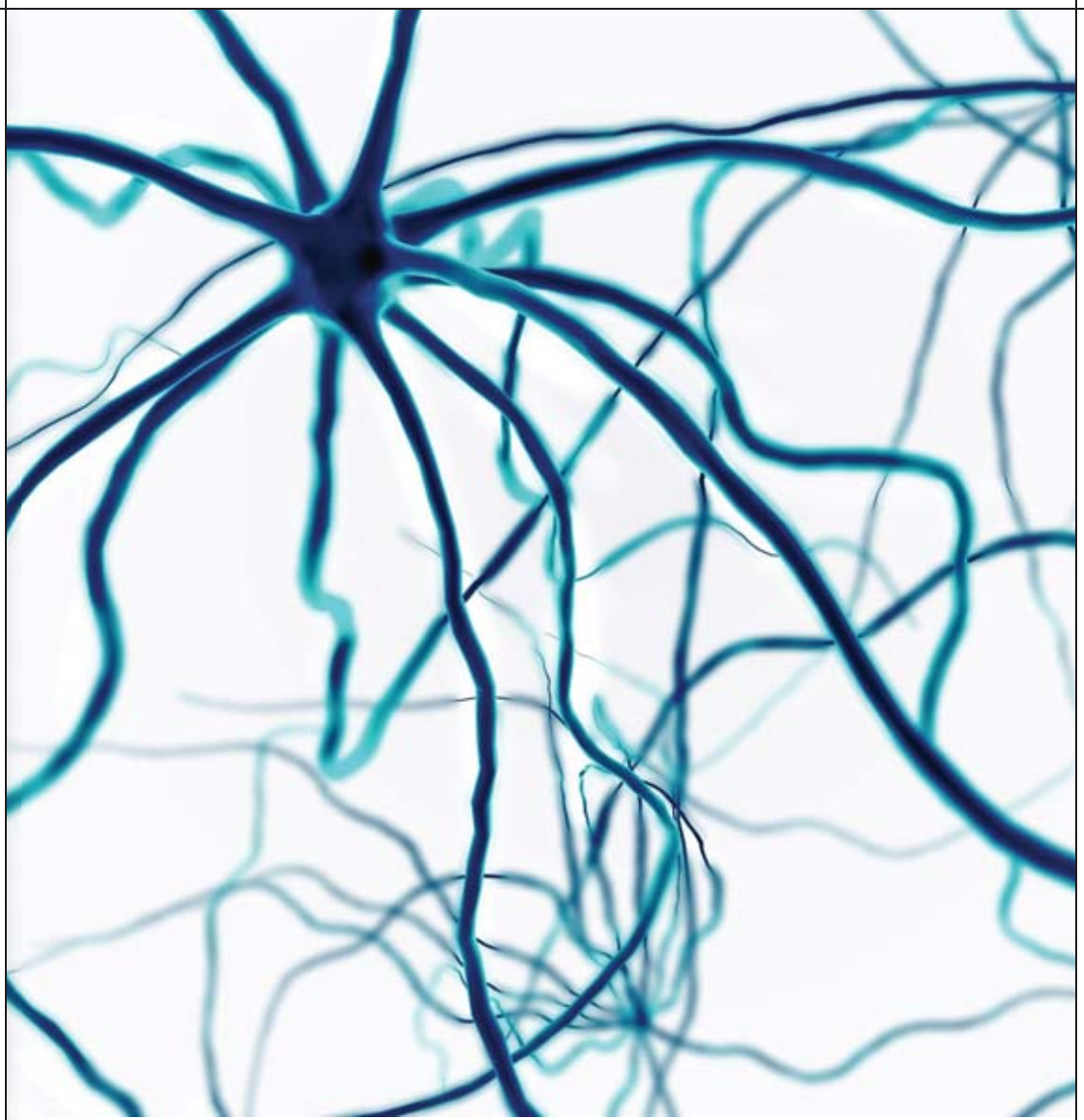
GETTY IMAGES

We debate about whether to medicate our kids. But why are they sick in the first place?

ERRATA The painting by Salvador Dalí on page 63 ("Rhythm and Blues," by Ulrich Kraft) was inverted.

In the further reading for "Betting on Consciousness," by Christof Koch and Kerstin Preuschoff, the citation for Persaud et al. lists the incorrect month of publication. "Post-Decision Wagering Objectively Measures Awareness" appeared in the February 2007 issue of *Nature Neuroscience.* The paper also appeared online January 21, 2007.

Head Lines



>> NEUROSCIENCE

The Spaces Between

Cells get all the glory, but the spaces surrounding them are important, too

What's in a brain? Neurons, chemical messengers, electric signals—and a lot of empty space. The space between cells takes up a fifth of the volume inside our brains. And although all our thoughts and mental functions traffic through this vital region, scientists are just beginning to unlock its secrets.

Neurobiologists Charles Nicholson of New York University and Eva Syková of the Institute of Experimental Medicine in Prague have developed ways to probe the unseen intercellular space in the brain. By injecting tracers and tracking their diffusion through the living brains of rats and other animals, they have discovered that about 20 percent is extracellular space, filled with cerebrospinal fluid—the same liquid that surrounds and cushions the brain and spinal cord. Nicholson and colleagues also found that diffusion is slow because the many nooks and crannies between cells impede the flow of molecules as they enter microscopic blind alleys and become trapped. Through this pattern of diffusion, chemicals released by nerve cells build up to higher concentrations, which improves communication between neurons.

Syková and her colleagues are studying the way extracellular space changes with disease and aging. Conditions producing a lack of oxygen, such as stroke, shrink the extracellular space. As the space constricts, the diffusion of substances between cells slows, and toxic substances are concentrated, impeding recovery. Aging has the same effect, and the shrinkage may be linked to learning. When Syková compared elderly rats that were fast learners in a maze test with their slower-learning peers, she found that the quick learners had lost much less extracellular space. *—R. Douglas Fields*

AGE FOTOSTOCK

>> BEHAVIOR

Pay It Forward

Animals show altruism toward strangers

LWA-PAUL CHMIELOWIEC *Corbis*

People are more likely to lend a hand to a perfect stranger if they have benefited from such kindness in the past. Now scientists have discovered that rodents show this behavior, too. A research team at the University of Bern in Switzerland trained rats to deliver food for one another by pulling a stick. Then they divided the animals into two groups: some rats received food from other animals, whereas others did not. The team observed that rats that had received help were more likely to pull the stick for unfamiliar animals—going one step beyond the well-documented "you scratch my back, I'll scratch yours" reciprocity that is seen in many species.

Studies have demonstrated this kind of altruism toward strangers—termed generalized reciprocity—in humans. For example, one experiment showed that people who found money in a telephone booth were more likely to help a stranger pick up dropped papers. But scientists have not yet figured out whether cultural experience or natural selection explains such acts of kindness. The fact that rats show generalized reciprocity hints that an evolutionary mechanism is involved, the researchers say. *—Nicole Branan*

A rat will help an unfamiliar peer get food if it has experienced similar kindness in the past.

>> PSYCHOLOGY

All in the Family

Birth order affects our personality and health

Your family—the number of siblings you have and how old they are—has a big effect on whom you become, research suggests. For one thing, there's intellect: a large Norwegian study just confirmed that first-borns have slightly higher IQs than their younger siblings do. Because the study found that second-born children whose older sibling died at a young age are also slightly smarter and because "only" children do not show this IQ advantage, the intellectual disparity is more likely to be the result of differences in a child's environment after birth than of biological effects. Scientists speculate that eldest kids communicate with and coach their younger siblings, which requires them to consolidate knowledge at a young age and potentially gives them a slight intellectual edge. These findings build upon a body of research suggesting birth order and family size influence a number of traits and risk factors. *—Melinda Wenner*

RANK	EFFECT	THEORY
Oldest or Only	More likely to end up in intellectual careers	Parents focus their encouragement on oldest children, who receive on average 20 to 30 more minutes of quality time per day than second-borns do, according to a recent Cornell University study.
Oldest	More creative	Eldest children who have many siblings close in age and of the opposite sex are exposed to playmates with a spectrum of behaviors and perspectives.
Older	More likely to develop a brain tumor	People with four or more younger siblings are twice as likely to have a brain tumor later in life, probably as a result of infections caught from younger siblings in childhood.
Younger	Funnier	More than half of people with older brothers and sisters say that they can easily make people laugh, perhaps because they had to compete for family attention. A third of those with younger siblings and only one out of 10 "only" children say they can easily get people to giggle.
Younger	More likely to be gay	The more older brothers a boy has, the more likely he is to be gay. This "fraternal order effect" is thought to stem from prenatal influences, such as male hormone levels in the womb, because boys raised with nonbiological older brothers are not more likely to be gay.

>> MEDICINE

Gene Therapy for Parkinson's

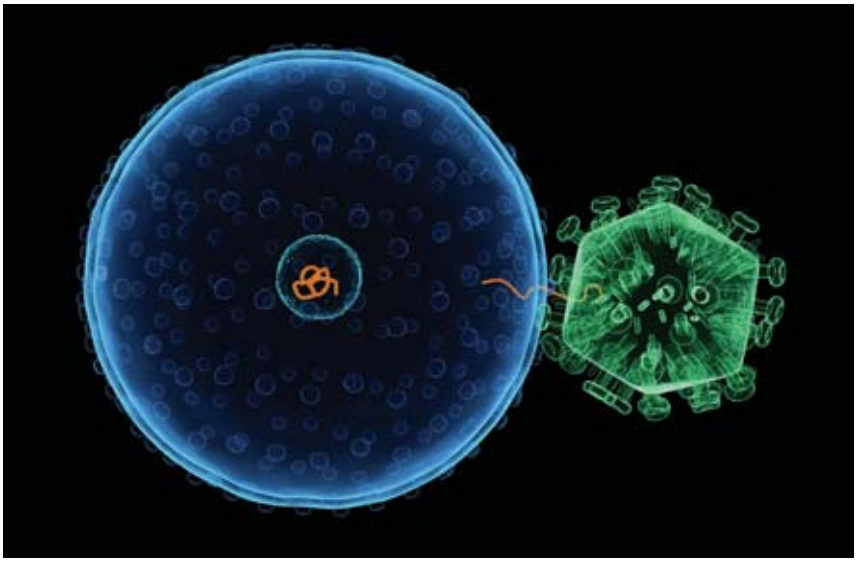
A promising new application treats symptoms with no side effects

Patients with Parkinson's disease may be the first group to benefit from gene therapy, the much hyped technique that has yet to result in a single reliable treatment despite nearly two decades of experimentation. Now researchers report that a gene-bearing virus injected directly into the brain was able to improve patients' motor function without causing any adverse side effects.

In the 1990s gene therapy was hailed as an impending revolution in medicine because of its potential to attack disease at its genetic roots. The research results did not live up to the hype, however, and in 1999 much of the remaining hope for gene therapy was destroyed when an 18-year-old boy suffered an unexpectedly severe immune reaction and died during an experiment. But small-scale research continued with new safety rules in place, and studies such as this one may give the treatment option a second life.

This trial is the first time gene therapy has been tested to fight Parkinson's, which affects an estimated 500,000 Americans. The disease, which typically strikes people in their 60s, is characterized by tremors, stiffness, loss of speech and difficulty with motor function. Neuroscientists have tracked its biological cause to the death of neurons in a midbrain region called the substantia nigra, which produces the neurotransmitter dopamine. Low levels of dopamine cause the nearby subthalamic nucleus to overproduce glutamate, the brain's primary excitatory chemical messenger. The excess glutamate overstimulates other areas of the brain, disrupting motor control.

The research team used a harmless virus to transport a gene coding for gamma-aminobutyric acid (GABA), an inhibitory neurotransmitter that counteracts glutamate's excitation, into the nerve cells of the subthalamic nucleus. By ramping up GABA production, the gene therapy corrected the chemical imbalance and drastically improved motor function in all 12 patients. Especially significant, according to the researchers, is that this improvement persisted even when the patients were taking their Parkinson's drugs—meaning the two treatments could be combined for extra impact.

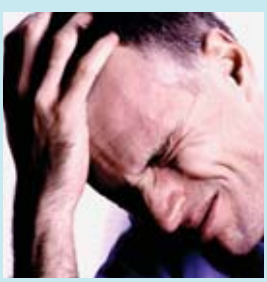


Viruses replicate by inserting their genetic material into cells. Gene therapy exploits this process, using viruses to deliver human DNA.

"The safety and effectiveness clearly indicate that this is something worth pursuing," says lead author Michael Kaplitt, a neurological surgeon at New York–Presbyterian Hospital/Weill Cornell Medical Center. "But we still need to do a larger, more definitive study to prove this for sure." Kaplitt hopes to have a large-scale trial under way by the end of the year.

—Nikhil Swaminathan

Study subjects were unable to focus on the task at hand if they had a painful hand.



>> ATTENTION

Mind under Matter

Pain wins in the battle for your brain's attention

Everyone knows that it is impossible to concentrate with a splitting headache, but now neuroscientists can explain why. Researchers at the University Medical Center Hamburg-Eppendorf in Germany have identified a region of the brain that processes both working memory and pain, and it seems to give preference to painful stimuli. Using functional magnetic resonance imaging, the researchers found that applying pain to volunteers' hands increased activity in brain areas involved in pain processing, while decreasing activity in areas that were working on the assigned visual task.

Ulrike Bingel, who led the study, says the work might have implications for pain management. When doctors decide whether to use strong painkillers such as opiates, they weigh the cognitive side effects of treatment, Bingel says, but they do not always consider that the pain itself can interfere with mental function.

—Kat Leitzell

SEBASTIAN KAULITZKI iStockphoto (top); CORBIS (bottom)

>> MEMORY

Forgetting to Remember

Forgetting is a vital brain function

Lucy? Jane? Melissa? The next time someone's name stays frustratingly on the tip of your tongue, don't feel bad—your brain is just doing its job. Forgetting not only helps the brain conserve energy, it also improves our short-term memory and recall of important details, according to two recent studies.

Stanford University scientists asked students to study 240 word pairs and then instructed them to memorize only a small subset of the list, requiring the students to selectively retain some pairs and mentally discard others. Then the researchers performed MRI scans on the participants while testing them to see how well they had learned all the pairs. Those who could most often summon the target pairs were also the worst at remembering the others, suggesting that they were better at unconsciously filtering out unwanted memories. In addition, these subjects' MRI scans showed reduced activity in the prefrontal cortex, an area associated with detecting and resolving memory conflicts.

"When we want to remember things that are relevant, we put in much less neural effort if we have forgotten the things that are irrelevant," says psychologist Anthony Wagner, a co-author of the paper. The findings suggest that memory suppression helps to conserve energy and improve efficiency—and some research indicates that efficient brains think faster.

A second study reveals that working memory, a form of short-term memory that both passively stores and actively manipulates information, benefits from an inhibition of long-term memory. Researchers investigating mice used x-rays or genetic techniques to stop the formation of new neurons in the hippocampus, which is important for long-term memory. These mice performed maze-related working-memory tasks better than normal mice did, suggesting "that by impairing one form of memory, long-term memory, it is actually possible to improve another form," says Gaël Malleret, a neuroscientist at Columbia University and co-author of the study. So if you accidentally call Lucy "Melissa," take heart—your brain probably just chose to dump her name in favor of a more crucial fact, such as where you left your keys. —*Melinda Wenner*

>> TECHNOLOGY

Shocked into Consciousness

Electronic implants may offer hope to patients with brain damage

A severely brain-injured man showed marked improvements after treatment with deep brain stimulation, a technique in which surgically implanted electrodes deliver electrical impulses to the brain. For six years the patient, who sustained head trauma during a violent assault, had been in a minimally conscious state—he could not communicate verbally, and he only sporadically seemed to be aware of himself and his surroundings. After the procedure, the 38-year-old man's attention, verbal and motor skills improved during intervals of brain stimulation, report researchers led by Nicholas D. Schiff of Weill Cornell Medical College. Over the course of a year the patient became able to speak intelligible words, chew and swallow food, and use objects in a purposeful manner (such as bringing a cup to his lips).

Although the results are promising, the researchers caution that every brain injury is unique; much more work is needed to understand whether the treatment with deep brain stimulation is truly responsible for the patient's improvement and to find out if the procedure can help others. The team is currently planning a more extensive study of 12 minimally conscious patients, to be completed in about two years. —*Amelia Thomas*

GETTY IMAGES (*top*); CLEVELAND CLINIC (*bottom*)

BRIEFS

■ **Conventional wisdom** holds that women talk more than men do—one oft-quoted statistic puts female chattering at 20,000 words a day, compared with 7,000 words for men. But that sex difference is bunk, says the first study to systematically record the natural conversations of a large population. Researchers at the University of Arizona and the University of Texas at Austin listened in on nearly 400 college students and found that both sexes spoke about 16,000 words a day.

■ **Female mice** grow new brain cells after getting a whiff of a dominant male's urine, reports a team from the University of Calgary. The alpha male's pheromones promote neurogenesis in the olfactory bulb and in the hippocampus, an area important for memory formation. The ability to recognize and remember pheromonal signatures could be important for regulating mating behavior in female mice, which prefer to mate with dominant males.

■ **Obesity** is contagious, according to a new study from Harvard Medical School and the University of California, San Diego. Sociologists followed about 12,000 people for more than 30 years and found that a person's chance of becoming obese was greatly increased if a close friend, sibling or spouse gained weight. The scientists blame shifting attitudes—a person may become more accepting of fat if someone he or she esteems packs on the pounds.

>> AGING

Anxiety and Alzheimer's

A lifetime of stress could lead to memory problems and disease

Mounting evidence indicates that chronic exposure to emotional stressors, such as anxiety or fear, can make a person more susceptible to Alzheimer's disease. The latest study comes from a team at the Salk Institute for Biological Studies in San Diego that replicated the body's reaction to mild stress by physically restraining mice for half an hour. The incident modified the tau protein, which gives neurons structural support, rendering it unable to fulfill its role. "This conversion is a key event in the development of Alzheimer's," says Robert A. Rissman, lead author of the study. After a single stress episode, tau morphed back into its original state within 90 minutes. When the team induced stress every day for two weeks, however, tau remained in its modified state long enough to allow the individual protein molecules to clump together. These protein heaps are the first step toward neurofibrillary tangles, one of the hallmarks associated with Alzheimer's.

Simply being prone to worry and tension can cause memory problems in old age, another recent study shows. Robert Wilson and his colleagues at Rush University Medical Center in Chicago evaluated the distress susceptibility of more than 1,000 elderly people by rating their agreement with statements such as "I am often tense and jittery." Over a period of up to 12 years, volunteers who were anxiety-prone had a 40 percent higher risk of developing mild cognitive impairment than more easygoing individuals did. Mild cognitive impairment is thought to be a precursor for Alzheimer's.

Brain autopsies on participants who have died did not turn up evidence of neurofibrillary tangles or any of the other known features indicative of Alzheimer's, Wilson says. But he thinks it is possible that chronic distress gradually compromises memory systems, ultimately rendering a person more vulnerable to the physical changes in the brain associated with Alzheimer's.

—Nicole Branan

>> BEHAVIOR

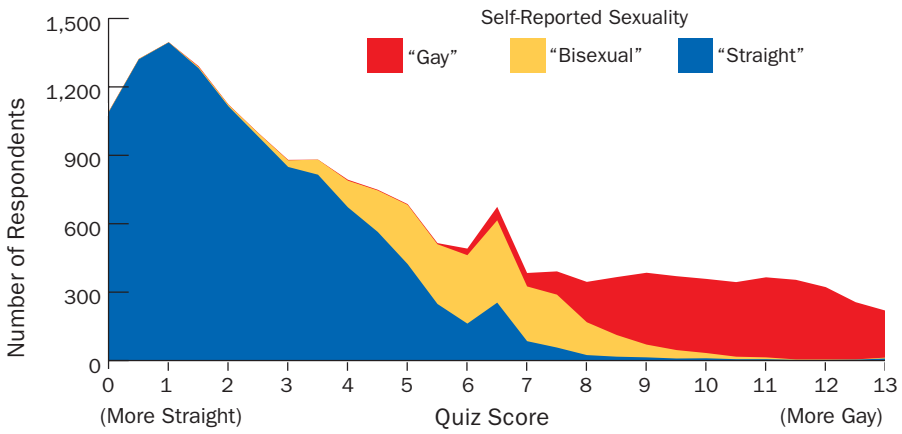
Smooth Thinking about Sexuality

"Gay" and "straight" are misleading terms

Is sexual orientation similar to eye color, consisting of fairly discrete categories? Or is it more like height—that is, falling along a continuum? As a psychologist, I have explored that question in several venues, including the February/March 2006 issue of SCIENTIFIC AMERICAN MIND ["Do Gays Have a Choice?"]. Although common thinking holds that everyone is either "gay" or "straight," my new survey of nearly 18,000 people who voluntarily answered an online quiz shows that these terms are highly misleading. Sexual orientation actually lies on a smooth continuum, and the way people state their orientation is often a poor predictor of their true sexual behaviors and fantasies. Someone can call himself "gay" but behave "straight," and vice versa.

At the Society for the Scientific Study of Sexuality meeting in November, I will report that the same continuum of scores exists in the U.S. and in the average of scores from a dozen countries outside the U.S. I also find that fewer than 10 percent of subjects score as "pure" heterosexual or homosexual and that females place, on average, farther toward the gay end of the continuum than males do. My study suggests that characterizing sexual orientation properly requires two numbers: mean sexual orientation (where a given person lies on the continuum) and sexual orientation range (how much flexibility or "choice" the person has in expressing that orientation, which also forms a continuum).

—Robert Epstein



An online survey of nearly 18,000 people shows that sexual orientation falls on a continuum and that the labels "straight," "gay" and "bisexual" are often misleading. You can take the quiz for yourself at http://MySexualOrientation.com

GETTY IMAGES (*top*); SOURCE: ROBERT EPSTEIN (*bottom*)

>> LEARNING

Mom Was Right

So you goofed …

We learn more from our mistakes than from our successes, the old cliché says—and now scientists know why. Researchers at the University of Exeter in England discovered a brain mechanism that alerts us to situations in which we previously went wrong.

In the study, students playing physicians had to diagnose a fictitious disease based on images from equally fictitious blood samples. When participants saw images that had previously led them to an erroneous diagnosis, warning signals in the brain appeared only a tenth of a second later—much more quickly than did signals triggered by images that had resulted in a correct diagnosis. Earlier studies had confirmed that slipups do indeed result in better learning, but this one is the first to show the brain's specific reaction to a prior blunder.

This early-warning signal may be invaluable in situations ranging from the dangerous to the mundane. A child who touches a hot stovetop learns the hard way not to do it again—when she sees a glowing burner in the future, her brain will alert her to avoid the painful decision she made the last time. *—Graciela Flores*

>> THE SENSES

Finding the Connection

People who experience sensory cross talk shed light on brain wiring

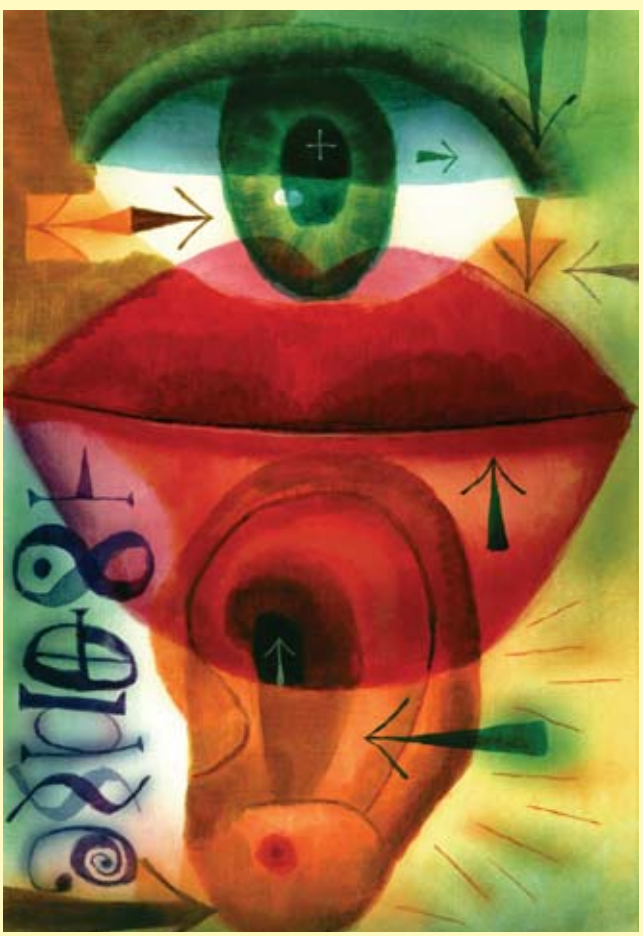
Many people dream in color. Some also read and hear in color. In people with synesthesia, different senses blend in a variety of ways—one person might see the numeral four as bright yellow, and another might taste cucumbers when she hears words beginning with the letter "F." And because synesthetes are aware of connections among parts of the brain that to most people seem distinct, they may help scientists map the mind's higher cognitive functions.

Julia Simner, a linguistic psychologist at the University of Edinburgh, is among a new crop of researchers exploring how conceptual thinking (not simply physical stimuli) may evoke colors and flavors in synesthetes. By inducing a "tip of the tongue" state—in which a known expression eludes immediate recall—in synesthetes who taste words, Simner discovered that the meanings of words can produce the same flavors as their sound or written shape. For instance, trying to remember the term "castanet" caused one woman to taste tuna, the same flavor triggered when she heard the word. Through this type of "word tasting," Simner is exploring the potential relation between conceptual thought and perceptual experience.

People with a different type of synesthesia, who feel a sensation on their own body when they observe somebody else being touched, may provide insight into the genesis of emotions. A University College London study found that these mirror-touch synesthetes showed higher capacities for emotional empathy than others did. They may, for example, experience stronger gut reactions when they see someone in distress. When trying to rationally imagine how other people feel, however, the synesthetes scored similarly to everyone else—which suggests that more than one path through the brain ends in empathy.

Many unidentified synesthetes assume their perception of the world is ordinary. When the study about mirror-touch synesthesia made the news, many people were surprised to discover that experiencing this type of disembodied contact is considered unusual. Scientists believe that about 4 percent of the population experiences some form of synesthesia and that the phenomenon probably stems from normal cognitive development in the womb and early childhood. As the brain grows, a large number of neural connections are formed. Many of these synapses are then pruned away as processes in the brain differentiate. Synesthesia may arise from an incomplete shedding of these connections.

Everyone may possess these same pathways in the brain to some degree, but most people do not realize it. Simner sees synesthetes as decoders because "they experience the relationship to conscious awareness." *—Melissa Mahony*

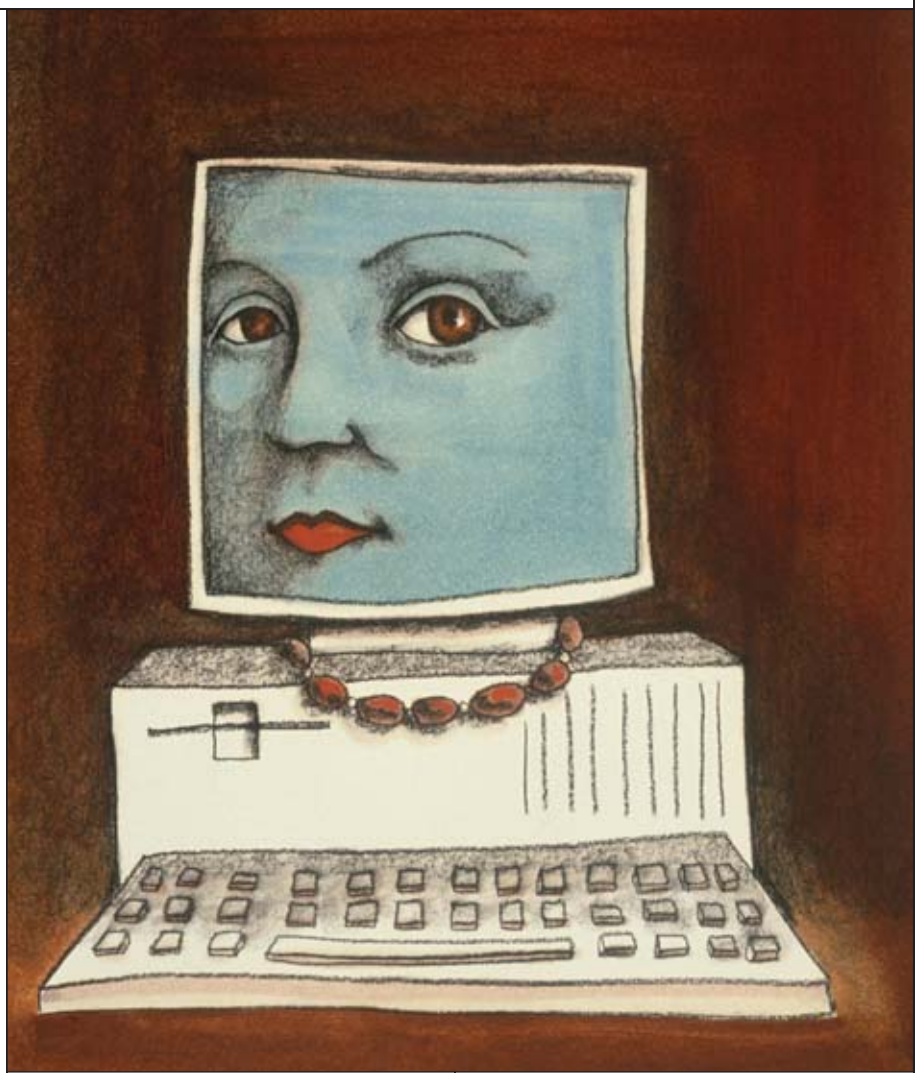


GETTY IMAGES (*top*); IMAGES.COM/CORBIS (*bottom*)

From Russia, with Love

How I got fooled (and somewhat humiliated) by a computer

BY ROBERT EPSTEIN



IT ALL STARTED with an online dating service. I was looking for a date. Like most men (we dogs), I made my initial judgment based largely on a photo. Yes, that's shallow, and when one is online, it's also fairly stupid because photos are all too easy to fake. But this time, I *really* blew it.

The main photo showed a slim, attractive brunette, supposedly living in California not far from me. She didn't say much about herself, and her English was choppy, suggesting that she was a recent immigrant. That's okay, though; all four of my grandparents were from Russia, after all.

Her screen name was a variation on "Amélie Poulain." Had I been more of a European film buff, this moniker would have worried me. *The Fabulous Destiny of Amélie Poulain* is a 2001 French film starring Audrey Tautou as Amélie, a strange young woman who has a crush on a man but is incapable—*completely* incapable—of communicating with him in conventional ways. Hmm.

She responded to my e-mail quite affectionately—and also admitted that she really lived in Russia, not California. Normally I find that kind of distance daunting, but her photos were so attractive and her e-mails so warm that I continued to correspond with her. She sent me her real name; I'll call her "Ivana."

Here is an example of the kind of e-mail I received from her:

> *I have told to mine close friends about you and to my parents and them happy that I really interested someone and regardless of the fact that not here in Russia and all from them happy for me, that I have met you. I have very special feelings about you … It—in the same way as the beautiful flower blossoming in mine soul … I only cannot explain … but I confident, that you will understand me so I wish to know that makes you, think, and I shall wait your answer, holding my fingers have crossed …*

After two months of e-mails I started to get, well, not suspicious exactly but at least concerned. Online dating can be a slow, frustrating process [see "The Truth about Online Dating," by Robert Epstein; SCIENTIFIC AMERICAN MIND, February/March 2007]. Our romance was progressing especially slowly: no phone calls, very vague talk on Ivana's part about get-

After **two months of e-mails** I started to get, well, not suspicious exactly but at least concerned.

CHRIS RASCHKA *Getty Images*

ting together—no real *movement*.

I also noticed that Ivana's letters seemed a bit redundant and, let's say, narrow in scope. She wrote, over and over, about her interactions with her mother and her friends, but she never brought up a million other things: politics, movies, music, books, fashion, you name it. More important, when I made very specific observations that presumably would have been of interest to her—for example, a comment about Russian president Vladimir Putin's latest crackdown—she seemed to just ignore me. Hmm. Now *that* should have tipped me off.

> Like all good scientists, I am trying hard now to turn **lemons into lemonade**.

A Walk in January

Finally, in a January e-mail Ivana mentioned all the nice things she was saying about me to her friend while they were on a walk in a park. I wondered: Do people really go for walks in Nizhniy Novgorod—a large city about 200 miles from Moscow—in the dead of winter? A weather site on the Internet told me that it was 12 degrees Fahrenheit and snowing heavily when she was supposedly on her walk. I questioned her about that—*but she ignored my query.*

I started scrutinizing her subsequent e-mails very carefully. Sure enough, all the signs were there: the content of Ivana's notes was generally only marginally responsive to my correspondence, and when I sent her queries that demanded replies to specific questions, she was *never* responsive.

At that point, I sent her the ultimate test. I wrote:

> *asdf;kj as;kj l;jkj;j ;kasdkljk ;klkj 'klasdfk; asjdfkj. With love, /Robert*

And Ivana reacted with another long letter about her mom.

Aha. I had been interacting for nearly four months with a computer program—specifically, a chatterbot, which is a program designed to converse with people over the Internet.

I had been fooled partly because I wasn't thinking clearly: I had wanted to believe that a beautiful young woman really cared about me. But let's face it—this was also darned clever programming. The most successful conversational computer programs these days often fool people into thinking they are human by setting expectations low, in this case by posing as someone who writes English poorly.

Tricks That Work

A truly intelligent, thinking program has been the holy grail of computer science for more than half a century [see "My Date with a Robot," by Robert Epstein; Scientific American Mind, June/July 2006]. The grail is still well out of reach at the moment, with programmers relying mainly on what many would call trickery to create the impression—usually for no more than a few minutes—that their programs are people. Jabberwacky, A.L.I.C.E., ELIZA and other conversational programs often circumvent real intelligence simply by echoing back part of what a real human has written to them ("pattern matching") or by being humorous and irreverent.

I should know about such things, and I certainly should have known better in my exchanges with Ivana. I am, you see, supposedly an expert on chatterbots. I have been a computer nerd most of my life, and in the early 1990s I directed the annual Loebner Prize Competition in Artificial Intelligence, a contest in which judges try to distinguish between people and computer programs. I am even editing a 600-page book, coming out in a few months, on this very subject.

Like all good scientists, I am trying hard now to turn lemons into lemonade. With Stephanie Alderson, an undergraduate student at the University of California, San Diego, I am in the process of cataloguing and rating the "humanness" of more than 80 online chatterbots. This exercise is, as you can imagine, largely for my own protection.

Meanwhile, somewhere in Europe or Russia (most likely), a very smug, very anonymous computer programmer has got Ivana chatting with hopeful, naive men around the world, carefully tabulating her successes—and tweaking her to be more humanlike every day. M

ROBERT EPSTEIN is a contributing editor for *Scientific American Mind,* former editor in chief of *Psychology Today,* and co-editor (with Gary Roberts and Grace Beber) of the upcoming book *Parsing the Turing Test: Philosophical and Methodological Issues in the Quest for the Thinking Computer* (Springer). You can learn more about Epstein's work at http://drepstein.com

(Further Reading)

- **The Turing Test: The Elusive Standard of Artificial Intelligence.** Edited by James H. Moor. Springer, 2003.
- **The Turing Test: Verbal Behavior as the Hallmark of Intelligence.** Edited by Stuart Shieber. MIT Press, 2004.

GETTY IMAGES

Ambiguities and Perception

What uncertainty tells us about the brain

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

THE BRAIN abhors ambiguity, yet we are curiously attracted to it. Many famous visual illusions exploit ambiguity to titillate the senses. Resolving uncertainties creates a pleasant jolt in your brain, similar to the one you experience in the "Eureka!" moment of solving a problem. Such observations led German physicist, psychologist and ophthalmologist Hermann von Helmholtz to point out that perception has a good deal in common with intellectual problem solving. More recently, the idea has been revived and championed eloquently by neuropsychologist Richard L. Gregory of the University of Bristol in England.

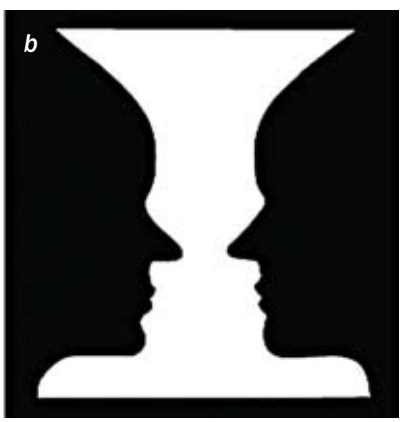
So-called bistable figures, such as the mother-in-law/wife (*a*) and faces/vase (*b*) illusions, are often touted in textbooks as the prime example of how top-down influences (preexisting knowledge or expectations) from higher brain centers—where such perceptual tokens as "old" and "young" are encoded—can influence perception. Laypeople often take this to mean you can see anything you want to see, but this is nonsense—although, ironically, this view contains more truth than most of our colleagues would allow.

Fun Flips

Consider the simple case of the Necker cube (*c* and variation in *d*). You can view this illusion in one of two ways—either pointing up or pointing down. With a little practice, you can flip between these alternate percepts at will (still, it is great fun when it flips spontaneously; it feels like an amusing practical joke has been played on you). In fact, the drawing is compatible not only with two interpretations, as is commonly believed; there is actually an infinite set of trapezoidal shapes that can produce exactly the same retinal image, yet the brain homes in on a cube without hesitation. Note that at any time, you see only one or the other. The visual system appears to struggle to determine which of two cubes the drawing represents, but it has already solved the much larger perceptual problem by rejecting trillions of other configurations that could give rise to the retinal pattern we call the Necker cube. Top-down attention and will, or intent, can only help you select between two percepts; you will not see any of the other possibilities no matter how hard you try.

Although the Necker cube is often used to illustrate the role of top-down influences, it, in fact, proves the very opposite—namely, that perception is generally immune to such influences. Indeed, if all perceptual computations mainly relied on top-down effects, they would be much too slow to help you in tasks related to survival and the propagation of your genes—escaping a predator, for example, or catching a meal or a mate.

It is important to recognize that ambiguity does not arise only in cleverly contrived displays such as on these two pages and in *e*, in which shading could make the circles appear to be convex or concave. In truth, ambiguity is the rule rather than the exception in perception; it is usually resolved by other co-



SWIM INK 2, LLC/CORBIS (*a*); SCIENTIFIC AMERICAN MIND (*b*)

> It is great fun when it flips spontaneously; it feels like an **amusing practical joke** has been played on you.

In truth, **ambiguity is the rule** rather than the exception in perception.

existing bottom-up (or sideways, if that is the right word) cues that exploit built-in statistical "knowledge" of the visual world. Such knowledge is wired into the neural circuitry of the visual system and deployed unconsciously to eliminate millions of false solutions. But the knowledge in question pertains to general properties of the world, not specific ones. The visual system has hardwired knowledge of surfaces, contours, depth, motion, illumination, and so on but not of umbrellas, chairs or dalmatians.

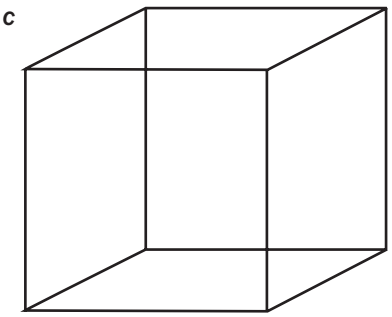
Motion Control

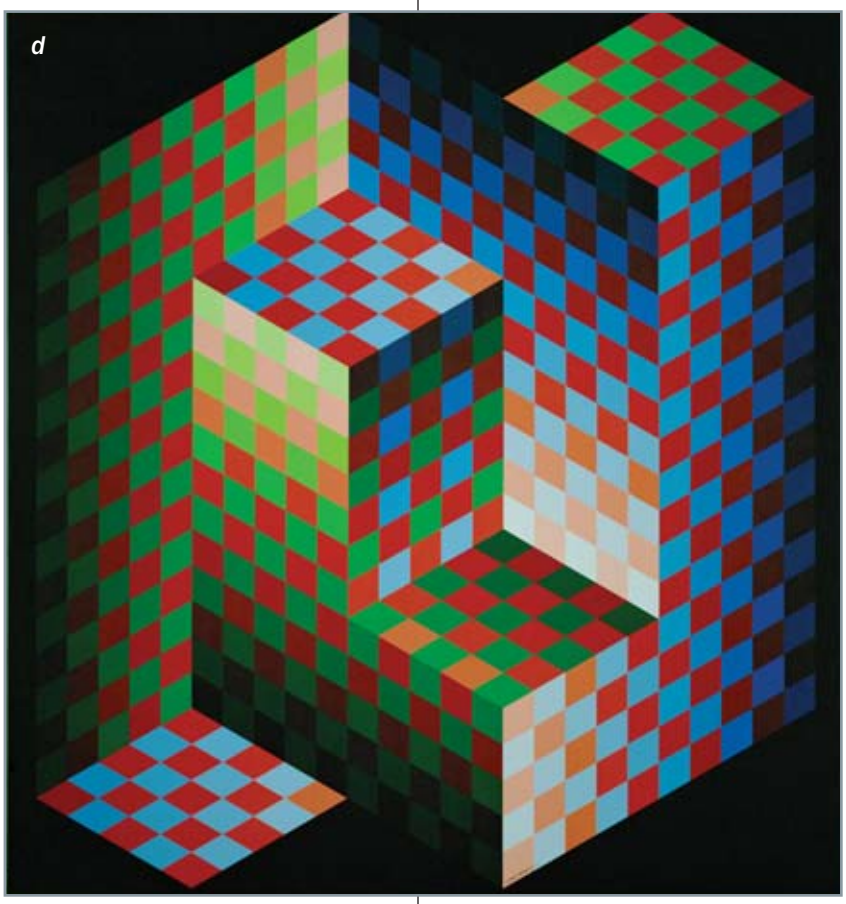
Ambiguity also arises in motion perception. In *f,* we begin with two light spots flashed simultaneously on diagonally opposite corners of an imaginary square, shown at *1*. The lights are then switched off and replaced by spots appearing on the remaining two corners, at *2*. The two frames are then cycled continuously. In this display, which we call a bistable quartet, the spots can be seen as oscillating vertically (*dashed arrows*) or horizontally (*solid arrows*) but never as both simultaneously—another example of ambiguity. It takes greater effort, but as with the cube, you can intentionally flip between these alternate percepts.

We asked ourselves what would happen if you scattered several such bistable-quartet stimuli on a computer screen. Would they all flip together when you mentally flipped one? Or, given that any one of them has a 50 percent chance of being vertical or horizontal, would each flip separately? That is, is the resolution of ambiguity global (all the quartets look the same), or does it occur piecemeal for different parts of the visual field?

The answer is clear: they all flip together. There must be global fieldlike effects in the resolution of ambiguity. You might want to try experimenting with this on your computer. You could also ask, Does the same rule apply for the mother-in-law/wife illusion? How about the Necker cube? It is remarkable how much you can learn about perception using such simple displays; it is what makes the field so seductive.

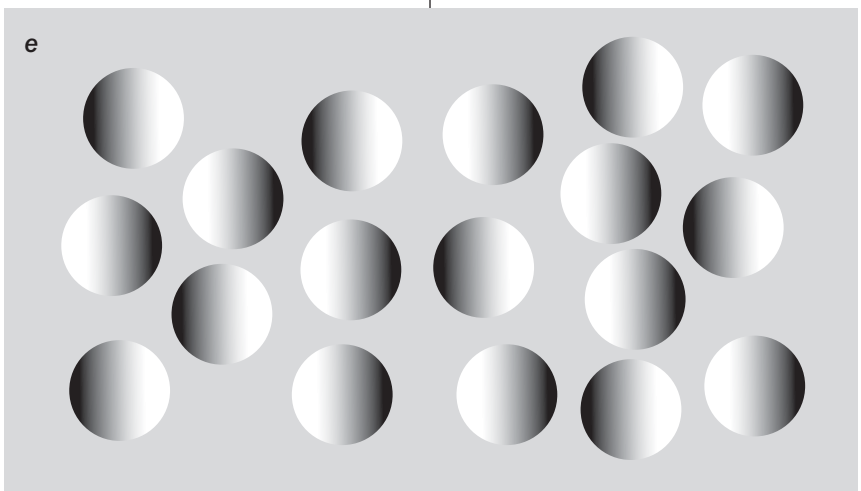
We must be careful not to say that top-down influences play no role at all. In some of the figures, you can get stuck in one interpretation but can switch once you hear, verbally, that there is an alternative interpretation. It is as if your visual system—tapping into high-level memory—"projects" a template (for example, an old or young face) onto the fragments to facilitate their perception. One could argue that the recognition of *objects* can benefit from top-down processes that tap into attentional selection and memory. In contrast, seeing contours, surfaces, motion and depth is mainly from the bottom up (you can "see" all the surfaces and corners of a cube and even reach out and grab it physically and yet not know or recognize it as a cube). In fact, we have both had the experience of peering at neurons all day through a microscope and then the next day "hallucinating" neurons everywhere: in trees, leaves and clouds. The extreme example of this effect is seen in patients who become





SCIENTIFIC AMERICAN MIND (*c*); VICTOR VASARELY, © ART RESOURCE, NEW YORK. PHOTOGRAPH BY ERICH LESSING, © 2007 ARTISTS RIGHTS SOCIETY, NEW YORK/ADAGP, PARIS (*d*)

It is almost as though perception involves selecting **the one hallucination** that best matches sensory input.



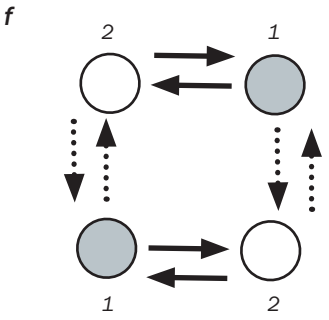
completely blind and start hallucinating elves, circus animals and other objects—called the Charles Bonnet syndrome. In these individuals, only top-down inputs contribute to perception—the bottom-up processes, missing because they are blind (from macular degeneration or cataracts), can no longer limit their hallucinations. It is almost as though we are all hallucinating all the time and what we call object perception merely involves *selecting* the one hallucination that best matches the current sensory input, however fragmentary. Vision, in short, is controlled hallucination.

But doesn't this statement contradict what we said earlier about vision being largely bottom-up? The answer to this riddle is "vision" is not a single process; perception of object*ness*—its outline, surface depth, and so on, as when you see a cube as cuboid—is largely bottom-up, whereas higher-level *identification* and categorization of objects into neurons or umbrellas do indeed benefit enormously from top-down memory-based influences.

How and What

Physiology also supports this distinction. Signals from the eyeballs are initially processed in the primary visual cortex at the back of the brain and then diverge into two visual pathways: the "how" pathway in the parietal lobe of the brain and the "what" pathway, linked to memories, in the temporal lobes. The former is concerned with spatial vision and navigation—reaching out to grab something, avoiding obstacles and pits, dodging missiles, and so on, none of which requires that you identify the object in question. The temporal lobes, on the other hand, enable you to recognize what an object actually is (pig, woman, table), and this process probably benefits partially from memory-based top-down effects. There are hybrid cases in which they overlap. For example, with the faces/vase illusion there is a bias to get stuck seeing the faces. But you can switch to seeing the vase without explicitly being told "look for the vase," if you are instead instructed to attend to the white region and see it as a foreground figure rather than as background.

Can the perception of ambiguous, bistable figures be biased in any way if they are preceded with other nonambiguous figures—a technique that is called priming? Priming has been explored extensively in linguistics (for instance, reading "foot" preceded by "leg" evokes the body part, but reading "foot" preceded by "inches" might suggest a ruler). Intriguingly, such priming can occur even if the first word appears too briefly to be seen consciously. Whether perception can be similarly primed has not been carefully studied. You might try it on friends.



Finally, as we noted in one of our previous columns, you can construct displays that are always ambiguous, such as the devil's pitchfork or the perpetual staircase [see "Paradoxical Perceptions," April/May 2007]. Such paradoxical figures evoke wonder, delight and frustration at the same time—a microcosm of life itself. M

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. They serve on *Scientific American Mind*'s board of advisers. The authors dedicate this column to Rama's mother, V. S. Meenakshi, who had an extremely quick, but not at all ambiguous, mind and who infinitely encouraged her son's curiosities.

(Further Reading)

- **The Intelligent Eye.** Richard L. Gregory. McGraw-Hill, 1970.
- **The Perception of Apparent Motion.** Vilayanur S. Ramachandran and Stuart M. Anstis in *Scientific American,* Vol. 254, No. 6, pages 102–109; June 1986.
- **A Critique of Pure Vision.** P. S. Churchland, V. S. Ramachandran and T. J. Sejnowski in *Large Scale Neuronal Theories of the Brain.* Edited by C. Koch and J. L. Davis. MIT Press, 1994.

(calendar)

October

2 Neuroscience luminary **Eric Kandel** explains the current scientific understanding of depression and bipolar disorder in a public lecture sponsored by the Mood Disorders Support Group of New York City. Kandel received the Nobel Prize in Physiology or Medicine in 2000 [*see box*]. A recording of the lecture will also be available for purchase online.
New York City
www.mdsg.org/lectures.html

Eric Kandel of Columbia University

7–10 Hundreds of clinical and research teams investigate nervous system diseases every year, but only eight studies merit inclusion among the special presentations at the **American Neurological Association's 132nd Annual Meeting**. Poster sessions and symposia will highlight many additional advances in the latest theories of neurological diagnosis and treatment.
Washington, D.C.
www.aneuroa.org

16 Imagine a therapy that could unlock hidden emotional states, treat brain damage and sensory disorders, serve as a memory aid and improve mental health on a daily basis. According to neurologist **Oliver Sacks**, such a therapy exists—and we call it music. Master storyteller Sacks tackles the biological basis of music's power and allure in his new book, *Musicophilia: Tales of Music and the Brain.*
Knopf ($26)
www.oliversacks.com/musicophilia.htm

26 Human compassion has the power to overcome grief, as a widow and a drug addict learn in the drama ***Things We Lost in the Fire***. Halle Berry plays a newly single mother who finds support in an unlikely friendship with a ruined lawyer (Benicio Del Toro) who was her husband's childhood best friend. Even as Del Toro's character struggles with heroin addiction, he helps the family find strength to cope with their loss.
DreamWorks Pictures
www.thingswelostinthefiremovie.com

November

3–7 Neuroscientists from around the world gather for the **37th Annual Meeting of the Society for Neuroscience**. Frequent *Scientific American Mind* contributor Michael Gazzaniga is a featured lecturer, along with many other leaders in the field. Symposia, workshops and poster sessions round out the opportunities for meeting attendees to exchange innovative ideas about the brain's structure and function.
San Diego
http://sfn.org/am2007

9 Experience your thoughts and feelings in surprising ways in a new exhibit at the **Exploratorium** museum of science, art and human perception. In the hands-on activities that make up **Mind**, explore judgment and decision making, perceptions of yourself and others, your senses and the meaning of consciousness as you learn about the latest brain science. Live demonstrations and appearances by scientists are scheduled throughout the exhibit's run.
San Francisco
www.exploratorium.edu/mind

16 Penelope Cruz and Ben Kingsley star in ***Elegy***, a drama about sexual possessiveness based on Philip Roth's novel *The Dying Animal.* David Kepesh (Kingsley), a renowned 70-year-old cultural critic, recalls a devastating, obsessive affair he had with 24-year-old Consuela Castillo (Cruz). The end of the affair threw David into a long depression, which finally breaks when Consuela contacts him again eight years later—and the turmoil starts anew.
MGM
www.mgm.com

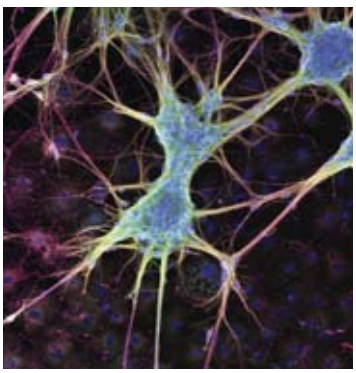
NOBEL WINNERS

AWARDS SEASON

Since 1901 October has marked the announcement of the year's Nobel Prize winners. The prize in physiology or medicine has often honored researchers whose work represented a milestone in our understanding of the mind and brain. Some past highlights:

October 27, 1949
Walter R. Hess wins for elucidating the functions of the midbrain, which he found to regulate vision, hearing and body movement. Hess's work opened a new avenue of research into the brain's subconscious control of our organs.

October 15, 1970
Julius Axelrod, **Sir Bernard Katz** and **Ulf von Euler** are awarded for their studies of the release and reuptake of neurotransmitters in the brain—an important step toward the development of drugs for depression.

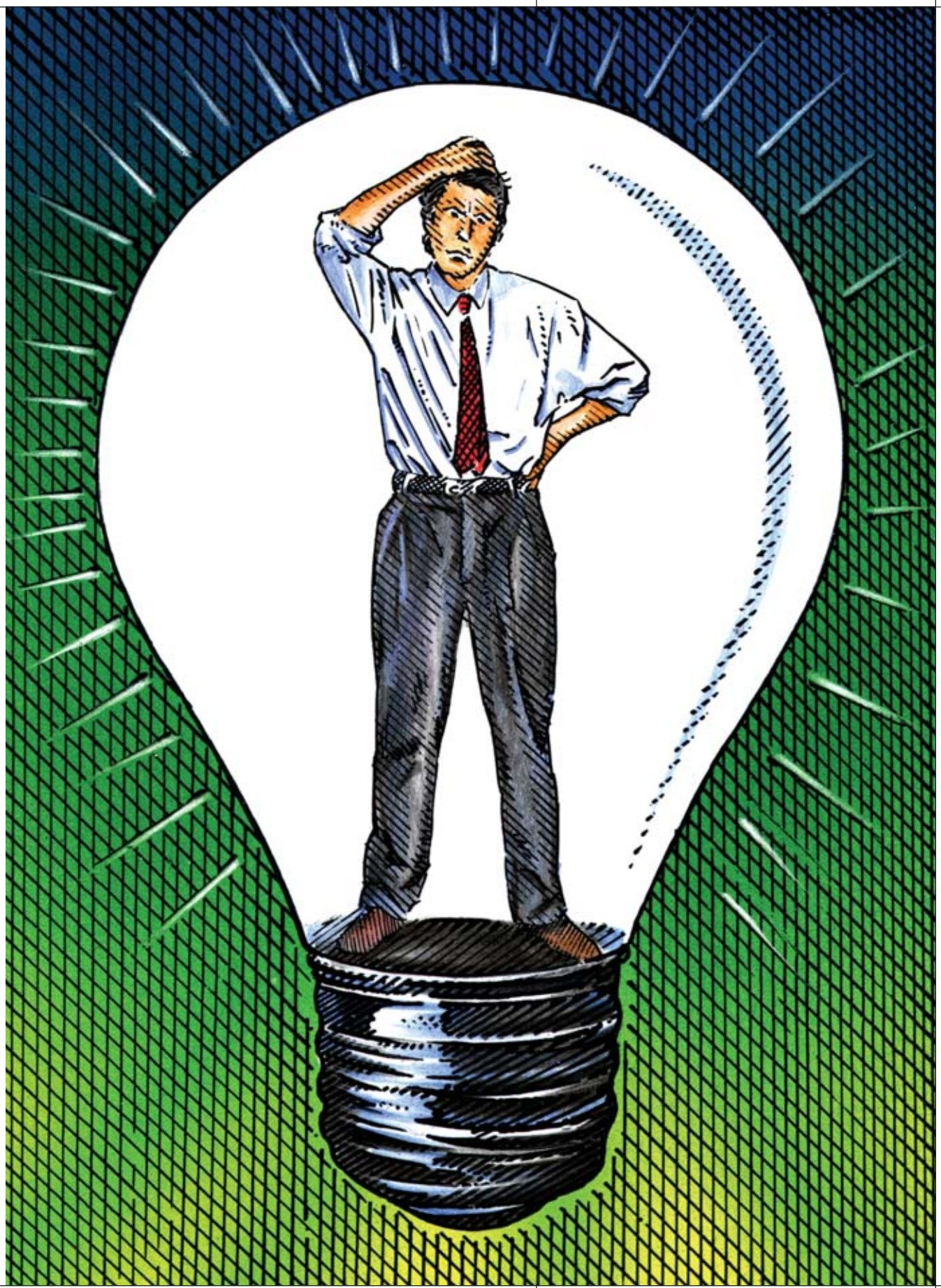


October 9, 1981
Roger Sperry is recognized for mapping the locations of many higher cognitive processes and showing that the right and left hemispheres each perform vital, noninterchangeable functions.

October 9, 2000
Arvid Carlsson, **Paul Greengard** and **Eric Kandel** split the prize for their separate studies of chemical signaling between nerve cells in the brain. Their findings led to better treatments for disorders that stem from signal disruption, such as Parkinson's disease.

BARBARA GINDL *epa/Corbis (Kandel)*; © THE NOBEL FOUNDATION *(Nobel medal)*; FRANCOIS PAQUET-DURAND *Photo Researchers, Inc. (neurons)*

Compiled by Karen Schrock and Amelia Thomas. Send items to editors@sciammind.com



JERRY HOARE *Getty Images*

Solving the IQ Puzzle

The 20th century saw the "Flynn effect"—massive gains in IQ from one generation to another. Now Flynn explains why

By James R. Flynn

On a rather dull Saturday in November 1984, I found a bombshell in my letterbox. I had received data from a distinguished Dutch researcher and saw immediately that Dutch males had made enormous IQ gains in a single generation. Today similar findings have occurred in almost 30 nations—in every country for which we have data. IQ escalation may not persist, but it has dominated the 20th century. That is enough to create a crisis of confidence. Either the children of today are far brighter than their parents, or at least in some circumstances, IQ tests are not good measures of intelligence. Paradoxes begin to multiply. Only now can we resolve them—and doing so illuminates the nature of intelligence as well as the gulf that separates our minds from those of our ancestors.

Intelligence and the Atom

Understanding intelligence is like understanding the atom: we need to know not only what holds its components together but also what splits them apart. What binds the components of intelligence together is the general intelligence factor, or *g*; what acts as an atom smasher is cognitive trends measured over time. The best IQ test to exemplify both these forces is the Wechsler Intelligence Scale for Children, or WISC, which has been used from 1947 through today.

The WISC's 10 subtests measure various cognitive skills. The Similarities subtest

Adapted from *What Is Intelligence?* by James R. Flynn. Cambridge University Press, 2007.

We find **something surprising**: discrepancies between the magnitude of IQ subtest gains and cognitive complexity.

measures one's ability to perceive what things have in common; Vocabulary, whether you have accumulated the words used in everyday life; Information, your store of general information; Arithmetic, your ability to solve mathematical problems. People who are above average on one subtest tend to excel on them all. Therefore, we speak of a general intelligence factor. A mathematical technique called factor analysis measures the tendency of performance on a wide variety of cognitive tasks to be intercorrelated, and the construct called *g* is the quantified result.

A good performer typically exceeds the average person's results on some cognitive tasks more than others. These tasks tend to be those that are more cognitively complex, which reinforces the claim that *g* measures general intelligence. The WISC subtests can be ranked in terms of their *g* loadings. That simply means you rank them from the subtest on which high-IQ people beat the average person by the most down to the subtest on which they excel the least.

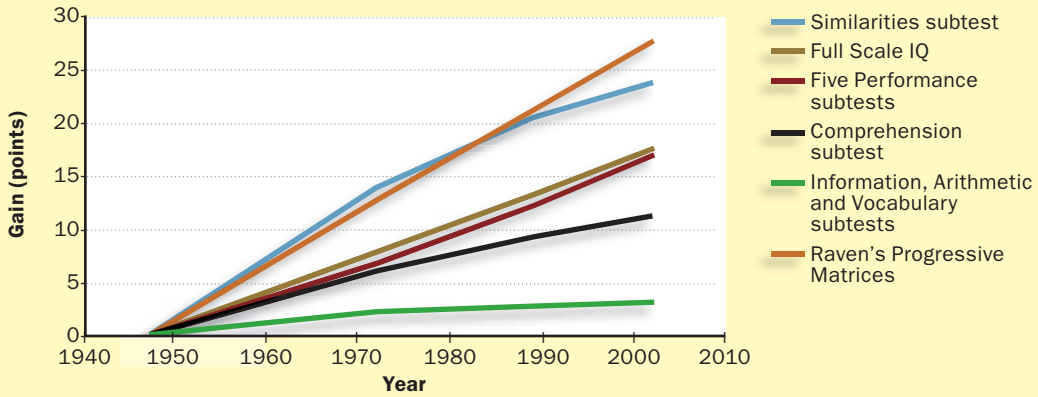
There is nothing mysterious about various traits or tasks having different *g* loadings. Musical people tend to be higher above average on the piano than on the drums. A talented chef is more likely to outdo the average person in the delicate task of whipping up a soufflé than in the simpler undertaking of scrambling eggs. The former is more complex than the latter and, therefore, is a better test of excellence in cooking.

Trends over Time

If general intelligence has increased over time, we would expect gains on each of the 10 WISC subtests to tally with their *g* loadings. But when we turn to IQ gains, we find something surprising: discrepancies between the magnitude of subtest gains and subtest *g* loadings. Similarities and Information have much the same *g* loadings, yet the former shows gains 12 times the size of the latter. Remember cooking. If skills improved over time, it would be amazing if the *g* loadings were ignored—for example, if there was an unexpected cooking gain in scrambling eggs but no gain in making soufflés.

Recent IQ gains show a chaotic pattern: 24 points on Similarities, whereas Vocabulary, Arith-

The Long Rise of IQs



Gains are measured in IQ points (adopting the usual convention of setting the standard deviation at 15). One IQ test, the Wechsler Intelligence Scale for Children (WISC), was updated three times, which yields estimates of gains over three periods, collectively covering 1947 to 2002. Although there are no reliable U.S. data for Raven's Progressive Matrices, another IQ test, I have put gains conservatively at 0.5 IQ point per year. (This rate is the lowest for any developed nation for which we have data.) *—J.F.*

SOURCE: JAMES R. FLYNN

metic and Information cluster around a mere three-point gain over 55 years [*see box on opposite page*]. The WISC gives not only subtest scores but also a summary judgment on intelligence, called Full Scale IQ. Its gains are huge, amounting to about 18 points. Raven's Progressive Matrices, which asks students to find the next step in a series of pictures, is also an important test in analyzing IQ trends. Because American data are scant, I have offered a conservative estimate of a five-point gain per decade based on comparative data. How can our recent ancestors have been so unintelligent compared with ourselves? Even worse, British data suggest we have to extend the trend all the way back to 1900.

Now that I have explained the basic concepts behind the IQ boom, I can present the four paradoxes that it creates. Three arise out of the pattern and magnitude of IQ gains. The fourth also involves what we thought we knew about genes and environment.

The Factor Analysis Paradox

The patterns of IQ gains on the WISC subtests bear little relation to factor loadings. How can intelligence be both unitary (as it appears in factor analysis) and multiple (per the trends over time)? The key to this paradox is that factor analysis occurs in a static setting in which individuals are compared with social change held constant. IQ trends over time, however, take place in a dynamic setting in which social change alters cultural priorities, including which conceptual skills get greatest emphasis.

At any given time, for example, factor analysis would show that sprints and the high jump have large and similar *g* loadings, which is to say that people who have springy legs do well at both. But over time, young people may find sprinting romantic and the high jump boring. Performance on the first will escalate, and performance on the second will remain static. The correlation between the two events conceals the fact that there is little functional relation between the skills they require. You do not maximize your high-jump performance by sprinting toward the bar at top speed because you would mistime your jump. Improvement over time on the first is perfectly compatible with no improvement on the second.

To explain the IQ patterns, we need a functional analysis of what has elevated various cognitive skills over time. The rise of science has engendered a sea change in two respects: it has taught us that classifying the world using the categories of science is just as important as manipulating the world; and it has freed logic from the concrete, allowing us to work on abstractions with no concrete referents. In the early 20th century, a typical syllogism would have been: "Basset hounds are good at hunting rabbits. That is a basset hound. Therefore, I will use that dog when I hunt." Today we are far more likely to say the following: "Only mammals bear their young alive. Rabbits and dogs both bear their young alive. Therefore, they are both mammals."

If asked what dogs and rabbits have in common, a boy in 1900 would have said, "You use dogs to hunt rabbits." A boy in 2007 will say, "They are both mammals." It would never have occurred to someone a century ago to offer something so trivial. Who cares that dogs and rabbits are both mammals? What is important is what things are useful and under one's control.

The Similarities subtest of the WISC shows impressive gains throughout the past century because it gives zero for the hunting, or utilitarian, answer and full marks for the mammal, or classifying, answer. Subtests such as Vocabulary and Information are quite different. They sample the core vocabulary and general information needed in everyday life, and therefore the transition from the concrete to the abstract has left them largely unaffected.

The other IQ test that shows sizable gains is Raven's Progressive Matrices. These increases

FAST FACTS

Probing the Nature of Intelligence

1» During the 20th century, unexpected and massive gains on IQ tests—the Flynn effect—appeared in almost 30 countries, all of the nations for which data exist. Puzzlingly, the gains on subtests, which measure distinct components of intelligence, varied in a seemingly chaotic pattern.

2» The results set off a crisis in intelligence research. Either the children of today are far brighter than their parents, or at least in some circumstances, IQ tests are not good measures of intelligence. Paradoxes began to multiply.

3» The solutions to the paradoxes tell us something new about the nature of intelligence and what society must do to foster critical thinking.

PANORAMIC IMAGES/GETTY IMAGES

Sample IQ Test Questions

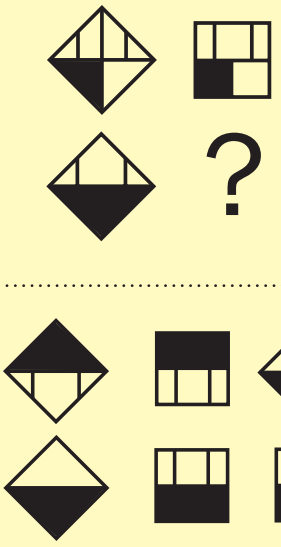
Below are examples of the types of questions students answer on the 10 subtests of the WISC and Raven's Progressive Matrices.

WISC

Information	On what continent is Argentina?
Arithmetic	If four toys cost six dollars, how much do seven cost?
Vocabulary	What does "debilitating" mean?
Comprehension	Why are streets usually numbered in order?
Picture Completion	Indicate the missing part from an incomplete picture.
Block Design	Use blocks to replicate a two-color design.
Object Assembly	Assemble puzzles depicting common objects.
Coding	Using a key, match symbols with shapes or numbers.
Picture Arrangement	Reorder a set of scrambled picture cards to tell a story.
Similarities	In what way are dogs and rabbits alike?

RAVEN'S

Find the missing piece from the six pictured below.



are no longer mysterious. To do well, you must find it second nature to use logic to deal with abstract patterns—that is, you must perceive logical sequences in a series of shapes, something that is abetted by a modern culture that is more visually oriented.

It is easy to misunderstand the relation between Similarities and Raven's. Factor analysis of a wide range of mental tests showed that scores on these two have more in common than those of any other pair of tests. And now, both tests show the same huge gains over time. Nevertheless, the two tests are like sprints and the high jump, with almost nothing functional in common. The reason they correlate and their gains are so similar is that when a person benefits from seeing the world through scientific spectacles, he or she gets two distinct advantages. One is the liberation of logic from the concrete to analyze the abstract, which raises the Raven's score. The other is the transition from viewing the world as something to classify rather than merely to utilize, which raises the Similarities score. The same people are likely to enjoy both these benefits much to the same degree. But they relate to two quite separate cognitive tasks nonetheless.

Factor analysis also shows that both Arithmetic and Raven's have high *g* loadings for a common factor. This fact has encouraged the notion that mathematical thinking and the cognitive problems posed by Raven's are functionally related. After all, Raven's problems demand that you see logical relations between shapes on the spot (without a previously learned method for doing so). Mathematics requires dealing with nonverbal material to master new proofs. Therefore, it seems sensible to teach young children Raven's-type problems so that they will become better mathematics problem solvers. Many U.S. schools have been doing just that since 1991.

Nevertheless, the large gains on Raven's and the virtually nonexistent gains on Arithmetic show that there cannot be a strong functional relation between the two. For nonmathematicians,

SOURCE: JAMES R. FLYNN

(The Author)

JAMES R. FLYNN is professor emeritus at the University of Otago in New Zealand and recipient of the university's Gold Medal for Distinguished Career Research. He has been named Scientist of the Year by the International Society for Intelligence Research and is a distinguished associate of the Psychometrics Center at the University of Cambridge.

These **large gaps** in IQ between generations should be noticeable in conversations and in everyday life.

mathematics is less a logical enterprise than a separate reality that obeys laws at variance with those of the natural world. Just as infants explore the natural world, children must explore the world of mathematics and become familiar with its "objects" through self-discovery. Raven's-type tasks make no contribution to that whatsoever.

Our first paradox is resolved. At any particular time, factor analysis will extract a robust *g* factor. Intelligence appears unitary, and the major cognitive skills are all highly intercorrelated. Over time, social reality reveals cognitive skills swimming freely of *g*, so intelligence appears multiple. If you want to see *g*, stop the film and extract a snap shot; you will not see it while the film is running. Society does not do factor analysis; it is a juggernaut that flattens factor loadings and imposes its own priorities.

PARADOX 2

The Intelligence Paradox

Gains in Full Scale IQ and Raven's suggest that our parents are some nine to 15 points duller than we are and that our children are nine to 15 points brighter. These gaps between generations should be noticeable in conversation and everyday life. Otherwise, must we not ask ourselves whether IQ gains really are intelligence gains?

But that is the wrong question. It implies all-or-nothing cognitive progress, whereas the 20th century has seen striking exceptions to the general trend. Look again at the box on page 26: the WISC subtests that show small gains are those most relevant to school-taught subjects. It is illuminating to compare their trends with those for the National Association of Educational Progress (NAEP) tests, often called the nation's report card.

From 1971 to 2002, fourth and eighth graders made a reading gain equivalent to almost four IQ points. By the 12th grade the gain dropped off to almost nothing. If we focus on WISC trends from 1972 to 2002, we see that schoolchildren made no gain in their store of general information and only minimal vocabulary gains. Therefore, although today's children may learn to master pre-adult literature at a younger age, they are no better prepared for reading more demanding adult literature. You cannot enjoy *War and Peace* if you have to run to the dictionary or encyclopedia every other paragraph.

From 1973 to 2000, fourth and eighth graders made mathematics gains equivalent to almost seven IQ points. The gain fell off at the 12th grade, this time literally to nothing. Increasing numbers of children have been mastering computational skills at younger ages. But the WISC Arithmetic subtest measures both computational skills and something extra. For example, consider this problem: "If four toys cost six dollars, how much do seven cost?" Many who can do straight paper calculations cannot diagnose the two operations required: that you must first divide and then multiply. Others cannot do mental arithmetic involving fractions.

My hypothesis is that children have mastered calculating skills at an earlier age but have made no progress in acquiring mathematical reasoning skills. Reasoning skills are essential for higher mathematics. Therefore, by the 12th grade the failure to develop enhanced mathematical problem-solving strategies begins to bite.

We now know why children today do not put their grandparents to shame in conversation. Assume we hear a recent high school graduate chatting with his grandfather (who also finished high school) about a novel they both read the week before. There is no reason to believe either would have to make any allowance for the obtuseness of the other. If we were to discover essays on current affairs they both wrote shortly after graduation, there is no reason to believe that either would strike us as inferior to the other in terms of vocabulary or supply of general information.

PARADOX 3

The Mental Retardation Paradox

Paradox three refers to our more remote ancestors, the Americans of 1900. If we put the average American of today at 100, the Americans of 1900 had a mean IQ of 50 to 70, which seems to

DON CARSTENS (*left*) AND ED HONOWITZ (*right*) Getty Images

IQ gains have not inoculated people **against credulity**. Look at the number who believe in creationism and astrology.

signal a plague of mental retardation. We now know why we need draw no such inference. Our ancestors were no less intelligent; it is just that their intelligence was anchored in everyday reality. And it is an inability to cope with everyday life that characterizes someone who truly suffers from mental retardation.

The Vineland Adaptive Behavior Scale tells us coping skills remained stable during a period of rapid IQ gains. The performance of today's children (ages seven to 18) was compared with that of a random sample of children tested in 1984. Children had made no gains on the Communication and Socialization subtests. They had actually lost ground on a Daily Living Skills subtest. (It had obsolete items, such as "sews or hems clothes.")

The fact that we have not become more intelligent since 1900 does not imply that massive IQ gains over time are trivial. We can use abstractions, logic and the hypothetical to attack the formal problems that arise when science liberates thought from concrete situations. Since 1950 we have become much more ingenious in going beyond previously learned rules to solve problems on the spot [*see box on opposite page*].

PARADOX 4

The Genes and Environment Paradox

When identical twins are separated at birth and raised apart, they grow up to have IQs much more alike than randomly selected individuals would have. The obvious explanation is their identical genes, and these studies are taken as evidence that genes are potent and the environment is feeble. Yet massive IQ differences between one generation and another seem to signal the existence of environmental factors of enormous potency. Our fourth paradox asks, How can solid evidence show that environment is negligible (kinship studies) and powerful (IQ gains) at the same time?

Consider the identical twins John and Joe, who were separated at birth. Both live in an area that is basketball-mad. Their identical genes make them both taller and quicker than average to the same degree. John goes to school in one city, where he plays basketball a bit better on the playground, enjoys it more, practices more than most, catches the eye of the grade school coach, plays on a team and goes on to compete in high school, where he gets professional-style coaching. Joe goes to school in a city a few hundred miles away. Because his genes are identical to John's, and because he is taller and quicker than average to the same degree, he is likely to have a similar life history.

In other words, a genetic advantage that may have been quite modest at birth has a great effect on eventual basketball skills as they get matched with better environments—and genes thereby get "credit" for the potency of powerful environmental factors such as more practice, team play and professional coaching.

Now imagine one child who is born with a slightly higher aptitude than another child. Which of them will tend to like school, be encouraged, start haunting the library, get into top-tier classes and attend university? And if that child has a separated identical twin who has much the same academic history, what will account for their similar adult IQs? Not identical genes alone—rather the ability of those identical genes to co-opt environments of similar quality will be the missing piece of the puzzle.

Genes have "profited" from seizing control of strong feedback loops that operate between performance and environment. A gene-based performance advantage causes a more-homework-done environment; the latter magnifies the academic performance advantage, which upgrades the environment further by leading to entry into a top-level class; this in turn magnifies the performance advantage once again, which facilitates access to a good university environment. These feedback loops have such an influence on the fate of individuals that my collaborator William T. Dickens of the Brookings Institution and I call them "individual multipliers."

There is also a "social multiplier." The industrial revolution in the late 19th and early 20th centuries demanded additional years of education. When a grade school education became the norm, everyone with middle-class aspirations wanted a high school diploma. When a high school diploma became the norm, everyone be-

GETTY IMAGES

IQ Gains and the Real World

Professional work roles enhance the ability to be innovative. They could hardly do that unless innovation was necessary to perform professional duties. Because society needs more and more people to do managerial, technical and professional jobs, gains in the ability to think on the spot rather than just follow rules (as measured by a test called Raven's Progressive Matrices [*see box on page 28*]) have social significance.

First-born children have more analytical interests. Reduced family size means that a higher percentage of children in recent years are first-born. Enhancing cognitive skills becomes a prerequisite for being a good parent. Parents must take "hypothetical" questions seriously—that is, they need to answer rather than dismiss the eternal string of "whys."

Video games and electronic games enhance problem solving in visual and symbolic contexts. Note the cognitive demands of games such as Tetris (spatial geometry), Myst (engineering riddles) and Grand Theft Auto (mapping). Enhanced problem-solving skills have become necessary to fully enjoy our leisure activities. Chess grand masters are getting younger, yet the standard of play in tournaments continues to rise.

A generation ago TV programs such as *I Love Lucy, Dragnet* and *Starsky and Hutch* required virtually no concentration to follow. Beginning in 1981 with *Hill Street Blues,* single-episode dramas began to weave together as many as 10 threads into their plotlines. The hit drama *24* connects the lives of 20 or more characters, each with a distinct story. *—J.F.*

gan to want a bachelor's degree. Economic progress created a middle class with new expectations about stimulating children intellectually, performing highly paid professional jobs in which they would be expected to think for themselves, and enjoying more cognitively demanding leisure activities. No one wants to seem deficient as a parent, unsuited for promotion, boring as a companion. Everyone responds to the new milieu by enhancing their performance, which pushes the average higher; they respond to that new average, which pushes the average higher still. Result: a dramatic escalation of cognitive skills in a single generation.

Within a generation, genetic differences drive feedback processes; between generations, environmental trends drive feedback processes. What looks potent depends on whose hand is on the throttle.

A Hidden Trend and the Future

IQ gains have not inoculated people against credulity. Abstract categories and analysis can be used to defend nonsense rather than sense. Look at the number of people who believe in creationism, flying saucers and astrology.

Yet recent history has seen a second trend. The language of educated people has been enriched by words that can greatly enhance critical acumen. These terms each stand for a cluster of concepts that chart a method of analysis applicable to social and moral issues. I refer to concepts such as market (which became current in 1776), percentage (1860), natural selection (1864), control group (1875), random sample (1877), naturalistic fallacy (1903), charisma effect (1922), placebo (1938) and falsification (1959).

Thanks to division of the universities into specialties, no graduate is trained to use more than a fragment of these terms. The full potential of IQ gains over time goes unrealized. Because universities could have better educated their students at any time over the past century, improved performance in the 21st century is far from certain. **M**

(Further Reading)

- **The Rising Curve: Long-Term Gains in IQ and Related Measures.** Edited by Ulric Neisser. American Psychological Association, 1998.
- **What Is Intelligence: Beyond the Flynn Effect.** James R. Flynn. Cambridge University Press, 2007.

DANIEL HOROWITZ Getty Images

JESSICA WYNNE

Eric Kandel: From Mind to Brain and Back Again

Awarded the Nobel Prize for work 40 years ago that revealed memory's most basic mechanisms, this psychiatrist-turned-neuroscientist is still working his discipline's cutting edge

By David Dobbs

The sea slug *Aplysia californica* is not unlike an eggplant. It is big—up to a foot long and six pounds—and bruise-purple from gorging on seaweed. Harass one, and it will emit "a very fine purplish-red fluid," as Charles Darwin found long ago, "which stains the water for the space of a foot around." Hardly a jewel of the sea.

Yet neuroscientist Eric R. Kandel looked at the slug 50 years ago and saw a gemlike formal simplicity, which he used to help build the foundations of modern neuroscience. With *Aplysia,* Kandel revealed that we learn not by altering neurons but by strengthening or building new synapses, or connections, between them—a breakthrough of a lifetime. Then he went on to elucidate the most intricate and basic mechanisms underlying this vital process, including how this synaptic remodeling embodies the concept now known as gene expression; that is, it occurs because genes, along with shaping our bodies and coloring our hair, constantly alter our brains by responding to experience.

These discoveries, for which Kandel shared the 2000 Nobel Prize in Physiology or Medicine with Arvid Carlsson of Goeteborg University in Sweden and Paul Greengard of the Rockefeller University, provide a central structure in neuroscience's "connectionist" view of the brain as a highly plastic organ defined by interlaced connections among neurons and brain regions. To use the phrasing of New York University's Joseph E. LeDoux—one of a generation of neuroscientists whom Kandel profoundly influenced—Kandel first made clear that "you are your synapses."

If Kandel's career helped to define the foundations of neuroscience in the 20th (and 21st) century, his life in turn reflects some of the past century's most essential forces. A psychiatrist before he was a neuroscientist, Kandel came to his new discipline because he wanted more testable, physical explanations of human behavior than psychiatry in the 1950s could provide. And he came to the country he now calls home, the U.S., while fleeing the Nazis and the great upheaval that was World War II. The power of his own recollections of this era helped to forge his fascination with memory. To decipher memory's making, he decided, was to strive to decipher one's essence and identity.

"We are who we are," Kandel points out,

"because of what we have learned and what we remember." He has shown not merely that this is true but also how it happens.

An Unexpected Journey

Some would argue that reducing memory to mechanism dilutes its magic. Kandel, however—as fond of Proust as of Pavlov and intensely humanistic—makes no apologies for insisting that even our deepest thoughts and emotions rise from mechanistic biology. In his office at Columbia University—a room large and impressive yet comfortable, with a sitting area facing views of the Hudson River and coffee kindly offered to a visitor—he laughs and says, "Of *course*, the mind is a product of the brain! How could it not be?"

> "Of *course,* the mind is a product of the brain," says Kandel, laughing. "How could it not be?"

Yet Kandel is hardly a cold reductionist. For starters, he is gracious, warm and funny. And he wears no blinders. Born in Vienna in 1929, he grew up—first there, then in New York City after his family fled—loving literature, music, history and science. He is intrigued by memory's mechanisms and its shaping of character and culture. His interest in psychiatry, for instance, stems partly from his admiration of Sigmund Freud's elegant writings and partly from his pained fascination with the swings in individual and social psychology that convulsed mid-20th-century Europe. And his interest in memory rises from the power of his own childhood recollections, particularly that of the night on which the ugliest part of the 20th century intruded into a happy home.

Kandel related this tale to me in his office, and it appears at greater length in his memoir *In Search of Memory*. It is November 9, 1938, two days after Eric's ninth birthday, and the boy is steering a treasured new birthday gift, "a beautiful, shiny blue car," around his parents' Vienna apartment. It is early evening. Kandel's father is due home from running the family's toy store. A thunderous pounding on the door interrupts Eric's play. The Nazi police have come to roust out this Jewish family. They order his mother to pack some things and leave the apartment. When the family returns after a few days—reunited, incredibly, with Eric's father, who won his release from captivity because he had fought for the Austrians in World War I—they find the apartment ransacked. All the family's valuables, including Eric's new toy, have been taken. "One humiliating and frightening year" later, Kandel and his brother fled to the U.S., to be joined later by their parents.

Those memories would prove the most vivid of Kandel's life. To their power, Kandel writes, "I cannot help but link my later interest in mind—in how people behave, the unpredictability of motivation, and the persistence of memory." And so fascism's intrusion inspired some of neuroscience's most elegant, innovative and influential work.

Kandel graduated from a public high school in New York and then attended Harvard University, where he developed an interest in psychoanalysis that led him to enter New York University Medical School in 1952. There, in a second-year neuroanatomy course, a seemingly prosaic assignment to build a model of a brain out of clay fired his interest in the brain as mind. "Nothing I ever did," Kandel tells me half a century later, "provoked my understanding of the brain as much as building that model did." He soon began studying the brain in earnest, first in the Columbia laboratory of electrophysiology pioneer Harry Grundfest during elective semesters in medical school and then, having earned his M.D., at the National Institute of Mental Health. After working there on memory in mammalian brains, he decided to focus on the neural dynamics of a much simpler animal: the sea snail *Aplysia*.

FAST FACTS

Mental Mechanisms

1» **Born in Vienna in 1929, Eric R. Kandel later escaped the Nazis with his family and settled in the U.S.**

2» **Kandel originally trained as a psychiatrist but turned to neuroscience to probe the mechanisms of the mind.**

3» **Now at Columbia University, Kandel shared the 2000 Nobel Prize in Physiology or Medicine for his work in understanding neural signaling. He hopes psychotherapy can benefit from the lessons of biology.**

A Path Revisited

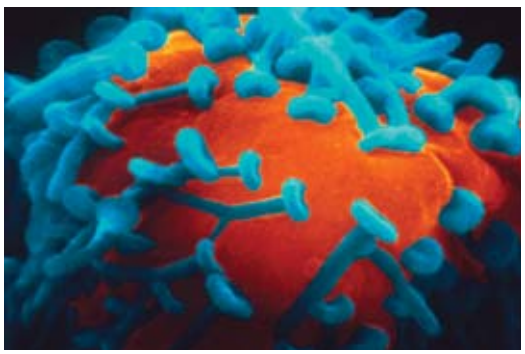
"Reductionism," Kandel notes, "is not a philosophy but a method." Yet in the early 1960s, when he decided to focus on memory mechanisms in *Aplysia,* many of the authorities he consulted doubted that such a simple animal could illuminate a process as labyrinthine as human memory. Kandel had already tried to study memory in the monkey hippocampus and found its complexity confounding. He had a hunch that the simpler *Aplysia* could reveal the kind of "elementary forms of learning," as he puts it, "common to all animals." Certainly *Aplysia* is elementary. The strange, squishy beast has only 20,000 neurons, many big enough to see with the naked eye and easy to probe and monitor with electrodes and sensors.

Kandel's 45 years of work on *Aplysia* make for an epic tale, full of great brainstorms and bulldog tenacity. But at its center is a simple set of conditioning and sensitization experiments.

His first step was to establish a basic sea-slug reflex: touch *Aplysia* near its gill, on its back, and the slug will retract the gill. Kandel then added, just before the gill touch, a light shock to the animal's tail. After a few repetitions the slug would retract the gill at the tail shock alone.

Behaviorally, such association was nothing new; it was Pavlov redux. Unlike Pavlov, however, Kandel was watching more than the animal's behavior: he sought to understand its neural circuitry. Over several years (with many different slugs and colleagues), he identified and monitored the precise synaptic circuits, dynamics, signaling mechanisms and, finally, even the genes and gene actions that such tasks engaged. One of his first great discoveries was that although the slugs varied in how quickly they absorbed their lessons, they all learned by using the same 30-neuron circuit. This finding produced the central insight about the synaptic nature of memory. For if this learning always involved the same neurons, then the differences in what and how fast various animals learned must lie in the connections between neurons. Subsequent investigations confirmed and elaborated on this idea.

This discovery was only the first of many that Kandel made with *Aplysia*. He soon found, for instance, that although short-term memory is created by strengthening existing synapses, long-term memory requires the creation of new synapses. He then identified, confirmed or refined the understanding of the roles that several key neurotransmitters play in creating these signals. And since the 1990s he has been distinguishing ever



As a study subject, the sea slug *Aplysia californica* appealed to Kandel precisely because it was one of the simplest beasts he could find (*above*). A color-enhanced electron microscope image shows bulbous nerve endings on the nerve cell body of an *Aplysia* (*left*).

smaller elements in the "cascades" of genetic expression—genes creating messengers that activate other genes that build the proteins that activate or control yet other genes—that create these synapses. All this work showed, wrote Kandel in a recent essay on reductionism in art and science, that "genes are not simply the determinants of behavior—they are also servants of the environment."

Remaking Analysis

These insights into gene-environment interaction and memory's synaptic nature remain the core of Kandel's work. They also drive a bold campaign he has undertaken to remake psychiatry, the specialty he trained in and left for neuroscience. It is time, he has announced in prominent journal articles and many talks, to transform the "interpretive healing art" of psychiatry into "a modern discipline based on molecular biology." Psychiatry's aging interpretive framework, he argues, must be reworked to incorporate what we have learned about the biological bases of memory and emotion.

For someone who admires Freud as much as Kandel does, this campaign carries some historical irony. Kandel's discovery and proof that

(The Author)

DAVID DOBBS (www.daviddobbs.net) is contributing editor for *Scientific American Mind* and founding editor of the Mind Matters seminar blog (www.sciammind.com).

NORBERT WU *Minden Pictures* (Aplysia); OMIKRON *SPL/Photo Researchers, Inc.* (*nerve endings*)

Spry, slender and sharp at 78, Kandel heads what is still one of the world's most productive neuroscience laboratories.

memory is synaptic confirmed a notion first offered by the great Spanish neuroscientist Santiago Ramón y Cajal, who held a view of the mind quite different from that of Freud. In 1894 Ramón y Cajal suggested that memory is stored not in neurons (his discovery of which would win him a Nobel Prize in 1906) but in the growth of new connections between them. But because he lacked the tools needed to explore synaptic change, he could not pursue his synaptic hypothesis of memory. Into that evidentiary vacuum walked Freud, who offered the mytho-literary-metaphorical model of memory and psychodynamics that would dominate psychological theory for most of the 20th century. Meanwhile Ramón y Cajal's synaptic model of learning lay dormant—that is, until Kandel proved it in the 1960s. When Kandel presses his psychiatric colleagues to get biological, he is not just urging them to modernize; he is calling them back to a path they once abandoned to follow Freud.

Yet integrating psychiatry's path with that of neuroscience is a big job, and psychiatrists sharing Kandel's agenda admit they are only beginning to merge biology and interpretation. "We're trying," says Stuart Yudofsky, a former Kandel protégé at Columbia who now directs clinical psychiatry at the Baylor College of Medicine. "But I don't think any of us has got to where we want to." Nevertheless, a new Kandelian psychiatry, if you will, is already taking shape and stands to accelerate rapidly in the years to come.

The most direct potential lies in drug design. Today's psychiatric drugs may improve on yesterday's, but they are still crude. For instance, because SSRI (selective serotonin reuptake inhibitor) antidepressants alter serotonin availability everywhere rather than only at mood-crucial receptors, they have unwanted effects on sexual function and make some people dizzy, sleepless or fatigued. SSRIs also ignore genetic variation among people, so they leave some patients unchanged. Even those who find relief may have to try several different SSRIs before hitting on one that works.

What is needed is a variety of drugs that aim precisely at the chains of gene expression that cause mental distress. Researchers are now identifying key gene variants associated with disorders that include schizophrenia, bipolar disorder, anxiety disorder and depression. With some luck and more hard work, such research could facilitate the production of psychiatric drugs that can alter specific gene-environment interactions, manipulating, for instance, the chain of gene expression through which a particular variant in the serotonin transporter gene—the "short" allele—is known to make people vulnerable to depression. Such drugs would work more effectively and with fewer side effects than today's medications.

Talk therapy will change, too—it already has. Recent studies have shown, for instance, that counseling can change brain chemistry in some patients just as effectively as drug therapy can [see "The Best Medicine?" by Hal Arkowitz and Scott O. Lilienfeld, on page 80]. Talk therapy, for instance, creates marked, measurable reductions in activity in a brain area called the right caudate nucleus in obsessive-compulsive patients, and it returns serotonin levels as well as sleep patterns to normal in some people with depression. Such therapy-driven changes seem to arrive through different avenues than changes tied to medication do. A 2004 study showed that effective psychotherapy in depressed patients causes meta-

JESSICA WYNNE

bolic changes primarily in the brain's "thinking" areas, such as the forebrain, whereas SSRIs most strongly affect "nonthinking" subcortical areas. This finding jibes perfectly with Kandelian insights into the two-way nature of gene-environment interaction: psychotherapy, being a change in one's environment that engages the conscious mind, works from the top of the environment–gene expression loop, whereas drugs work from the bottom.

Some psychiatrists are altering their approach accordingly. Glen Gabbard, a psychoanalyst and professor of psychiatry at Baylor, argues that the bottom-up dynamics addressed by drugs are associated with what we might call basic temperament, whereas the top-down processes accessible by counseling relate more to learned behavior. With "a general tendency toward despondency or passivity, you're probably going to have better luck with drugs," Gabbard says. "But drugs aren't going to change someone's tendency to, say, demonize others or fail to listen. That requires therapy. You have to choose your battles."

A Change of Mind

Meanwhile the connectionist theory of mind that Kandel helped to create has already led the rest of us to see ourselves differently. Our humor reflects this change, as jokes about Freudian slips give way to quips about psychochemistry. "He must be off his meds" may express an unfortunate stigma about mental illness, but as a replacement for cracks about Oedipal hostilities it denotes a significant shift. We see the mind in ever more mechanistic terms, replacing tales of conflicted psyches and warring inner selves with stories of errant messengers and deaf receptors. This vision is arguably a more hopeful take on human nature. It sees us neither as preprogrammed genetic machines nor as impossibly conflicted inner selves but as malleable networks that we can alter and heal.

Kandel's snails, meanwhile, foot-long and luridly purple, are still yielding secrets. Over the past five years, for instance, a team in Kandel's lab has discovered that a protein called CPEB plays a key role in *Aplysia*'s long-term memory retention by taking a form distinctly like that of a prion, the strange, proteinlike structure that causes spongiform brain diseases such as mad cow. It is the first time anyone has shown that a prionlike protein plays a role in normal physiology. Kandel is now investigating just how CPEB aids memory and whether it might be manipulated to improve memory.

He is also investigating the role that certain genes called *Grp* and *stathmin* play in how mice construct memories and process ideas about fear and safety. And with mice Kandel is finally returning to his study of the hippocampus and the larger dynamics of brain-wide neurocircuitry that were simply beyond reach when he tried to study them in monkeys 45 years ago. "The big excitement now," he says, "is on the systems level. With something like *Aplysia*, you can take a molecular question and drive it into the ground. But it's not a cosmic animal. It doesn't have awareness or think great thoughts. But mice, in their own way, they do."

> "Ladies and gentlemen, this is not just a scared little snail. This snail is *anxious*."

Kandel can expand his mission, of course, only because he and others have defined many of the molecular and cellular fundamentals underlying these wider brain functions.

If he is indebted to his own early success, so is the rest of neuroscience. Jack Barchas, chair of psychiatry at Weill Cornell Medical College and himself a groundbreaking researcher of endorphins and other stress-related hormones, says, "Eric has changed the landscape again and again. It started when he had the balls to see how fear is created in *Aplysia* and say, 'Ladies and gentlemen, this is not just a scared little snail. This is humanity. This is anxiety. This snail is *anxious*.'

"That alone changed everything. But Eric's real genius has been having the courage to change and develop and keep asking new questions. We in science are always climbing a slippery rope. Every once in a while somebody ties a knot in it that lets everybody stand on and keep going. Eric's tied a bunch of those." M

(Further Reading)

- **Psychiatry, Psychoanalysis, and the New Biology of Mind.** Eric Kandel. American Psychiatric Publishing, 2005.
- **In Search of Memory: The Emergence of a New Science of Mind.** Eric Kandel. W. W. Norton, 2006.
- Eric R. Kandel's research laboratory Web site: **www.erickandel.org**

FRY DESIGN LTD *Getty Images*

Searching *for* God *in the* Brain

Researchers are unearthing the roots of religious feeling in the neural commotion that accompanies the spiritual epiphanies of nuns, Buddhists and other people of faith

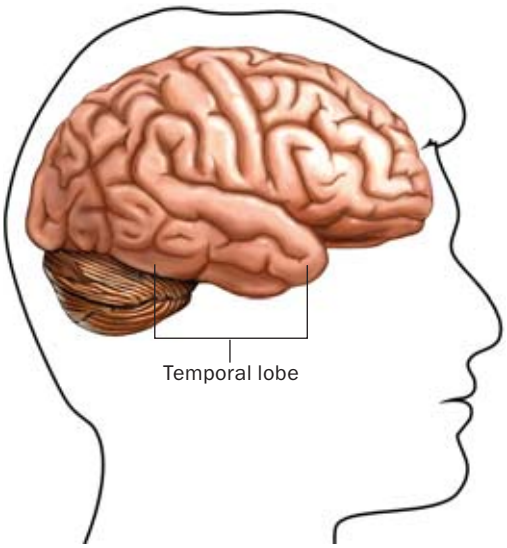
By David Biello

The doughnut-shaped machine swallows the nun, who is outfitted in a plain T-shirt and loose hospital pants rather than her usual brown habit and long veil. She wears earplugs and rests her head on foam cushions to dampen the device's roar, as loud as a jet engine. Supercooled giant magnets generate intense fields around the nun's head in a high-tech attempt to read her mind as she communes with her deity.

The Carmelite nun and 14 of her Catholic sisters have left their cloistered lives temporarily for this claustrophobic blue tube that bears little resemblance to the wooden prayer stall or sparse room where such mystical experiences usually occur. Each of these nuns answered a call for volunteers "who have had an experience of intense union with God" and agreed to participate in an experiment devised by neuroscientist Mario Beauregard of the University of Montreal. Using functional magnetic resonance imaging (fMRI), Beauregard seeks to pinpoint the brain areas that are active while the nuns recall the most powerful religious epiphany of their lives, a time they experienced a profound connection with the divine. The question: Is there a God spot in the brain?

The spiritual quest may be as old as humankind itself, but now there is a new place to look: inside our heads. Using fMRI and other tools of modern neuroscience, researchers are attempting to pin down what happens in the brain when people experience mystical awakenings during prayer and meditation or during spontaneous utterances inspired by religious fervor.

Such efforts to reveal the neural correlates of the divine—a new discipline with the warring titles "neurotheology" and "spiritual neuroscience"—not only might reconcile religion and science but also might help point to ways of eliciting pleasurable otherworldly feelings in people who do not



TEMPORAL TEMPEST: Some scientists speculate that intense religious feelings arise from unusual electrical activity in the brain's temporal lobe, in some cases connecting spirituality with temporal lobe epilepsy.

have them or who cannot summon them at will. Because of the positive effect of such experiences on those who have them, some researchers speculate that the ability to induce them artificially could transform people's lives by making them happier, healthier and better able to concentrate. Ultimately, however, neuroscientists study this question because they want to better understand the neural basis of a phenomenon that plays a central role in the lives of so many. "These experiences have existed since the dawn of humanity. They have been reported across all cultures," Beauregard says. "It is as important to study the neural basis of [religious] experience as it is to investigate the neural basis of emotion, memory or language."

FAST FACTS

Nerves for Religion

1» Using the tools of modern neuroscience, researchers are attempting to pin down what happens in the brain when people experience spiritual awakenings during prayer and meditation.

2» Some believe that religious experience grows out of neural activity emanating from a specific section of the brain—the temporal lobe—whereas others point to a broader network of brain areas as the biological basis of spirituality.

3» Efforts to reveal the neural correlates of the divine—a new discipline with the warring titles "neurotheology" and "spiritual neuroscience"—not only might reconcile religion and science but also might help point to ways of eliciting pleasurable otherworldly feelings in people who do not have them.

Mystical Misfirings

Scientists and scholars have long speculated that religious feeling can be tied to a specific place in the brain. In 1892 textbooks on mental illness noted a link between "religious emotionalism" and epilepsy. Nearly a century later, in 1975, neurologist Norman Geschwind of the Boston Veterans Administration Hospital first clinically described a form of epilepsy in which seizures originate as electrical misfirings within the temporal lobes, large sections of the brain that sit over the ears. Epileptics who have this form of the disorder often report intense religious experiences, leading Geschwind and others, such as neuropsychiatrist David Bear of Vanderbilt University, to speculate that localized electrical storms in the brain's temporal lobe might sometimes underlie an obsession with religious or moral issues.

Exploring this hypothesis, neuroscientist Vilayanur S. Ramachandran of the University of California, San Diego, asked several of his patients who have temporal lobe epilepsy to listen to a mixture of religious, sexual and neutral words while he tested the intensity of their emotional reactions using a measure of arousal called the galvanic skin response, a fluctuation in the electrical resistance of the skin. In 1998 he reported in his book *Phantoms in the Brain* (William Morrow), co-authored with journalist Sandra Blakeslee, that the religious words, such as "God," elicited an unusually large emotional response in these patients, indicating that people with temporal lobe epilepsy may indeed have a greater propensity toward religious feeling.

The key, Ramachandran speculates, may be the limbic system, which comprises interior regions of the brain that govern emotion and emotional memory, such as the amygdala and hypothalamus. By strengthening the connection between the temporal lobe and these emotional centers, epileptic electrical activity may spark religious feeling.

To seal the case for the temporal lobe's involvement, Michael Persinger of Laurentian University in Ontario sought to artificially re-create religious feelings by electrically stimulating that large subdivision of the brain. So Persinger created the "God helmet," which generates weak electromagnetic fields and focuses them on particular regions of the brain's surface.

In a series of studies conducted over the past several decades, Persinger and his team have trained their device on the temporal lobes of hundreds of people. In doing so, the researchers induced in most of them the experience of a sensed

NUCLEUS MEDICAL ART, INC. *Phototake*

The ability to artificially induce mystical experiences could transform people's lives by making them happier.

presence—a feeling that someone (or a spirit) is in the room when no one, in fact, is—or of a profound state of cosmic bliss that reveals a universal truth. During the three-minute bursts of stimulation, the affected subjects translated this perception of the divine into their own cultural and religious language—terming it God, Buddha, a benevolent presence or the wonder of the universe.

Persinger thus argues that religious experience and belief in God are merely the results of electrical anomalies in the human brain. He opines that the religious bents of even the most exalted figures—for instance, Saint Paul, Moses, Muhammad and Buddha—stem from such neural quirks. The popular notion that such experiences are good, argues Persinger in his book *Neuropsychological Bases of God Beliefs* (Praeger Publishers, 1987), is an outgrowth of psychological conditioning in which religious rituals are paired with enjoyable experiences. Praying before a meal, for example, links prayer with the pleasures of eating. God, he claims, is nothing more mystical than that.

Expanded Horizons

Although a 2005 attempt by Swedish scientists to replicate Persinger's God helmet findings failed, researchers are not yet discounting the temporal lobe's role in some types of religious experience. After all, not all such experiences are the same. Some arise from following a specific religious tradition, such as the calm Catholics feel when saying the rosary. Others bring a person into a perception of contact with the divine. Yet a third category might be mystical states that reveal fundamental truths opaque to normal consciousness. Thus, it is possible that different religious feelings arise from distinct locations in the brain. Individual differences might also exist. In some people, the neural seat of religious feeling may lie in the temporal lobe, whereas in others it could reside elsewhere.

Indeed, University of Pennsylvania neuroscientist Andrew Newberg and his late colleague, Eugene d'Aquili, have pointed to the involvement of other brain regions in some people under certain circumstances. Instead of artificially inducing religious experience, Newberg and d'Aquili used brain imaging to peek at the neural machinery at work during traditional religious practices.

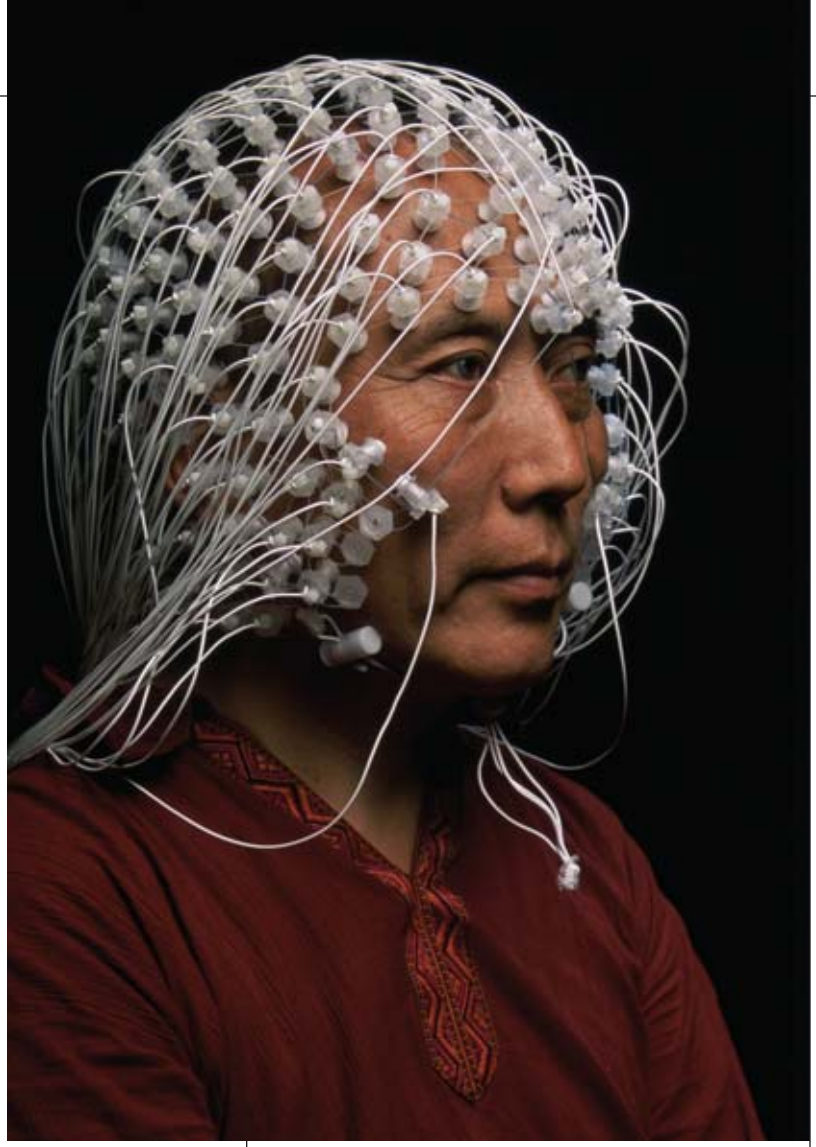
In this case, the scientists studied Buddhist meditation, a set of formalized rituals aimed at achieving defined spiritual states, such as oneness with the universe.

When the Buddhist subjects reached their self-reported meditation peak, a state in which they lose their sense of existence as separate individuals, the researchers injected them with a radioactive isotope that is carried by the blood to active brain areas. The investigators then photographed the isotope's distribution with a special camera—a technique called single-photon-emission computed tomography (SPECT).

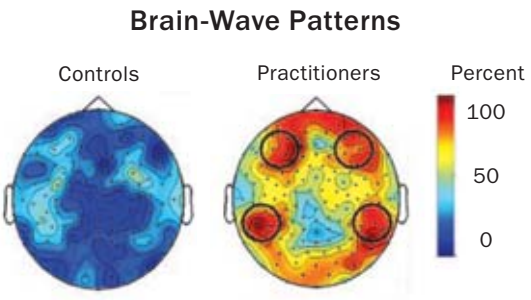
The height of this meditative trance, as they described in a 2001 paper, was associated with both a large drop in activity in a portion of the parietal lobe, which encompasses the upper back of the brain, and an increase in activity in the right prefrontal cortex, which resides behind the forehead. Because the affected part of the parietal lobe normally aids with navigation and spatial orientation, the neuroscientists surmise that its abnormal silence during meditation underlies the perceived dissolution of physical boundaries and the feeling of being at one with the universe. The prefrontal cortex, on the other hand, is charged with attention and planning, among other cognitive duties, and its recruitment at the meditation peak may reflect the fact that such contemplation often requires that a

GOD GENERATOR: The "God helmet" (*above*) can create a state of cosmic bliss in a wearer by stimulating certain parts of the brain with weak electromagnetic fields. The helmet supposedly had no sway, however, over evolutionary biologist and staunch atheist Richard Dawkins (*top*).

COLIN McPHERSON *Corbis (Dawkins)*; COURTESY OF MICHAEL PERSINGER *Laurentian University (helmet)*



MEDITATION MONITOR: Researchers can use electrodes to detect characteristic brain-wave patterns during meditation (*above*). The patterns of experienced Buddhist practitioners (*far right*) differ from those of student volunteers (*right*). The colors indicate the percentage of subjects in each group who showed an increase in gamma-wave activity (25 to 42 hertz) during meditation. The resting-state gamma-band patterns also differ between the two groups.



person focus intensely on a thought or object.

Neuroscientist Richard J. Davidson of the University of Wisconsin–Madison and his colleagues documented something similar in 2002, when they used fMRI to scan the brains of several hundred meditating Buddhists from around the world. Functional MRI tracks the flow of oxygenated blood by virtue of its magnetic properties, which differ from those of oxygen-depleted blood. Because oxygenated blood preferentially flows to where it is in high demand, fMRI highlights the brain areas that are most active during—and thus presumably most engaged in—a particular task.

Davidson's team also found that the Buddhists' meditations coincided with activation in the left prefrontal cortex, again perhaps reflecting the ability of expert practitioners to focus despite distraction. The most experienced volunteers showed lower levels of activation than did those with less training, conceivably because practice makes the task easier. This theory jibes with reports from veterans of Buddhist meditation who claim to have reached a state of "effortless concentration," Davidson says.

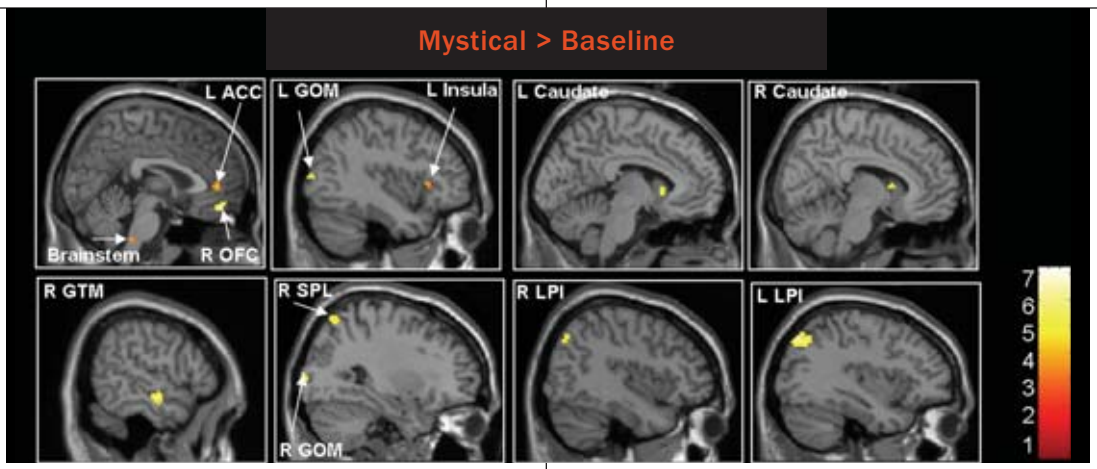
What is more, Newberg and d'Aquili obtained concordant results in 2003, when they imaged the brains of Franciscan nuns as they prayed. In this case, the pattern was associated with a different spiritual phenomenon: a sense of closeness and mingling with God, as was similarly described by Beauregard's nuns. "The more we study and compare the neurological underpinnings of different religious practices, the better we will understand these experiences," Newberg says. "We would like to [extend our work by] recruiting individuals who engage in Islamic and Jewish prayer as well as revisiting other Buddhist and Christian practices."

Newberg and his colleagues discovered yet another activity pattern when they scanned the brains of five women while they were speaking in tongues—a spontaneous expression of religious fervor in which people babble in an incomprehensible language. The researchers announced in 2006 that the activity in their subjects' frontal lobes—the entire front section of the brain—declined relative to that of five religious people who were simply singing gospel. Because the frontal lobes are broadly used for self-control, the research team concluded that the decrement in activity there enabled the loss of control necessary for such garrulous outbursts.

Spiritual Networking

Although release of frontal lobe control may be involved in the mystical experience, Beauregard believes such profound states also call on a wide range of other brain functions. To determine exactly what might underlie such phenomena, the Quebecois neuroscientist and his colleagues used fMRI to study the brains of 15 nuns during three different mental states. Two of the conditions—resting with closed eyes and recollecting an intense social experience—were control states against which they compared the third: reminiscence or revival of a vivid experience with God.

CARY WOLINSKY *Getty Images (photograph)*; COURTESY OF RICHARD DAVIDSON, SOURCE: ANTOINE LUTZ ET AL. IN *PNAS*, VOL. 101, NO. 46; NOVEMBER 16, 2004 (*brain-wave patterns*)



MYSTICAL HOT SPOTS: In a 2006 study the recall by nuns of communion with God invigorated the brain's caudate nucleus, insula, inferior parietal lobe (IPL) and medial orbitofrontal cortex (MOFC), among other brain regions.

There is no God spot in the brain, Beauregard says. An extensive neural network mediates spiritual states.

As each nun switched between these states on a technician's cue, the MRI machine recorded cross sections of her brain every three seconds, capturing the whole brain roughly every two minutes. Once the neural activity was computed and recorded, the experimenters compared the activation patterns in the two control states with those in the religious state to elucidate the brain areas that became more energized during the mystical experience. (Although Beauregard had hoped the nuns would experience a mystical union while in the scanner, the best they could do, it turned out, was to conjure up an emotionally powerful memory of union with God. "God can't be summoned at will," explained Sister Diane, the prioress of the Carmelite convent in Montreal.)

The researchers found six regions that were invigorated only during the nuns' recall of communion with God. The spiritual memory was accompanied by, for example, increased activity in the caudate nucleus, a small central brain region to which scientists have ascribed a role in learning, memory and, recently, falling in love; the neuroscientists surmise that its involvement may reflect the nuns' reported feeling of unconditional love. Another hot spot was the insula, a prune-size chunk of tissue tucked within the brain's outermost layers that monitors body sensations and governs social emotions. Neural sparks there could be related to the visceral pleasurable feelings associated with connections to the divine.

And augmented activity in the inferior parietal lobe, with its role in spatial awareness—paradoxically, the opposite of what Newberg and Davidson witnessed—might mirror the nuns' feeling of being absorbed into something greater. Either too much or too little activity in this region could, in theory, result in such a phenomenon, some scientists surmise. The remainder of the highlighted regions, the researchers reported in the September 25, 2006, issue of *Neuroscience Letters,* includes the medial orbitofrontal cortex, which may weigh the pleasantness of an experience; the medial prefrontal cortex, which may help govern conscious awareness of an emotional state; and, finally, the middle of the temporal lobe [*see illustration above*].

The quantity and diversity of brain regions involved in the nuns' religious experience point to the complexity of the phenomenon of spirituality. "There is no single God spot, localized uniquely in the temporal lobe of the human brain," Beauregard concludes. "These states are mediated by a neural network that is well distributed throughout the brain."

Brain scans alone cannot fully describe a mystical state, however. Because fMRI depends on blood flow, which takes place on the order of seconds, fMRI images do not capture real-time changes in the firing of neurons, which occur within milliseconds. That is why Beauregard turned to a faster technique called quantitative electroencephalography (EEG), which measures the voltage from the summed responses of millions of neurons and can track its fluctuation in real time. His team outfitted the nuns with red

(The Author)

DAVID BIELLO is associate editor of SciAm.com.

"NEURAL CORRELATES OF A MYSTICAL EXPERIENCE IN CARMELITE NUNS," BY M. BEAUREGARD AND V. PAQUETTE, IN *NEUROSCIENCE LETTERS*, VOL. 405, NO. 3; 2006. REPRODUCED WITH PERMISSION OF ELSEVIER

DIVINE RECKONING: Researchers are looking inside the brains of nuns for biological signs of a connection with God.

TYLER HICKS *New York Times/Redux*

bathing caps studded with electrodes that pick up electric currents from neurons. These currents merge and appear as brain waves of various frequencies that change as the nuns again recall an intense experience with another person and a deep connection with God.

Beauregard and his colleagues found that the most prevalent brain waves are long, slow alpha waves such as those produced by sleep, consistent with the nuns' relaxed state. In work that has not yet been published, the scientists also spotted even lower-frequency waves in the prefrontal and parietal cortices and the temporal lobe that are associated with meditation and trance. "We see delta waves and theta waves in the same brain regions as the fMRI," Beauregard says.

Fool's Errand?

The brain mediates every human experience from breathing to contemplating the existence of God. And whereas activity in neural networks is what gives rise to these experiences, neuroimaging cannot yet pinpoint such activity at the level of individual neurons. Instead it provides far cruder anatomical information, highlighting the broad swaths of brain tissue that appear to be unusually dynamic or dormant. But using such vague structural clues to explain human feelings and behaviors may be a fool's errand. "You list a bunch of places in the brain as if naming something lets you understand it," opines neuropsychologist Seth Horowitz of Brown University. Vincent Paquette, who collaborated with Beauregard on his experiments, goes further, likening neuroimaging to phrenology, the practice in which Victorian-era scientists tried—and ultimately failed—to intuit clues about brain function and character traits from irregularities in the shape of the skull.

Spiritual neuroscience studies also face the profound challenge of language. No two mystics describe their experiences in the same way, and it is difficult to distinguish among the various types of mystical experiences, be they spiritual or traditionally religious. To add to the ambiguity, such feelings could also encompass awe of the universe or of nature. "If you are an atheist and you live a certain kind of experience, you will relate it to the magnificence of the universe. If you are a Christian, you will associate it with God. Who knows? Perhaps they are the same," Beauregard muses.

Rather than attempting to define religious experience to understand it, some say we should be boiling it down to its essential components. "When we talk about phenomena like a mystical experience, we need to be a lot more specific about what we are referring to as far as changes in attention, memory and perception," Davidson says. "Our only hope is to specify what is going on in each of those subsystems," as has been done in studies of cognition and emotion.

Other research problems abound. None of the techniques, for example, can precisely delineate specific brain regions. And it is virtually impossible to find a perfect so-called reference task for the nuns to perform against which to compare the religious experience they are trying to capture. After all, what human experience is just one detail different from the awe and love felt in the presence of God?

Making Peace

For the nuns, serenity does not come from a sense of God in their brains but from an awareness of God with them in the world. It is that peace and calm, that sense of union with all things, that Beauregard wants to capture—and perhaps even replicate. "If you know how to electrically or neurochemically change functions in the brain," he says, "then you [might] in principle be able to help normal people, not mystics, achieve spiritual states using a device that stimulates the brain electromagnetically or using lights and sounds."

Inducing truly mystical experiences could have a variety of positive effects. Recent findings suggest, for example, that meditation can improve people's ability to pay attention. Davidson and his colleagues asked 17 people who had received three months of intensive training in meditation and 23 meditation novices to perform an attention task in which they had to successively pick out two numbers embedded in a series of letters. The novices did what most people do, the investigators announced in June: they missed the second number because they were still focusing on the first—a phenomenon called attentional blink. In contrast, all the trained meditators consistently picked out both numbers, indicating that practicing meditation can improve focus.

Meditation may even delay certain signs of aging in the brain, according to preliminary work by neuroscientist Sara Lazar of Harvard University and her colleagues. A 2005 paper in *NeuroReport* noted that 20 experienced meditators showed increased thickness in certain brain regions relative to 15 subjects who did not meditate. In particular, the prefrontal cortex and right anterior insula were between four and eight thousandths of an inch thicker in the meditators; the oldest of these subjects boasted the greatest increase in thickness, the reverse of the usual process of aging. Newberg is now investigating whether meditation can alleviate stress and sadness in cancer patients or expand the cognitive capacities of people with early memory loss.

Artificially replicating meditative trances or other spiritual states might be similarly beneficial to the mind, brain and body. Beauregard and others argue, for example, that such mystical mimicry might improve immune system function, stamp out depression or just provide a more positive outlook on life. The changes could be lasting and even transformative. "We could generate a healthy, optimal brain template," Paquette says. "If someone has a bad brain, how can they get a good brain? It's really [a potential way to] rewire our brain." Religious faith also has inherent worldly rewards, of course. It brings contentment, and charitable works motivated by such faith bring others happiness.

To be sure, people may differ in their proclivity to spiritual awakening. After all, not everyone finds God with the God helmet. Thus, scientists may need to retrofit the technique to the patient. And it is possible that some people's brains will simply resist succumbing to the divine.

Moreover, no matter what neural correlates scientists may find, the results cannot prove or disprove the existence of God. Although atheists might argue that finding spirituality in the brain implies that religion is nothing more than divine delusion, the nuns were thrilled by their brain scans for precisely the opposite reason: they seemed to provide confirmation of God's interactions with them. After all, finding a cerebral source for spiritual experiences could serve equally well to identify the medium through which God reaches out to humanity. Thus, the nuns' forays into the tubular brain scanner did not undermine their faith. On the contrary, the science gave them an even greater reason to believe. M

It is possible that some people's brains will simply resist succumbing to the divine.

(Further Reading)

- **Neural Correlates of a Mystical Experience in Carmelite Nuns.** M. Beauregard and V. Paquette in *Neuroscience Letters,* Vol. 405, No. 3, pages 186–190; September 25, 2006.
- **Why We Believe What We Believe.** A. Newberg and M. Robert Waldman. Free Press, 2006.
- **Mental Training Affects Distribution of Limited Brain Resources.** H. A. Slagter, A. Lutz, L. L. Greischar, A. D. Francis, S. Nieuwenhuis, J. M. Davis and R. J. Davidson in *PLoS Biology,* Vol. 5, No. 6, pages 1228–1235; June 2007. Available at **http://biology.plosjournals.org/perlserv/?request=get-document&doi=10.1371%2Fjournal.pbio.0050138&ct=1**
- **The Spiritual Brain.** M. Beauregard and D. O'Leary. HarperCollins, 2007.
- John Templeton Foundation attempts to bring together science and religion: **www.templeton.org**
- Metanexus Institute funds research into the intersection of science and religion: **www.metanexus.net**

Traumatic therapies can have long-lasting effects on mental health

BRAIN STAINS

By Kelly Lambert and Scott O. Lilienfeld

A wave of nausea washed over Sheri J. Storm when she opened the *Milwaukee Journal Sentinel* on a February morning a decade ago and saw the headline: "Malpractice lawsuit: Plaintiff tells horror of memories. Woman emotionally testifies that psychiatrist planted false recollections." The woman in the article shared a lot with Storm—the same psychiatrist, the same memories, the same diagnosis of multiple personality disorder. At that moment, Storm suddenly realized that her own illness and 200-plus personalities, though painfully real to her, were nothing more than a figment of her imagination—created by her trusted therapist, Kenneth Olson.

Storm initially sought treatment from Olson because of insomnia and anxiety associated with divorce proceedings and a new career in radio advertising. She had hoped for an antidepressant prescription or a few relaxation techniques. But after enduring hypnosis sessions, psychotropic medications and mental-ward hospitalizations, Storm had much more to worry about than stress. She had "remembered" being sexually abused by her father at the age of three and forced to engage in bestiality and satanic ritual abuse that included the slaughtering and consumption of human babies. According to her psychiatrist, these traumatic experiences had generated alternative personalities, or alters, within Storm's mind.

Storm is now convinced that her multiple personality disorder was iatrogenic, the product of her "therapy." But years after the psychiatric sessions have ceased, she is still tormented by vivid memories, nightmares and physical reactions to cues from her fictitious past. Although she was told that the false memories would fade over time, she has had a difficult time purging these "brain stains" from the fabric of her mind.

Storm's case is similar to those of many other patients who underwent recovered-memory therapy that revealed sordid histories of sexual abuse and demonic ceremonies. Although the scientific literature suggests that traumatic events are rarely, if ever, repressed or forgotten, this type of therapy was widespread in the 1990s and is still practiced today. Only after several high-profile lawsuits did the American Medical Association issue warnings to patients about the unreliability of recovered memories. Nadean Cool, the patient described in the newspaper story that turned Storm's life upside down, filed one such lawsuit. Cool received a $2.4-million settlement after 15 days of courtroom testimony. Amid the heated controversy, the American Psychiatric Association discontinued the diagnostic category of multiple personality disorder, replacing it with the slightly different diagnosis of dissociative identity disorder.

SHERI J. STORM

HOLD ME: Sheri J. Storm's psychiatrist encouraged her to express her alternative personalities by writing and drawing while in a trancelike state. Drawn in 1995, this picture represented Storm's wish to comfort an inner child who had survived incest. The code stamped at upper right identifies the drawing as court evidence in Storm's still pending malpractice lawsuit.

It seemed that science and the legal system had triumphed over sloppy therapeutic techniques. Some patients received substantial monetary settlements, their therapists were exposed in the media, and scientists produced convincing evidence that false memories could indeed be implanted in the human mind. Case closed. Or was it? For Storm and others like her, bad therapy seems to have altered the brain's emotional circuitry, with lasting effects on memory and mental health. Fortunately, as with most other blemishes, such brain stains may be reversible, though only after considerable effort.

The problem with the brain is that it is not a very **discriminating processor**. It has no spam folder.

The Fallibility of Memory

In 1949 Canadian psychologist Donald O. Hebb proposed that cellular changes lead to the establishment of "memory circuits" in the brain. Neuroscientists Tim Bliss of the National Institute for Medical Research in London and Terje Lømo of the University of Oslo validated this idea in 1973 by demonstrating that electrical signals delivered to certain brain areas, such as the hippocampus, had long-lasting effects on the connections among nerve cells. Research over the past century has provided unequivocal evidence that the brain's functional structures are continually modified to generate and maintain memories.

The problem with the brain is that it is not a very discriminating processor. It has no spam folder for imaginary or coerced memories. Movie plots, unsubstantiated rumors and images from dreams are stored in our brain alongside memories of our 10th-birthday party, first kiss and high school graduation.

Research by Elizabeth F. Loftus, then at the University of Washington and now at the University of California, Irvine, has shown how difficult it can be to distinguish real memories from fictitious ones. In 1995 she and her research associate Jacqueline E. Pickrell contacted the family members of 24 individuals and, after gathering information about their lives from relatives, constructed memory booklets containing actual childhood events along with a false story of being lost in a mall at five years of age. The researchers found that 29 percent of the subjects "remembered" the false event and were even able to provide details of it.

Recovered-memory therapy relies fundamentally on the notion that some memories are so unspeakable that the mind represses them to protect itself. Decades of research conducted by neurobiologist James L. McGaugh of U.C.I. suggest, however, just the opposite—that one key function of memories is to recall threatening situations so that they can be avoided in the future. Human experiments by McGaugh and neurobiologist Larry Cahill, also at U.C.I., have shown that emotional arousal tends to make memories stronger. Likewise, when animals receive injections of the stress hormone epinephrine (also known as adrenaline), they sail through memory tests. Not only do these experiments run counter to the notion that traumatic memories are repressed routinely, but they also may elucidate why patients such as Storm, whose therapy focused on "guided imagery" and enactments of traumatic scenes, report that these experiences have become fixtures in their memories.

FAST FACTS

Traumatic Memories

1» **Some patients who underwent recovered-memory therapy, which was widespread in the 1990s and is still practiced today, were diagnosed with multiple personality disorder. It now appears that many of their "memories" and "personalities" may have been inadvertently induced through suggestive therapy. Scientists have discovered that emotional arousal tends to make most memories stronger.**

2» **The stress, fear and helplessness associated with traumatic memories may have significant and long-lasting impacts on the brain's functioning. Even when patients become convinced that they did not actually experience child sexual abuse, satanic rituals and infant cannibalism, they may be tormented by vivid memories of such events.**

3» **Recent research on people who have been exposed to traumatic events suggests that encouraging patients to relive disturbing memories may diminish resilience and impede recovery from these events.**

Multiple Personalities

Storm's relationship with her psychiatrist was based on trust. She knew that he had professional credentials and a prestigious reputation at the local hospital. Once she was diagnosed with multiple personality disorder, she received official-looking publications that seemed to confirm the surprising judgment. Storm reports that over time, her "memories" were fabricated and consolidated by a multitude of techniques—long hypnotherapy sessions, multiple psychotropic medications, sodium amytal (purportedly a truth serum), isolation from family members and mental-ward hospitalizations.

Transcripts of Storm's sessions with Olson reveal that he did most of the talking [*see box on page 52*]. Although Storm provided no initial information about the alters, Olson identified and conversed with them. When she repeated and responded to the terrifying accusations revealed during her sessions, she was videotaped so that her alters could be validated once the sessions were over. As the sessions progressed, the acts Storm described became more horrific, and the alters became active even when she was not in her therapist's office.

"I felt absolutely stark-raving mad," Storm later wrote. "Under Olson's tutelage, dissociation became second nature to me. I randomly switched from alter to alter so frequently that I lost time or forgot how to perform even simple, routine daily functions."

The idea that emotionally laden memories can be induced in a clinical setting dates back to experiments conducted nearly a century ago. Famed behaviorist James B. Watson "conditioned" an 11-month-old infant, known in every introductory psychology text as Little Albert, to fear a white rat. The infant showed no sign of fear toward the furry creature in the first session, but after the white rat was paired with a very loud noise, Albert responded with tears. Later, Albert cried when he was presented with a variety of stimuli that resembled the rat. This early case suggested that a therapist (or experimental psychologist, in this case) could easily create emotional associations and that these mental connections could be so powerful that they generalized to similar stimuli. In the case of Little Albert, the memories were "implicit"—that is, not consciously recalled—but Watson's findings remind us that powerful emotional memories can be enduring.

In Storm's case, a technique called abreactive therapy helped to create these emotional associations. Storm was told that abreactions were total-body "flashback" reactions that would enable her to relive the traumatic events in her life, complete with the sounds, smells, sights and tactile experiences of these events. Olson instructed Storm to allow her alters to come forward and share their participation in unthinkable acts such as eating babies. For Storm, this therapy was physically, mentally and emotionally grueling. Years later the conditioned associations remain strong. Storm is plagued not only by her explicit memories of the disturbing scenes brought to life in her therapist's office but also by implicit memories that provoke reflexive physical reactions.

When Storm found a hair in her pizza at a local restaurant, it triggered visual and emotional memories of gagging, eating babies and cult activity. Cigar smoke brought up memories of cigar burns and subsequent rapes by her uncle. The cries of a baby provoked an intense desire to "save" the child. And the list goes on: stale air in the car made her recall sensations of being buried alive; dead animals on the road awakened grief and dread associated with satanic ritual abuse; and any form of anxiety or stress led to stuttering, crying hysterically and choking sensations. Worst of all, Storm became convinced that her parents—the people previously associated with nurture, safety and love—had tortured her in unimaginable ways.

Long-Term Impacts

Before she began therapy, Storm's symptoms consisted of minor insomnia and mild anxiety. After Olson's therapy commenced, she experienced migraines, dizziness, backaches, nausea, bowel disturbances and severe insomnia. Olson prescribed lithium, Prozac, Desyrel, Tegretol, Xanax and several migraine medications to address these new symptoms. A decade later Storm

SHERI J. STORM

SATANIC RITUAL ABUSE: Storm drew this face in 1994 to communicate how dark and menacing it felt to have evil alternative personalities coexisting within her. At the time, she was an inpatient at Green Oaks, a psychiatric treatment center in Dallas.

From the brain's perspective, **guided imagery** could be just as powerful as viewing home movies of abusive events.

reports continued use of psychotropic medications—Prozac, Xanax, Cytomel and a rotation of sleep medications. She continues to experience intrusive images and thoughts and remains unemployed and socially isolated.

Research suggests that Storm's case is not unique. According to a 1996 report of the Crime Victims Compensation Program in Washington State, recovered-memory therapy may have unwanted negative effects on many patients. In this survey of 183 claims of repressed memories of childhood abuse, 30 cases were randomly selected for further profiling. Interestingly, this sample was almost exclusively Caucasian (97 percent) and female (97 percent). The following information was gleaned:

- 100 percent of the patients reported torture or mutilation, although no medical exams corroborated these claims
- 97 percent recovered memories of satanic ritual abuse
- 76 percent remembered infant cannibalism
- 69 percent remembered being tortured with spiders
- 100 percent remained in therapy three years after their first memory surfaced in therapy, and more than half were still in therapy five years later
- 10 percent indicated that they had thoughts of suicide prior to therapy; this level increased to 67 percent following therapy
- Hospitalizations increased from 7 percent prior to memory recovery to 37 percent following therapy
- Self-mutilations increased from 3 to 27 percent
- 83 percent of the patients were employed prior to therapy; only 10 percent were employed three years into therapy
- 77 percent were married prior to therapy; 48 percent of those were separated or divorced after three years of therapy
- 23 percent of patients who had children lost parental custody
- 100 percent were estranged from extended families

Although there is no way to know whether recovered-memory techniques were the sole cause of these negative outcomes, these findings raise profoundly troubling questions about the widespread use of such techniques.

Whereas traditional therapeutic approaches are designed to reduce problematic symptoms, recovered-memory therapy exacerbates symptoms, sometimes intentionally. In a 1993 article, Paul R. McHugh, former director of the psychiatry department at Johns Hopkins University, noted that most patients later diagnosed with multiple personality disorder (MPD) had come to therapists with ordinary psychological symptoms such as problems with relationships or feelings of depression. The therapists, according to McHugh, suggested that there was a deep emotional root for these symptoms and that they were caused by alternative personalities.

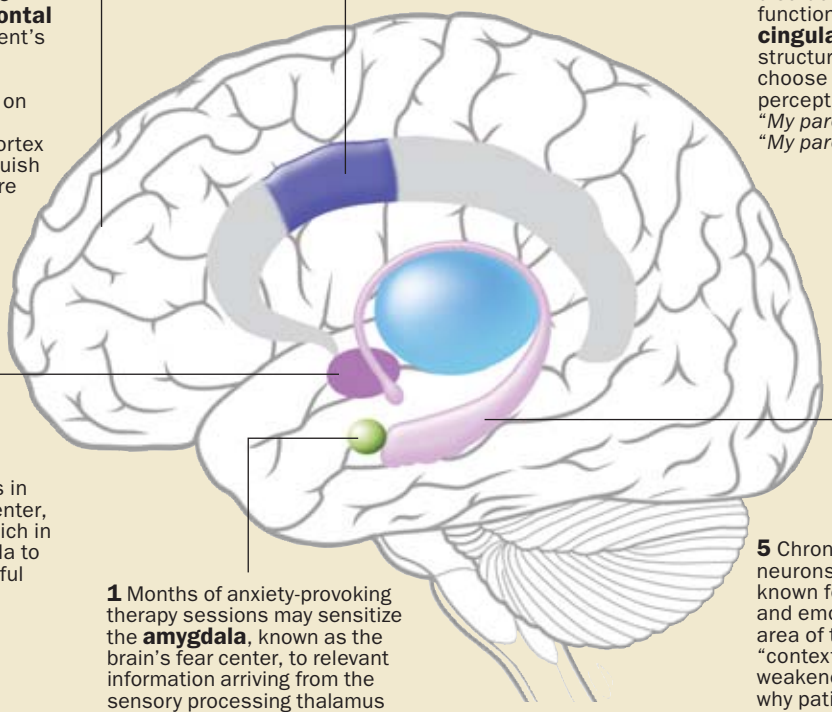
After viewing their problems in this new and perhaps interesting way, some patients display repeated shifts of demeanor and deportment on command. Eventually these patients are diagnosed with dissociative identity disorder (DID). In the most recent (2000) version of the American Psychiatric Association's *Diagnostic and Statistical Manual,* the diagnostic criteria for DID include the presence of at least two distinct identities that frequently take control of a person's behavior. The *DSM* also states that the average time between the appearance of the first symptom and the diagnosis is six to seven years. Most patients begin therapy with no clear signs of DID, and determination of the disorder comes mostly from a small number of DID "specialists."

SHERI J. STORM

RAGE UNDER WRAPS: Storm drew this picture in 1995 to illustrate how fragmented she felt inside. At the time, she hoped that her sunnier personalities might hide her evil selves from the outside world if the latter could not be purged.

Head Trauma

No large-scale systematic studies have been conducted on patients who have undergone recovered-memory therapy. Nevertheless, research on the effects of chronic stress and fear point to one potential set of explanations for how recovered-memory therapy may lead to mental and emotional impairment in some patients:



3 Chronic stress associated with traumatic memories compromises the **prefrontal cortex**, reducing a patient's ability to forget false memories after ceasing therapy. In experiments on rats, animals without a functioning prefrontal cortex lose the ability to extinguish fearful memories that are no longer relevant.

4 Research on patients with post-traumatic stress disorder reveals diminished functioning of the **anterior cingulate cortex**, a structure that helps us choose between conflicting perceptions (for example, *"My parents love me"* versus *"My parents harmed me"*).

2 Heightened anxiety activates stress centers in the brain's regulatory center, the **hypothalamus**, which in turn primes the amygdala to quickly consolidate fearful memories, regardless of their authenticity.

1 Months of anxiety-provoking therapy sessions may sensitize the **amygdala**, known as the brain's fear center, to relevant information arriving from the sensory processing thalamus (*blue*) and the higher cognitive center known as the prefrontal cortex.

5 Chronic stress impairs neurons in the **hippocampus**, known for its role in learning and emotion processing. This area of the brain is involved in "contextual" learning and, if weakened, may help explain why patients report losing track of time and experiencing confusion in unfamiliar surroundings.

In 2004 August Piper, a Seattle psychiatrist in private practice, and Harold Merskey, a professor emeritus of psychiatry at the University of Western Ontario, examined the scientific literature and concluded that there was no compelling evidence that DID is caused by childhood trauma. They reported that the disorder is not reliably diagnosed, that DID cases in children are practically never reported and that recurring evidence of blatant iatrogenesis is seen in the practices of some therapists utilizing recovered-memory methods—for example, calling out alters by name and referring to them as different people. Piper and Merskey concluded that DID is "best understood as a culture-bound and often iatrogenic condition."

In popular culture, books and films may have played a role in turning MPD, and later DID, into a fad. The 1976 made-for-television movie *Sybil* portrayed the life of a shy graduate student, Shirley Ardell Mason, who was diagnosed with MPD. This compelling movie, based on a 1973 book, won Sally Field an Emmy. Further confirmation of the power of Field's performance may be found in the sharp increase in MPD diagnoses after the release of the book and movie. Before 1973 fewer than 50 cases of MPD associated

(The Authors)

KELLY LAMBERT is a professor of psychology, chair of the psychology department and co-director of the Office of Undergraduate Research at Randolph-Macon College. Her research interests focus on animal models of experience-based neuroplasticity, specifically the neurobiological effects of parental experience and the identification of coping strategies associated with enhanced resilience against the onset of mental illness. SCOTT O. LILIENFELD is a professor of psychology at Emory University and a member of *Scientific American Mind*'s board of advisers. His research interests include the causes and diagnosis of personality disorders and evidence-based practices in clinical psychology. The authors wish to thank Sheri J. Storm for her contributions to this article.

THERESA SAKNO

Abused or Just Confused?

Storm's license plate

Sheri J. Storm's psychiatrist, Kenneth Olson, videotaped some of her therapy sessions after administering sodium amytal (purportedly a truth serum). In this excerpt from a transcript of one such session, Olson tries to summon alternative personalities.

Sheri Storm: How does this operate with the brain? I mean, is it like alcohol?
Kenneth Olson: Yeah, I imagine.
SS: So, does this mean I won't remember this part?
KO: (inaudible)
SS: It's on tape, oh.
KO: I think the first question that Sheri wanted to ask, and probably the most important one, is did it really happen?
SS: (inaudible)
KO: Did it really happen? And I'll encourage you to talk to the camera as if you were talking to Sheri.
SS: Did what really happen?
KO: She wants to know if she was really abused. She's confused and thinks she's making it up.... Is there anybody who'd like to come forward and answer that question? For Sheri? Hi. Who's here?
SS: I don't know.
KO: I don't know is here?
SS: Must be.

with child abuse had been reported, but by 1994 the number had soared to more than 40,000.

Mason herself may have been a victim of iatrogenic practices. In 1997 Herbert Spiegel, a psychiatrist who worked with Mason for four years, told an interviewer that Mason's behavior was induced by the suggestive therapeutic techniques of her primary psychiatrist. That revelation has not stopped CBS from producing a remake of the film starring Jessica Lange as Sybil's psychiatrist, which has not yet been scheduled for broadcast.

Neural Restructuring

Decades of behavioral neuroscience experiments using animal models have consistently suggested that trauma and fear can change the architecture of the brain. For example, neuroscientist Bruce McEwen's group at the Rockefeller University has shown that chronic stress alters neuronal complexity in three key areas: the medial prefrontal cortex (involved in working memory and executive function), the hippocampus (involved in learning, memory and emotional processing) and the amygdala (involved in fear and intense emotions) [*see box on preceding page*].

McEwen found that chronic stress reduces length and branching of dendrites in the brain's medial prefrontal cortex by about 20 percent. This reduction is associated with an impaired ability to shift attention while learning new tasks. In contrast, neurons in the amygdala grow in response to fear. The functions of the brain areas that are affected by fear and stress in animal studies are closely aligned with the symptoms exhibited by recovered-memory patients. Compromised functioning of the prefrontal cortex may be associated with a patient's inability to distinguish reality from fiction, whereas growth of neurons in the amygdala may lead to hypervigilance and suspiciousness. Animal research also suggests that once therapy sessions cease, compromised prefrontal cortex functioning may diminish the ability to inhibit fearful memories.

Although investigations of brain responsiveness in MPD-DID patients are lacking, striking similarities to brain areas known to be affected by fear and stress in animals are found in neuroimaging studies of humans experiencing post-traumatic stress disorder (PTSD). PTSD is classified as an anxiety disorder characterized by recurrent intrusive memories of a past traumatic event; behavioral and cognitive avoidance; and psychophysiological arousal leading to mood disturbances and sleep disturbances—all resulting in functional impairment. Research on PTSD patients has shown diminished responsiveness in the medial prefrontal cortex and heightened activity in the amygdala proportional to the severity of PTSD symptoms.

Guided imagery and reenactments used in recovered-memory therapy may produce PTSD-like symptoms. Harvard University psychologist Stephen M. Kosslyn has found evidence that the same areas of the brain activated when we see an object are activated when we close our eyes and *imagine* seeing the object. From the brain's perspective, guided imagery could be just as powerful as viewing home movies of abusive events.

The feelings of helplessness associated with recovered-memory therapy may increase the likelihood of negative effects. In animal research conducted in 1967 at the University of Pennsylvania, psychologists Martin Seligman and Steven Maier (Maier is now at the University of Colorado at Boulder) found that when dogs were allowed to escape an aversive shock stimulus, they continued to show motivation to escape in the future. But when dogs were not given an opportunity to es-

SHERI J. STORM

cape the traumatic experience, many of them just gave up when exposed to the shock the second time, even when an escape route was provided.

It is difficult to imagine a context in which one would feel more helpless than that of MPD-DID patients learning that alternative personalities, including demonic ones, could emerge at any time. Yet the notion of demonic possession persists to this day among a handful of psychiatrists. Olson conducted an exorcism in the hospital on his patient Cool—complete with a fire extinguisher because he had read that patients sometimes self-combust in these circumstances.

Recovering from Recovered Memories

Storm initially fought her diagnosis of MPD but eventually came to believe it. She was convinced that if she did not continue therapy and accept her "history," her illness would worsen and one of her satanic alters would harm her children. When she finally realized that she had been misdiagnosed, she had nowhere to turn. There are no formal programs or clinics for "deprogramming" the victims of bad psychotherapy, and these victims often find it difficult to trust any potential new therapies.

Although research evidence is lacking, some patients might find relief through antianxiety medications that mitigate intense emotional responses. Others have been helped by behavioral conditioning designed to extinguish alters by ignoring them. These therapies have not been systematically assessed for MPD-DID in large-scale studies, however. McEwen's studies of animals exposed to chronic stress suggest that brain alterations, though physical in nature, could be reversed by medications or by living in a stress-free, enriched environment.

Harvard psychologist Richard McNally suggests that the malleability of memories is a product of the most prized aspects of human intelligence: inference, imagination and prediction. MPD-DID patients exhibit impressive abilities to weave the fragments of fiction and reality revealed in their therapists' offices into the neurobiological fabric of their minds. The development of MPD-DID symptoms appears to be the result of a highly functioning but misdirected mind.

Understanding the science of memory formation and the impacts that emotional experiences have on the brain is critical for refining mental-health therapies. Some long-standing therapeutic practices may need to be reconsidered. For example, research reviewed comprehensively in 2003 by psychologists McNally, Richard Bryant of the University of New South Wales in Australia and Anke Ehlers of King's College London has shown that reliving traumatic memories shortly after a terrifying event—performed in a popular therapeutic technique called crisis debriefing—may cause unnecessary stress and impede recovery.

Reliving traumatic memories shortly after a terrifying event may cause unnecessary stress and impede recovery.

Columbia University psychologist George Bonanno suggests that it is time to take a fresh look at the different ways individuals adapt to and flourish in the midst of traumatic events. After focusing throughout most of the history of psychology and psychiatry on individuals who do not exhibit natural resilience, it is time to learn more about effective coping strategies. Such endeavors will determine when it is beneficial and when it is harmful for individuals to engage in therapies that provide a constant reminder of traumatic events.

In the case of Storm and patients like her, "forgetting" traumatic events—whether they happened or not—may offer the best chance for regaining mental health. But forgetting may be especially difficult when a legal case remains unresolved. Storm filed a malpractice suit in September 1997. A decade later her case has not gone to trial. M

(Further Reading)

- **Multiple Personality Disorder.** Paul R. McHugh in *Harvard Mental Health Letter;* Fall 1993.
- **The Myth of Repressed Memory: False Memories and Allegations of Sexual Abuse.** Elizabeth F. Loftus and Katherine Ketcham. St. Martin's Press, 1994.
- **Victims of Memory: Sex Abuse Accusations and Shattered Lives.** Second edition. Mark Pendergrast. Upper Access, 1996.
- **The Persistence of Folly: A Critical Examination of Dissociative Identity Disorder,** Part I: **The Excesses of an Improbable Concept.** August Piper and Harold Merskey in *Canadian Journal of Psychiatry,* Vol. 49, No. 9, pages 592–600; September 2004. Available online at **ww1.cpa-apc.org:8080/Publications/Archives/CJP/2004/september/piper.asp**
- **Psychological Treatments That Cause Harm.** Scott O. Lilienfeld in *Perspectives on Psychological Science,* Vol. 2, No. 1, pages 53–70; March 2007.
- See more of Storm's artwork and read her description of the role art played in her therapy at **www.sciammind.com**

IMAGES.COM/CORBIS

Skewed Vision

Seeing things clearly, new evidence suggests, may be even harder than we thought

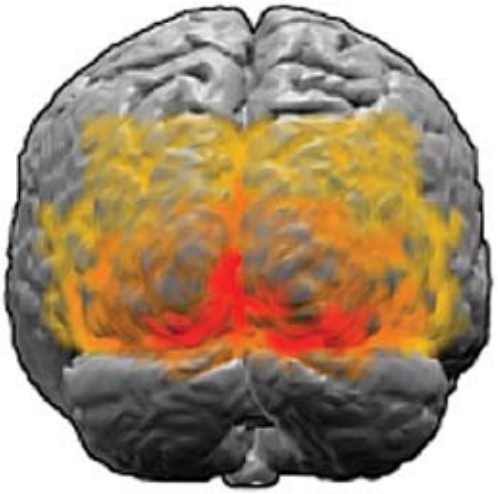
By Susana Martinez-Conde

My grade school in Spain had a color-coded system for test scores: "A" was red, "B" was blue, "C" was green and "F" was brown. So the color distribution in your academic chart revealed at a glance how well you were doing in your various classes. One result of this system was that red and brown became, respectively, my favorite and least favorite colors as a child.

This story is one of many examples of how an essentially neutral visual stimulus (the color red in this case) may become associated with a reward value (a good grade). From this information it is easy to predict that neurons in the brain's reward-processing system—a network of areas connecting the "thinking" cortex to the emotional centers in the brain's limbic system—may be activated by the physical properties of those sensory stimuli that come to be associated with rewards. We learn to associate certain stimuli with positive feedback; thus, my brain's reward centers learned to react happily to red.

(The Author)

SUSANA MARTINEZ-CONDE is director of the Laboratory of Visual Neuroscience at the Barrow Neurological Institute in Phoenix, where she studies visual perception, attention and visual illusions.



The primary visual cortex (*red*) was long thought to passively record unfiltered information from the eyes. New findings suggest that its role in the vision process is not quite so simple.

That this elemental learning system works so consistently is not terribly surprising. Less intuitive, however, is a phenomenon that was recently described in *Science* by cognitive neuroscientists Marshall G. Shuler and Mark F. Bear of the Massachusetts Institute of Technology. Working with rats, rat goggles and a water bottle, Shuler and Bear discovered that neurons in the brain's primary visual cortex—an area long thought to process purely sensory, value-free visual information before sending it on to other brain areas—can modulate their response as a function of expected reward. This finding sharply revises the standing view of vision's basic underlying mechanisms. Neurons in the primary visual cortex, once considered to be neutral collectors of features in the visual field, are in fact subject to complex cognitive influences. Even at the most fundamental level, it seems, our expectations shape how we view the world.

FAST FACTS

Believing Is Seeing

1» Scientists have long believed that the brain processes visual scenes in a series of hierarchical stages: from the simplest kinds of neutral assessments (such as color and contrast), made in the primary visual cortex at the outset of the visual-processing chain, to the more subtle value judgments that are made "higher" in the system.

2» New research shows that, in fact, the primary visual cortex is subject to complex cognitive influences.

3» Even at the most fundamental levels, our expectations shape how we view the world.

Hierarchy of Visual Understanding

Vision seems as if it is an immediate and simple system: you open your eyes and see. Yet the traditional view, established through decades of painstaking work, is that what we "see" is actually constructed by a hierarchical series of processing stages, each dealing with an increasingly complex aspect of perception. According to this scenario, neurons in the primary visual cortex—early in the visual-processing chain, just two stages after the retina becomes involved—are concerned primarily with distinguishing simple attributes such as contour and contrast. That information is then passed to higher visual areas that can process and interpret more complex stimuli such as hands and faces. Meanwhile neurons in "association areas" of the cortex integrate visual information with stimuli flowing in from other senses, such as hearing, and with cognitive processes such as attention, motivation or expectation.

Shuler and Bear challenge this traditional view by showing that neural activity in the brain's primary visual cortex, also known as V1, predicts with high accuracy the expected timing of rewards associated with various simple visual stimuli. In short, the visual cortex's response can vary depending on what the reward system expects, suggesting it plays a role in evaluating, rather than simply relaying, basic information. A supposedly clear window, as it were, turns out to be a sort of filter that colors what passes through it.

The experiment was quite clever. Shuler and Bear implanted rats with microelectrodes that recorded the activity of neurons in the primary visual cortex, then fitted the animals with head-mounted goggles that could create quick flashes of light in either eye. The researchers programmed the goggles to deliver a flash to the left eye or the right eye as the rats nuzzled a water tube. When the flash was presented, the animals had to lick the tube to obtain their reward: a drop of water. If the left eye was stimulated, water could be obtained more rapidly: the rats needed to lick the water tube half as many times as when the right eye was stimulated. Thus, the experimenters paired left-eye stimulation with a short wait for reward and right-eye stimulation with a relatively long wait.

In animals new to the experiment, all neuronal responses recorded were related to simply en-

It would be exciting to explore the ways in which the expectancy of reward may distort or bias perception.

coding the visual stimulus's physical properties, such as the onset of the flash, its duration, or which eye it flashed in. That is, the first couple of times the flash went off, the neurons responded to the stimulus—the flash—but did not differ in their response depending on which eye the flash was in or how long it took to get the reward. This result in naive rats (rats who had not learned the associations between flashes and reward timing) matched the classical conception of the primary visual cortex as a region that serves solely as a detector of visual features.

Primary Processing Gets Smart

After an animal had done the task three to seven times, however, about half its visual cortical neurons (43 percent on average) responded differently depending on whether the right or left eye got the flash; the neurons had learned that a flash in the left eye predicted a quicker reward than a flash in the right eye did. Once this expectation was established, the difference in neuronal activity occurred whether or not the actual reward appeared—that is, the V1 neurons responded differently to left and right flashes even if the water bottle did not deliver water.

Creating these unrewarded events was necessary because the lag between flash and bottle lick was often quite short (rats are fast), making it hard to know for certain that the rat was reacting to an expectation created by the flash rather than to the different reward itself. And indeed, these unrewarded flashes showed different responses, confirming a learned expectation. The primary visual cortex, in short, appeared to be able to exercise associative cognitive processes previously credited solely to higher cortical areas and wider networks. Those basic V1 neurons are pretty smart after all.

In a subsequent experiment, Shuler and Bear compared neuronal activity in "within-task" versus "outside-task" recording sessions, putting the experienced rats through trials in which the water tube was obstructed and in which no water reward was available. They wanted to see if the reward-response effect learned in the earlier trials would continue in that case. If it did, it would indicate not only that primary visual cortex circuits can create cognitive associations but also that those associations could be long-lasting. They found that these associations did persist. Once the tube was obstructed, the rats generally did not bother to approach it. Yet their previously trained primary visual cortical neurons continued to show reward-timing activity in response to the visual stimulation. This finding suggests that the alterations in neuronal responses produced by pairing a visual stimulus with a reward both persist and generalize to new contexts.

Hopes Spring Eternal—and Early

These discoveries hold multifaceted implications. As already noted, they challenge the traditional belief that the primary visual cortex is a visual area concerned strictly with low-level analyses of stimulus features. They also demonstrate that neurons in the primary visual cortex of adult animals have an unexpected degree of plasticity and can retain long-term effects.

I find especially intriguing a third aspect of this work. Reward expectation is a force driving our behavior: we tend to repeat actions that promise reward and avoid actions that promise no reward. Shuler and Bear have now shown that reward expectation plays a major role not just in shaping behavior but also in eliciting perceptual responses of neurons at the very early stages of visual processing. This demonstration suggests that our basic visual perception may be influenced at its most fundamental level by cognitive factors such as reward or attentional load. It would be exciting to see follow-up studies exploring ways in which the expectancy of reward may distort or bias perception or even create reward-based visual illusions. Such work could greatly improve our understanding of everyday decision making and of perceptual mistakes or anomalies. It could also throw light on impairments such as drug dependencies and other types of addictive behavior that involve the brain's reward pathways. That would be a rewarding result indeed. M

Each week in Mind Matters, www.sciammind.com's expert-written "blog seminar," researchers of mind and brain explain and discuss their disciplines' most notable recent findings. In this installment, Susana Martinez-Conde considers the finding that expectation colors what we see.

Mind Matters examines a new finding every week. Join the discussion at www.sciammind.com

(Further Reading)

- **Reward Timing in the Primary Visual Cortex.** Marshall G. Shuler and Mark F. Bear in *Science*, Vol. 311, pages 1606–1609; March 17, 2006.

Food fuels the mind as well as the body. Paying attention to what—and when—we eat can maximize our mental prowess

By Ingrid Kiefer

BRAIN FOOD

Many of us occasionally find ourselves eclipsed by mental fog. Our mind wanders in a lecture, and we miss its key point. We cannot focus on writing an article or preparing a presentation. We are unreasonably slow to calculate a waiter's tip at a restaurant—and then suddenly fail to recall a colleague's name when introducing her to a friend.

Mental slipups and slowdowns are a part of life, but we may be able to prevent some of them by paying attention to what we eat. Our diet affects not only our overall health and emotional well-being [see "Feeding the Psyche," by Michael Macht, on page 64] but also our ability to think, studies show. Nutrients in foods—or a lack of them—can influence memory, learning, concentration and decision making.

The brain operates best, for example, when blood glucose is stable. Consuming complex carbohydrates rather than simple sugars, researchers say, can help stabilize glucose in the blood and guard against mental lapses. In addition, consuming adequate amounts of iron is important for staying mentally sharp, because that metal chaperones vital oxygen to the brain. And studies indicate that protein-packed fare seems to boost attention, whereas certain fatty acids found in fish buttress brain function.

When we eat is also important. Research confirms, as the old adage advises, that breakfast is critically important for mental function in the morning. Snacking throughout the day can also be helpful in keeping blood glucose levels stable.

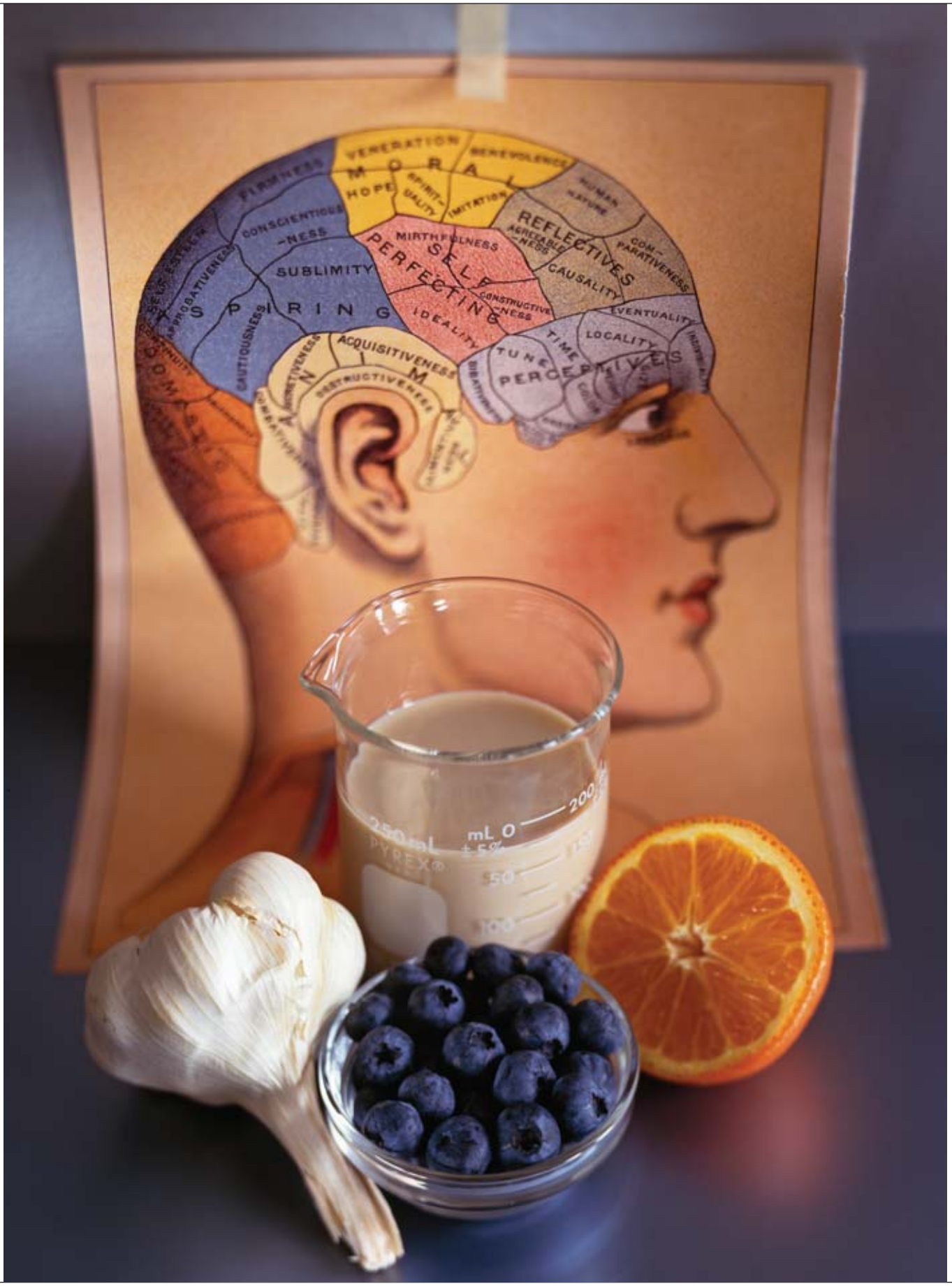
In general, what is good for the body is also good for the brain. Although much remains to be discovered about food's effect on mental function, the findings to date strongly suggest that good nutrition can help us more fully realize our intellectual potential.

Fuel for Thought

The brain takes shape in the womb and continues to mature in infancy and beyond. Its growth and development depend on adequate energy and on a variety of specific nutrients such as certain fats and proteins from the mother's diet. These molecules are especially critical for building the fatty membranes of nerve cells and the layer of insulation—called myelin—that encases nerve fibers. Studies of nutritionally deprived children in the developing world show that such malnourishment depresses IQ.

Regular food consumption also ensures that the 100 billion nerve cells in the adult brain remain active at all times. Although the brain makes up a mere 2 percent of our body weight, it uses 20 percent of the body's metabolic fuel. The brain, unlike muscles, cannot store carbohydrates, and so it re-

JUPITERIMAGES



GETTY IMAGES

Starch- and fiber-rich foods such as whole-grain breads and vegetables benefit brain function because they help keep glucose levels stable.

quires a constant supply of glucose. When blood glucose drops, say, from lack of food, our faculties fade and we lose the ability to concentrate.

If you fast for several days, the cognitive crisis worsens, because the brain must get the energy it needs by metabolizing compounds called ketone bodies, which are derived from the breakdown of body fat. That metabolic process requires the synthesis of specialized enzymes, a time-consuming activity that can lead to further lapses in concentration.

Very high blood glucose levels can also inhibit mental function. In a study reported in 2005, psychologist Daniel J. Cox and his colleagues at the University of Virginia Health System found that about half of the 230 diabetics they were monitoring performed basic verbal and math tasks more slowly and less accurately when their glucose levels rose above a certain threshold. Hyperglycemia might cause cognitive difficulties, the scientists speculate, by altering the structure of blood vessels at the blood-brain barrier, for example, or by triggering changes in the production of chemical messengers in the brain.

Such research indicates that a moderate, stable blood glucose level is the best way to buttress intellectual functioning. Most people can prevent wild fluctuations by being selective about which carbohydrates they consume.

Simple sugars such as sucrose (table sugar) and lactose (milk sugar) elevate blood glucose levels powerfully and quickly. Sweet foods can supply the body with quick energy—a useful pick-me-up when blood glucose plummets, such as from extreme physical exertion—but the effect does not last. The pancreas responds to a rapid rise in glucose by secreting the hormone insulin, which accelerates glucose uptake by body tissues—and glucose levels plunge once again. Starch- and fiber-rich foods such as whole-grain breads, legumes and vegetables, on the other hand, are thought to be better for brain function because they raise glucose levels slowly and moderately. Fiber, which is indigestible, also slows uptake.

Recent data support the idea that starchy and fibrous fare promote mental endurance. A research team led by cognitive psychologist Keith A. Wesnes of Northumbria University in England gave 64 children (aged six to 11) on two mornings either a sugary breakfast cereal that quickly boosted blood glucose to high levels or a starchier cereal that gradually raised concentrations. The investigators administered attention and memory tests at hourly intervals thereafter and found that although all the kids' test scores declined as the morning wore on, the decline was markedly less steep in the children who had breakfasted on the complex carbohydrates.

The Iron Effect

To metabolize glucose, our brain cells require oxygen, which is transported to the brain by hemoglobin, the large iron-containing protein in red blood cells. Consuming enough iron is thus important for mental function. In childhood, iron deficiencies impair brain development and lead to measurable deficits in speech, reading and math skills. In a 2005 review of the literature, for example, pediatrician Howard Taras of the University of California, San Diego, found that severely iron-deficient children are at an academic

GETTY IMAGES

FAST FACTS

Eat to Think

1» People may be able to prevent mental slipups by paying attention to what they eat. Nutrients in foods—or a lack of them—can influence memory, learning, concentration and decision making.

2» The brain operates best when blood glucose levels are stable. Consuming complex carbohydrates rather than simple sugars can help stabilize glucose concentrations and guard against mental lapses. Fish oil and iron-containing foods are also good food for thought.

3» When we eat is also important for brain function. To stay mentally sharp, eat breakfast and snack often throughout the day.

disadvantage and that iron supplements can reduce that intellectual deficit.

Among adults, women of reproductive age need to consume the most iron; the U.S. recommended daily allowance of this element for such women is 18 milligrams, compared with just eight milligrams for men and postmenopausal women. In a March study of reproductive-age women, nutrition scientists Laura E. Murray-Kolb, now at Johns Hopkins University, and John L. Beard of Pennsylvania State University found that concentrations of iron in the blood can also influence mental function in adulthood.

Boosting iron in the blood can significantly enhance mental function in adults as well as in children.

At the start of the study, only 42 of the 149 subjects had sufficient iron in their blood, and these women performed cognitive exercises better and faster than the women who were iron-deficient. In addition, the researchers found that 16 weeks of iron supplementation closed the intellectual gap for the anemic women who received it, improving their cognitive performance between five- and sevenfold.

Red meats such as beef or lamb contain the most easily absorbed iron, the so-called bivalent form. Plant seed oils, yeast, and some herbs and legumes carry trivalent iron, which is harder for the body to use. Foods rich in vitamin C—such as oranges and garlic—can aid iron absorption, however, so vegetarians can improve their iron status by eating such foods in conjunction with iron-containing plant foods.

Other vitamins, minerals and trace elements are important for brain function, too [*see table on next page*]. Potassium, sodium and calcium are used for nerve cell signaling and metabolic reactions in the brain. Vitamin B_1, in particular, enables glucose metabolism. Even slight vitamin and mineral deficits—which may result, for example, from a diet of fast food—can lead to fatigue, forgetfulness and concentration problems.

An overdose of vitamins and minerals, however, is unlikely to turn you into Einstein. Correcting a vitamin deficiency may raise a child's IQ, but it is not clear whether supplements can boost intelligence in people whose nutrient intake is adequate, according to a 2004 review of the literature by nutrition researcher France Bellisle of Hôtel-Dieu Hospital in Paris.

Protein Power?

The adult brain is also dependent on amino acids, the building blocks of proteins, for producing enzymes, transport molecules, structural materials and neurotransmitters (the brain's chemical messengers), among other essential molecules. For example, the amino acids tyrosine and phenylalanine are needed to produce the hormone epinephrine and the neurotransmitter dopamine, both of which contribute to alertness. A boost in these amino acids could partly explain why small high-protein meals featuring, for example, low-fat dairy products, fish, lean meats and legumes, may make people more alert and attentive, as some studies have indicated.

Protein may also boost attention by stabilizing blood glucose levels. In a 2002 study of 15 healthy male students who ate meals with differing ratios of carbohydrate to protein, nutrition scientist Karina Fischer of the Swiss Federal Institute of Technology in Zurich and her colleagues found that, relative to the carbohydrate-rich meal, the balanced and protein-rich meals led to more accurate short-term memory and improved attention beginning one hour after the meal was consumed. The meals with more protein seemed to cause less variation in glucose metabolism, implying that proteins may be useful in part because they help stabilize glucose levels.

High-protein meals, however, have a paradoxical effect on levels of another amino acid, tryptophan. Tryptophan is a precursor of the neurotransmitter serotonin, which not only helps to stabilize mood [see "Feeding the Psyche," by Michael Macht, on page 64] but also may influence cognitive processes, particularly learning and memory. Because most food proteins contain less tryptophan than other amino acids, which compete with tryptophan for transport into the brain, high-protein meals actually *decrease* the brain's tryptophan levels.

How such a decrease affects cognition is controversial. Some human and rat studies indicate

(The Author)

INGRID KIEFER is a nutrition scientist and health psychologist at the Institute for Social Medicine at the Medical University of Vienna in Austria.

Provisions for Brain Power

A well-balanced diet benefits the brain just as it does the body. The table below highlights examples of the best brain foods (*green type*) and describes the functions of other nutrients found in foods that can influence concentration, memory, learning and the overall health of the brain.

NUTRIENT	FUNCTION	PRESENCE IN FOODS
Carbohydrates 	Supply glucose for energy	Whole grains, fruits (especially **apples**), vegetables
Liquids	Stabilize circulation and nutrient transport, among other functions	Water, mineral water, unsweetened herbal and fruit teas
Caffeine, in small amounts	Dilates the blood vessels in the brain; increases concentration and memory	Coffee, black tea, **green tea** 
Iron	Transports oxygen	Red meats, pumpkin seeds, sesame, soy flour, millet, poppy seeds, pine nuts, wheat germ, **oats**, dill, parsley, yeast, spinach, watercress, lentils, soybeans, white beans
Calcium	Conducts neuronal signals 	Milk and milk products, poppy seeds, figs, sesame, soybeans, legumes, **nuts**, whole grains, wheat germ, oatmeal, broccoli, watercress, green vegetables, parsley
Zinc	Aids many chemical reactions in the brain; important for concentration and memory	Wheat germ, poppy seeds, sesame, pumpkin seeds, meat, eggs, milk, cheese, fish, carrots, whole-grain bread, potatoes
Phenylalanine, tyrosine	Act as precursors of epinephrine, norepinephrine and dopamine; important for alertness and concentration	**Fish** (tuna, trout), meat, milk products, **soybeans**, cheese (cottage cheese), peanuts, wheat germ, almonds
Serine, methionine 	Act as precursors of acetylcholine; essential for learning and memory formation	Fish, turkey, chicken, soybeans, beef, cashews, wheat germ, broccoli, peas, spinach, whole-grain bread, rice
Vitamin B_1 (thiamine)	Enables glucose metabolism; aids nerve cell function	Whole grains (wheat, spelt), oatmeal, wheat germ, sunflower seeds, legumes, nuts, pork
Unsaturated fatty acids, including omega-3 fatty acids	Build cell membranes 	Fish, walnuts, spinach, corn oil, peanut oil, soybean oil, grape seed oil

AGE FOTOSTOCK (*apple, coffee and broccoli*); WALTER CIMBAL Getty Images (*walnuts*); JAMES BAIGRIE Getty Images (*fish*)

that tryptophan depletion leads to deficits in long-term memory and information processing, whereas other data suggest that depleting the body of tryptophan has a beneficial effect: it improves decision making.

Boosting tryptophan levels in the brain, on the other hand, can benefit cognition under some circumstances. The consumption of carbohydrates pushes tryptophan into the brain. Although carbohydrates do not contain tryptophan, they trigger the release of insulin, which stimulates muscles to take up competing amino acids. Tryptophan then becomes relatively abundant in the blood—and more likely to get into the brain. Work by experimental psychologist C. Rob Markus, now at Maastricht University in the Netherlands, and his colleagues shows that carbohydrate-rich diets that increase the amount of available tryptophan improve cognitive performance—but only in stress-prone people. In such cases, some researchers speculate, the resulting swell of serotonin may provide a mental edge in part by decreasing a person's anxiety about performing intellectually challenging tasks.

Smart Seafood

Unsaturated fats are also good brain food, especially the polyunsaturated omega-3 fatty acids found in fish such as mackerel, tuna, herring and salmon. These fish oils are components of

nerve cell membranes and myelin, and they help to keep blood vessels in the brain healthy. Statistics show that eating as few as one to three portions of fish per month significantly decreases the risk of stroke.

Recent studies have found that fish consumption benefits the fetal brain, too. Nutrition scientist Joseph Hibbeln of the National Institute on Alcohol Abuse and Alcoholism and his colleagues surveyed 11,875 pregnant women about their seafood intake and evaluated the behavioral and cognitive development of their offspring from six months to eight years of age. They found that the children whose mothers had eaten less than 340 grams of fish a week during pregnancy were more likely to have lower IQs and poorer communication, fine-motor and social skills than were the children of mothers who had ingested more fish during pregnancy. These findings imply that nutritional benefits of eating fish may outweigh the risks of exposure to trace contaminants.

A person may gain similar health benefits from linseed, canola, soy and walnut oils. These oils contain significant quantities of alpha-linolenic acid, a shorter-chain lipid that the body converts into omega-3 fatty acids. But one should avoid using these plant oils for frying or sautéing because high heat turns them into trans-fatty acids, which may have detrimental effects on learning and overall health.

Nutrients from omega-3 fatty acids (or any other food) can reach the brain in adequate amounts only if the body gets enough fluid. Studies have shown that even slight dehydration slows the rate at which nutrients can enter the brain, producing short-term memory deficits and reasoning difficulties among other cognitive problems.

Caffeinated beverages such as tea and coffee have an additional advantage in limited quantities: caffeine can improve short-term concentration and facilitate learning and memory. Coffee's effect takes hold within about 20 minutes and lasts for two to three hours. Tea has a weaker but longer-lasting impact because it contains less caffeine than coffee and its caffeine is released more slowly. Drink too much caffeine (four cups of coffee or more), however, and your ability to concentrate will likely decline, studies suggest.

Perfect Timing

When a person eats can also influence cognitive performance. Eating breakfast is particularly important for cognitive function, yet some 10 to 30 percent of American and European children skip this meal. Results from 22 studies of the link between breakfast consumption and academic performance in school-age youth show that breakfast eaters have better memories, test scores and school attendance rates, according to a 2005 analysis by food scientist Gail C. Rampersaud of the University of Florida and her colleagues. A second 2005 literature review led by Taras shows that school breakfast programs improve cognitive functioning and academic performance among severely undernourished populations.

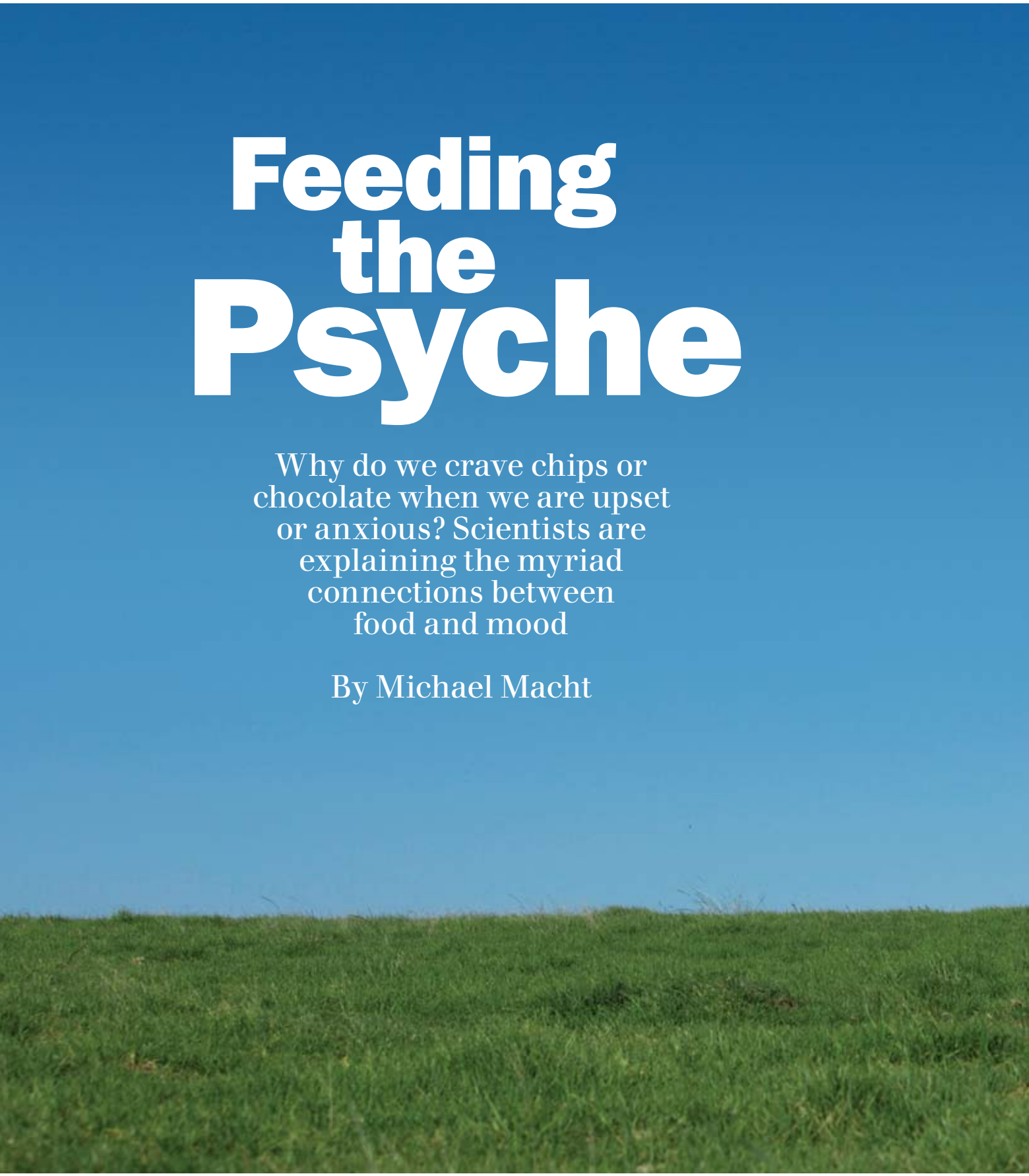
Between-meal snacks can ensure a consistent blood glucose level and thus prevent or reduce performance troughs. Choose combinations of complex carbohydrates and protein—say, fruit and yogurt or whole-grain bread and low-fat sausage or cheese. A protein-rich snack such as a tuna fish sandwich eaten shortly before a quiz or important meeting may help ward off inattention. If the exam or meeting will last longer than 20 minutes, avoid simple sugars to prevent a blood glucose drop before it ends.

But any snack boosts glucose, and at least one study shows that the mere act of chewing can improve memory. Cognitive neuroscientist Lucy Wilkinson and her co-workers at Northumbria reported in 2002 that subjects who chewed sugar-free gum were better able to remember words than subjects who did not chew anything, perhaps because chewing improves blood flow to brain areas that are important for memory.

Eat a low-calorie, protein-rich lunch that also includes lots of vitamins and minerals—say, fish or chicken with a salad. This repast will maintain attention and memory and minimize afternoon energy troughs. And at dinnertime, eat lightly and avoid caffeine. Studies show that rice, noodle, or grain dishes boost blood tryptophan levels, which can hasten sleep. Or simply relax with Grandma's recipe: honey dissolved in hot milk. M

(Further Reading)

- **Maternal Seafood Consumption in Pregnancy and Neurodevelopmental Outcomes in Childhood (ALSPAC Study): An Observational Cohort Study.** J. R. Hibbeln, J. M. Davis, C. Steer, P. Emmett, I. Rogers, C. Williams and J. Golding in *Lancet,* Vol. 369, No. 9561, pages 578–585; February 17, 2007.
- **Iron Treatment Normalizes Cognitive Functioning in Young Women.** L. E. Murray-Kolb and John L. Beard in *American Journal of Clinical Nutrition,* Vol. 85, No. 3, pages 778–787; March 2007.
- **A Low Glycaemic Index Breakfast Cereal Preferentially Prevents Children's Cognitive Performance from Declining throughout the Morning.** J. Ingwersen, M. A. Defeyter, D. O. Kennedy, K. A. Wesnes and A. B. Scholey in *Appetite,* Vol. 49, No. 1, pages 240–244; July 2007.
- For simple tips on what to eat for good mental health, see **http://health.ivillage.com/eating/ebenefits/0,,20j,00.html**



Feeding the Psyche

Why do we crave chips or chocolate when we are upset or anxious? Scientists are explaining the myriad connections between food and mood

By Michael Macht

GETTY IMAGES

Some days the refrigerator draws Hannah like a magnet. The 23-year-old pulls open the door, gropes for whatever looks interesting and gorges herself. Several times a week Hannah wolfs down mountains of food, more than 6,000 calories in a single day.

Hannah is a binge eater, subject to regular eating attacks and a loss of control over food consumption. In contrast to bulimia sufferers, Hannah makes no effort to counter her caloric intake by vomiting. As a result, she is obese. At five feet, six inches, she weighs 264 pounds.

Eating supplies the body with energy and essential nutrients. But that is surely not why Hannah regularly stuffs herself—she continues to eat long after her hunger pangs have subsided. Hannah eats for emotional reasons: when she is sad or anxious, food is her Prozac.

Food and emotions are inextricably linked in all of us, but some of us are more emotionally drawn to food than others [*see box on page 68*]. Hannah and those with similar habits are extreme examples of such a tendency. But research shows that sadness and anxiety can spawn bursts of overeating or indulgence in sweet and fatty foods in large numbers of people who have no defined eating pathology.

Scientists can even explain the impulse to snack on crackers or desserts. Carbohydrates and fats are thought to elevate a person's mood by lowering stress hormone levels—and in the case of carbohydrates, by increasing the amounts of a mood-altering chemical messenger in the brain. The taste of foods can also change a person's emotional state. Sweet foods are thought to induce the release of pain-relieving substances in the brain and to activate the brain's pleasure centers in the same way addictive drugs do.

People who gorge on sweet and fatty foods may be self-medicating. Such foods can depress the stress response.

BAY HIPPISLEY Getty Images

Meanwhile the social and physical environment in which we eat often connects food with positive emotions such as relaxation and companionship. By tracing the many links between consumption and contentment, researchers hope to find new ways to combat eating disorders such as Hannah's as well as patterns of emotional eating that may contribute to obesity.

Caloric Comfort

Laypeople and doctors alike have long observed that individuals tend to munch more in crisis situations because food helps to cushion negative emotions. The Germans have a word for this, *Kummerspeck*, literally "grief bacon," which may date back to observations that World War I widows often put on weight.

Today psychologists term this behavior emotional eating. Emotional eaters have a marked tendency to overeat when under some kind of emotional strain. A considerable proportion of overweight people are emotional eaters. In exaggerated form, emotionally driven food consumption can result in binge eating.

Psychologist Andrew Hill of the University of Leeds in England and his colleagues confirmed in a 2004 study that negative emotions can provoke eating attacks. The researchers showed a group of 40 obese female binge eaters either a sad or a neutral film and then offered them food in a supposed taste test. The women who watched the sad movie—and felt down as a result—ate considerably more than those who had seen the more upbeat flick, suggesting that negative mood can prompt overeating in susceptible individuals.

Emotional eating is not confined to individuals with eating disorders, according to psychologist Georgina Oliver and her colleagues at University College London, who reported in 2000 that anxiety and stress can lead to unhealthy eating habits among more ordinary consumers. The researchers first categorized 68 healthy men and women as emotional or nonemotional eaters using a standard questionnaire. Then they gave a mixed group a stressful task—to prepare a four-minute speech that they claimed would be videotaped and evaluated—while asking a comparison group to relax and listen to a reading.

FAST FACTS

Mood-Altering Food

1» Food and emotions are linked in all of us. Sadness and anxiety can spawn bursts of overeating or indulgence in sweet and fatty foods in otherwise healthy people.

2» Scientists can often explain a craving for chocolate or chips: carbohydrates and fats are thought to elevate a person's mood by lowering stress hormone levels, and sweet tastes alone can rapidly boost morale.

3» Tracing the connections between food and emotions may lead to ways of treating eating disorders and fighting obesity.

Emotional eaters have a marked tendency to overeat when under emotional strain. Food is their Prozac.

After 10 minutes, all the study participants were served a buffet lunch that included sweet, salty, and bland high- and low-fat foods. The emotional eaters under duress devoured almost twice the weight of energy-dense (sweet and fatty) edibles than did nonemotional eaters in that group. There was no difference, however, in the total amount of food consumed, suggesting that stress can lead some people to choose fattening fare over healthier food. In the group that was not under stress, both emotional and nonemotional eaters showed similar eating patterns.

Scientists now have an explanation for this preference: sweet, fatty foods seem to depress the stress response, so people may gorge on them in a subconscious effort to improve their emotional state. A 2003 study by physiologist Mary F. Dallman and her co-workers at the University of California, San Francisco, for example, showed that such diets diminish stress hormones in stressed-out rats. The researchers made the rats tense by confining them in a small clear-plastic cage for three hours a day for five days and then fed one group its usual fare and the other a diet enriched in lard and sugar. They found that the animals that gobbled the richer feed ate more (and got fatter) than those on the regular diet and produced lower amounts of stress hormones, suggesting that the fatty chow helped to reduce stress.

Carbohydrates may serve a similar function, perhaps explaining why some people crave, say, bagels and chips when they are depressed or anxious. Some animal and human data from Richard Wurtman, a neuropharmacologist at the Massachusetts Institute of Technology, hint that carbohydrate-rich meals elevate mood by boosting the amount of the amino acid tryptophan in the brain. Tryptophan is used to produce the neurotransmitter serotonin, which is involved in regulation of emotions, among other functions. The serotonin boost that results from higher levels of tryptophan, the theory goes, may elevate mood.

Some support for this hypothesis comes from a 1998 study by experimental psychologist C. Rob Markus, now at Maastricht University, and his colleagues at Utrecht University, both in the Netherlands. The researchers gave 48 test subjects—some of whom were particularly prone to stress—meals containing either lots of carbohydrates and little protein or the opposite, plenty of protein and few carbohydrates. They then gave everyone a challenging task: to solve difficult math problems in a noisy room.

As expected, the carbohydrate-rich diet elevated blood levels of tryptophan relative to other amino acids (which compete with tryptophan to enter to the brain) much more than the protein-packed fare did. The high-carbohydrate meals also dampened the stress hormone reactions to the math task in the high-stress individuals—but not in the others—far more than the low-carbohydrate food did. Thus, carbohydrates may decrease tension in susceptible people by boosting the brain's tryptophan dose. People who are not prone to such anxiety, on the other hand, may have enough tryptophan and serotonin in their brain already, the researchers surmised.

Consuming carbohydrates may raise levels of serotonin, a chemical messenger in the brain that regulates mood.

JUPITERIMAGES

Sweet Relief

Such changes in brain chemistry take time. They occur only after food is digested, its components absorbed into the bloodstream and transported into the brain. The serotonin and stress hormone responses could underlie the slowly growing waistlines of people under chronic stress, but faster mechanisms are undoubtedly at work in cases of impulsive indulgence such as Hannah's.

In anxious, sad or painful moments, a growing body of data suggests, a sweet taste alone is comforting. Classic research by biologist Jacob Steiner of the Hebrew University of Jerusalem shows that a liking for sweet tastes is innate. When Steiner gave newborns a sugar solution, the babies made sucking movements, licked their lips and relaxed their faces, looking satisfied.

(The Author)

MICHAEL MACHT is a psychology professor at the University of Wuerzburg in Germany.

Eating by the Numbers

Researchers use a diagnostic tool called the Dutch Eating Behavior Questionnaire (DEBQ) to gauge emotional-eating behavior. Subjects taking the DEBQ, which also measures other types of eating behavior, evaluate themselves on traits such as those listed below, deciding in each case how often they feel the inclination described. They score each answer from 1 to 5 (1 = never, 2 = rarely, 3 = sometimes, 4 = often and 5 = very often).

- Desire to eat when depressed or disappointed
- Desire to eat when feeling lonely or let down
- Desire to eat when worried or emotionally upset
- Desire to eat when restless or bored
- Desire to eat when afraid
- Desire to eat when irritated or angry

Researchers analyzing emotional consumption sum the numerical answers from 13 statements. Higher sums reflect a greater tendency toward emotional eating. Healthy normal-weight men tend to have lower totals than their female counterparts. Women who experience eating attacks often have very high scores.

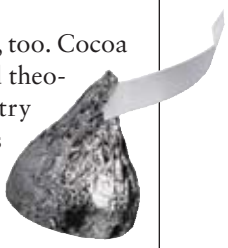
When given a bitter substance, the babies reacted with disgust, scrunching their eyebrows together and sticking out their tongues.

A sweet taste can even ease infant pain and distress. Psychologist Elliott Blass and his coworkers at the University of Massachusetts Amherst found in a 2003 study that tasting a sucrose solution worked as well as sucking a pacifier at diminishing crying in six- and nine-week-old infants. In other work, Blass's team found that a pacifier dipped in a sugar solution lessened the pain of circumcision far more than an unsweetened pacifier did, based on how much the infants cried and grimaced. The pain suppression from sugar occurs quickly, with the maximum effect achieved in two minutes, about the time it would take a sweet taste to trigger the release of endogenous opiates, natural brain chemicals that heighten pleasure and alleviate pain.

Recent work in my laboratory at the University of Wuerzburg in Germany suggests that a sweet taste has similar effects on adults. A 2006 study, for example, co-authored by psychologist Ellen Greimel, demonstrated that adults react to sweet and bitter tastes with facial expressions similar to those of infants. In addition, my colleagues and I have shown that the sweet—and generally scrumptious—taste of chocolate can ease emotional (if not physical) pain in adults.

We made volunteers sad by showing them a short film in which a little boy learns of his father's death. Eating chocolate afterward quickly made the viewers feel better. Why? The chocolate's effect, we found, depended on its taste—that is, how delicious it was to the taster. The less delicious a person judged the chocolate, the less effect it had on his or her disposition, indicating that chocolate's taste underlies much of its mood-altering magic.

Food as a Drug



Chocolate may act in other ways, too. Cocoa contains the stimulants caffeine and theobromine, which alter brain chemistry and might thus contribute to people's liking for chocolate. Nutrition scientist Hendrik Smit of the University of Bristol in England and his colleagues investigated this hypothesis in a 2005 study. On six mornings the researchers gave 64 people a "novel" drink and a capsule that contained either a nonactive substance or a combination of theobromine and caffeine. They asked the participants each day how much they liked the drink.

The people who took the active capsules reported enjoying the drink more and more each day, whereas those who swallowed placebo pills did not develop a similar appreciation for the same liquid. Thus, theobromine and caffeine may independently contribute to a fondness for chocolate. But because these druglike influences require several days to develop, chocolate's more immediate effects on mood probably stem from sensory factors.

Sugar may act like a drug in a different way: by inducing dependency under some circumstances. Princeton University psychologist Bartley Hoebel and his colleagues made rats sugar-dependent by depriving them of food for 12 hours a day and offering them a sucrose solution and chow for the next 12 hours. They repeated this schedule every day for one to four weeks. The cycle of fasting and

The delicious taste of chocolate, aided by the stimulants in cocoa, underlies much of its mood-altering magic.

intermittent sugar availability triggered strong demand: the rats gradually tripled their sucrose intake and learned to binge on the sugar as soon as they received access to it each day.

In the brains of the sugar-dependent rats, the researchers detected repeated rises in the amount of the chemical messenger dopamine in part of the brain's reward system. Such a dopamine increase is characteristic of all addictive drugs; it is thought to elevate mood and, in some cases, produce euphoria. In contrast, no such bingeing or dopamine boosts occurred in control rats that received as much sugar as they wanted or that received no access to sucrose, the researchers reported in 2005.

The addictive qualities of sugar are apparently a result of its taste, because they do not depend on digestion. In a 2006 experiment conducted by Hoebel's team, the dopamine rush occurred in sugar-dependent rodents even when the sugar they drank was immediately removed from the stomach by an implanted fistula.

Making Connections

But physiology cannot fully explain food's power over our feelings. Some of our emotional connections to food grow out of life experience. At birth, for example, eating is conflated with love and a sense of safety in all mammalian species. During nursing, a baby feels a sense of closeness that helps to cement critical bonds with its mother, linking food to a feeling of equilibrium.

Later in life, people share meals with friends and family, tying together food with the growth of friendship and love. They also prepare cuisine for celebrations and romantic picnics. In this way, food becomes associated with intense positive emotions such as relaxation, warmth and contentment.

Such connections exist in virtually all of us. Nobody knows, however, what causes a subset of humanity to seek solace in food in the absence of hunger. German psychiatrist Hilde Bruch suggested that part of the answer could be found in a person's upbringing. The more frequently a mother offers food to her child when he or she is upset but not actually hungry, Bruch hypothesized, the more apt that child will be to deal with negative emotions by eating.

Genes are probably also critical. After all, people are born with different taste sensitivities, particularly with regard to bitter substances [see "Bitter Could Be Better," by Stefanie Reinberger; Scientific American Mind, June/July 2006]. That said, no one yet knows how a more (or less) responsive palate might influence emotional eating behavior or how inborn features of brain chemistry might affect the extent to which emotions influence eating.

A liking for sweet tastes is innate. The taste of sugar can even relieve pain and distress.

No matter its origins, emotional eating behavior such as Hannah's will likely require an emotion-centered solution. Stanford University psychologist Christy Telch and her colleagues tested such a strategy on 44 women with binge-eating disorder. Some of the women received no treatment, whereas others underwent so-called dialectical-behavior therapy (DBT), in which they learned to deal with negative emotions in ways other than by eating. Over 20 sessions, a therapist explained the genesis and role of emotions and taught the women strategies for coping with stress, among other tactics.

The therapy seemed to work: by the end of the experiment, the women who had received DBT were having many fewer eating attacks than the control subjects, and 89 percent of those treated had stopped binge eating. Six months later 56 percent of the treated women were still abstinent, the researchers reported in 2001. From this therapy, Hannah learned to take charge of her negative emotions by relaxing and writing them down. Her eating attacks gradually became less frequent, and she is in far better emotional and physical shape today. M

(Further Reading)

- **Food & Mood: The Complete Guide to Eating Well and Feeling Your Best.** Second edition. E. Somer. Henry Holt and Company, 1999.
- **Stress and Food Choice: A Laboratory Study.** G. Oliver, J. Wardle and E. L. Gibson in *Psychosomatic Medicine,* Vol. 62, No. 6, pages 853–865; 2000.
- **Dialectical Behavior Therapy for Binge Eating Disorder.** C. F. Telch, W. S. Agras and M. M. Linehan in *Journal of Consulting and Clinical Psychology,* Vol. 69, No. 6, pages 1061–1065; December 2001.

KG-PHOTOGRAPHY *zefa/Corbis*

ALAN THORNTON *Getty Images*

FANTASY THERAPY

STEEPING PATIENTS IN COMPUTER-CREATED VIRTUAL WORLDS CAN HELP HEAL A MULTITUDE OF PSYCHIATRIC ILLS, INCLUDING PHOBIAS, EATING DISORDERS AND IMPLACABLE PAIN BY NIKOLAS WESTERHOFF

Jonah is inching upward in the glass-walled exterior elevator of a 70-story skyscraper. For each story he ascends, he rates his fear on a 100-point scale. At the top, he peers out over a microcosm of office towers, streets and gas stations—that are not really there. While donning a headset that produces three-dimensional images, Jonah is receiving an experimental therapy for a debilitating fear of heights.

The goal of the treatment is habituation, a form of learning in which a response to a stimulus diminishes with repeated exposure. Traditionally this exposure is done in real-world settings—in an actual skyscraper, on an airplane (for fear of flying) or with a spider (for spider phobia). But in a new twist, clinicians are increasingly replacing reality with 3-D computer simulations.

Simulated experiences require no actual travel or complicated arrangements. They also are less likely to trigger so much fear that the patient backs out of the treatment. And although subjects can hit the panic button and stop their fantasy trip in the elevator, this rarely happens. "Amazingly, not a single patient has ever hit that button," claims psychiatrist Marcus F. Kuntze, now at the Cura Bern clinic in Switzerland, who tested the program on Jonah (not his real name).

Such virtual-reality (VR) technologies can also help combat anorexia, post-traumatic stress disorder and pain, among other psychological ailments. Moreover, studies of virtual therapies are accumulating apace. In August, references to "virtual reality" appeared in 1,923 papers in the clinical database PubMed, an increase of more than 80 percent from December 2003.

Other computer-based technologies, from electronic games to cell phone text messaging, are also gaining guarded acceptance in clinical circles [see "The Promise of E-Therapy," by Beryl Lieff Benderly; Scientific American Mind, December 2005]. Recent applications of such technologies include therapy for obsessive-compulsive disorder and outpatient treatment of bulimia. The American Psychological Association (APA) estimates that some 2 percent of U.S. therapists are using virtual real-

Virtual-reality therapy has **proved to be as effective** as real-world exposure therapy for some phobias.

ity and other media-based modes of treatment. In Europe, pioneers of a venture called VEPSY Updated are developing digital media for psychotherapy tailored to disorders as diverse as social phobia, male sexual dysfunction and obesity.

"Virtual realities are beginning to play an important role in clinical psychology," says psychologist Giuseppe Riva of the Catholic University of the Sacred Heart in Milan. Although controversy still surrounds the efficacy of such treatments, some researchers now predict that media-based methods will ultimately supplant many more established psychotherapy techniques.

Facing Fear

Decades ago psychotherapy was mostly talk. Relaxing in an armchair, a therapist would listen to the proverbial couch-bound patient free-associate in hopes of revealing the roots of the patient's disorder. The process was open-ended and could stretch on for years.

Today, however, many clinical psychologists have scrapped such Freudian psychoanalysis for a more finite and pragmatic technique known as cognitive-behavior therapy (CBT). In CBT, counselors teach patients how to detect and combat distorted negative thought patterns (the cognitive part) and to use behavior-modification techniques to help them get on with their lives.

The new computer-based technologies are designed to work with CBT; most of them facilitate the therapy's behavior component. In addition to reducing the demand on a therapist's time and the cost and inconvenience of exposure therapy, the technology adds an element of control: a therapist can adjust the elevator's speed, the aerial view of the ground and the amount of time the elevator lingers on the top floor based on a patient's fear ratings. Such tuning can help ensure that a patient gets enough exposure for habituation to occur but does not get so scared that he or she panics.

In various studies, virtual-reality therapy has proved as effective as real-world, or in vivo, exposure therapy for some phobias. In Kuntze's experiments, for example, some patients' fear ratings dropped from 80 or 90 (out of 100) in the first minutes of exposure to below 30 after several hours, a sign that the fear had been overcome.

And last year psychologist Barbara O. Rothbaum of the Emory University School of Medicine and her colleagues reported successfully using the technique to treat the fear of flying. After four trips in either a virtual airplane or an actual airplane, 76 percent of 50 patients with this phobia were willing to go on a post-treatment flight, compared with just 20 percent of 25 people in the study's control group. Both real-world and virtual therapies were also equally effective in reducing patients' anxiety during a flight. What is more, the VR treatment had a lasting impact: more than 70 percent of the patients from both treatment groups reported flying in airplanes a year later.

Spider phobia has also succumbed to virtual-exposure therapy. In a VR program called SpiderWorld developed by psychologist Hunter G.

VIRTUAL FREE FALL: Simulations of the World Trade Center attacks have helped resolve symptoms of post-traumatic stress disorder in 9/11 survivors.

HOWARD ABRAMS AND DUFF HENDRICKSON, © HUNTER G. HOFFMAN *University of Washington*

FAST FACTS

Digital Healing

1» Therapies that use the artificial worlds of virtual reality, or VR, can help patients tolerate conditions that otherwise would cause them anxiety or pain.

2» When used to treat phobias, VR therapies replace exposure to real-world conditions, such as being in a skyscraper, and are less likely to trigger panic.

3» To treat pain, VR therapies can give patients a helpful distraction.

ON ICE: Patients with burn wounds are better able to endure painful bandage changes if they are simultaneously plunged into a virtual world of snow and ice.

HUNTER G. HOFFMAN *University of Washington*

Hoffman of the University of Washington and his colleagues, patients confront virtual spiders that descend on webs from a kitchen ceiling to the floor and crawl out of cupboards. One patient treated with SpiderWorld had been so afraid of the eight-legged critters that she had regularly fumigated her car with pesticides and sealed her clean laundry in plastic bags. At first, she hesitated to approach the virtual spiders, too. Gradually, though, she moved closer to them and eventually picked them up with her cyberhand. Her fear of real spiders also eased. The program has helped another 20 similarly haunted patients.

In the same vein, VR may ease the symptoms of post-traumatic stress disorder (PTSD), in which patients experience serious psychological disturbances as a result of traumatic experiences, such as war. In this case, VR enables participants to relive the situation that triggered their PTSD so that they can access emotion-laden memories they have been avoiding—the recall serves to desensitize them to these memories.

In a 2001 pilot study, Rothbaum's team showed 10 Vietnam veterans with PTSD a computer-rendered Huey helicopter soaring over a clearing encircled by a jungle in a simulated Vietnam environment. Eight to 16 sessions with the VR program improved the patients' symptoms by 15 to 67 percent. In a later study, published in 2006, Hoffman and his colleagues treated male disaster workers traumatized by the World Trade Center attacks of September 11 by exposing them to realistic renditions of planes flying over virtual twin towers, pictorial explosions with sound effects and animated humans leaping to their death from the buildings. After 14 weekly sessions, the VR therapy basically eliminated PTSD symptoms in five of the eight patients treated, compared with none of the patients on a waiting list for treatment.

U.S. Navy scientists are applying the technology to the Iraq War. They have built a virtual mini Fallujah with a base compound, marketplace, village, hospital and eight battle spaces and are now testing this fantasy battlefield on five Iraq War veterans who are suffering from PTSD.

Escaping Pain

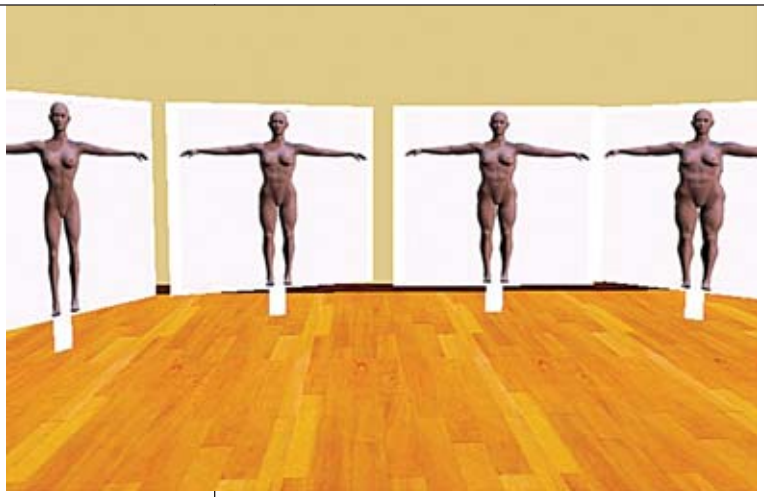
In contrast to phobias, for which the cure comes from confronting the fear, virtual-reality therapy for pain works by distracting patients from what ails them. A few years ago Hoffman sat burn victims in front of a computer and surrounded them with a frigid virtual landscape called SnowWorld. While their painful wounds were being debrided, the patients made their way through an icy canyon with a chilly river and waterfall, tossing snowballs at virtual robots and snowmen loitering along their route.

The winter trip dulled the patients' pain by providing an escape. "Virtual reality redirects people's attention away from the wound and to an artificial world," Hoffman says. He and his colleagues have also had similar success with other VR programs, such as SpiderWorld, in burn patients and in patients experiencing pain from other sources.

In a follow-up study, Hoffman, along with University of Washington radiologist Todd L. Richards and their colleagues, monitored the ef-

(The Author)

NIKOLAS WESTERHOFF is a psychologist and independent science journalist in Berlin.



BODY BEAUTIFUL: A woman weighs in on a virtual scale and defines her goal weight (*right*) in a type of cybertherapy that also exposes her to virtual female figures (*left*)—to test the accuracy of her own body image.

fects of VR on pain-related activity in the brain. They scanned the brains of healthy volunteers who received a brief heat stimulus to one of their feet. Without any virtual distractions, the patients experienced a lot of pain, and their brains correspondingly displayed heightened activity in five compartments known to process pain signals. But when the volunteers ventured into SnowWorld during the painful experience, the pain decreased by 30 to 45 percent, and the five relevant brain regions were significantly less active, the researchers reported in 2004.

Although people can conjure up their own fantasies as distractions, most human imaginations are weak analgesics compared with vivid simulations such as SnowWorld. Thus, researchers are testing the efficacy of virtual reality in other painful or anxiety-provoking situations. In one small study, Rothbaum and her colleagues showed that virtual-reality entertainment reduced pain and anxiety in young cancer patients during an invasive procedure—as assessed by nurses' reports and the children's decreased pulse rates—compared with either no diversion or a diversion that did not involve VR.

Virtual reality can help anorexics and the overweight form more **accurate mental images** of their bodies.

Digital Feedback

In some VR programs, a patient's profile can be incorporated into a simulated scene, a technique that Riva has applied to the treatment of anorexia. In Riva's programs, a computer uses a person's physical dimensions to generate an animated version of that person. The patient then guides her virtual image through a house with many doors in which she meets figures of various shapes and sizes, including some she had previously judged as ideal.

Eventually the patient encounters her own figure behind a door. The encounter, according to Riva, causes many patients to realize that they are slimmer than the people they had considered perfect. "The sight of her own body often triggers strong emotions," Riva says. In this way, the computer-generated image can help anorexics start to form more accurate mental pictures of themselves.

Riva and his colleagues have tested a similar approach in obese individuals, for whom dieting alone is often ineffective in diminishing their body dissatisfaction. In addition to receiving body-image therapy like that used in anorexic patients, the obese subjects enter virtual environments to learn how to cope with eating triggers at home or at a supermarket, pub or restaurant. In a study of 211 obese patients published last year, the researchers found that virtual-reality therapy was superior to cognitive-behavior or nutrition therapy alone in improving obese subjects' body satisfaction and eating behavior. Perhaps as a result, significantly more of the patients who received the VR treatment had lost 10 percent of their body weight after the study, and more of them had maintained that weight loss six months later.

Meanwhile other researchers are testing cell phone text messaging as a means of preventing

GIUSEPPE RIVA *Catholic University of the Sacred Heart*

relapse in bulimia patients. In a study at the University Hospital of Heidelberg in Germany, headed by psychiatrist Stephanie Bauer, patients send a text message to a computer once a week in which they rate their body perception and indicate the frequency of behaviors such as binge eating and self-induced vomiting. After a computer calculates the patient's progress, or regression, from the previous week, a therapist offers support and advice. For instance, if a patient has a low body-image rating but a positive eating report, a therapist might reply: "Don't let negative body perception get you down. You've got your eating disorder under control. That's something to be proud of!"

Other innovators have developed computer software to assist in the treatment of obsessive-compulsive disorder (OCD). Behavior therapy for OCD often involves repeated exposure to everyday scenarios, such as getting dirty or locking a door, to which OCD patients have strong emotional reactions. As with phobia treatment, such training dampens these reactions through habituation.

To lessen the monotony of such training for the clinician, psychotherapist Christoph Woelk of the University of Osnabrueck in Germany has developed an animated, talking computer assistant called Brainy that monitors OCD patients during their training sessions. First the patient selects an exercise—say, taking a shower—and enters a time limit into the computer. Then he starts the task, and if it takes too long, Brainy warns: "Your time for this activity is up." Brainy stops nagging only after the patient has stopped the repetitive activity and returned to the computer.

Brainy also helps patients prolong the time between a trigger for a repetitive ritual and the ritual itself. This delay helps to disconnect the trigger from the disruptive behavior and thus reduces a patient's need to engage in the behavior. Brainy is used in conjunction with traditional therapy: it keeps a log of the patient's successes and failures that is sent to the therapist, who monitors his or her progress.

The Personal Touch

Many researchers remain skeptical of the effectiveness of virtual reality and other computer technologies, citing a lack of hard data showing that they make patients better. "There are still too few [rigorous] controlled therapeutic studies," cautions psychologist Helmuth P. Huber of the University of Graz in Austria. In some cases, for example, researchers gauge treatment success with patient evaluations rather than with objective evidence that shows patients have been cured—that people afraid of public speaking, for instance, are actually giving speeches after virtual therapy rather than just saying they are less afraid.

BEHAVIOR MANAGEMENT: The computer therapist "Brainy" warns German patients with obsessive-compulsive disorder when they have spent too long performing a task, such as checking the stove before leaving the house.

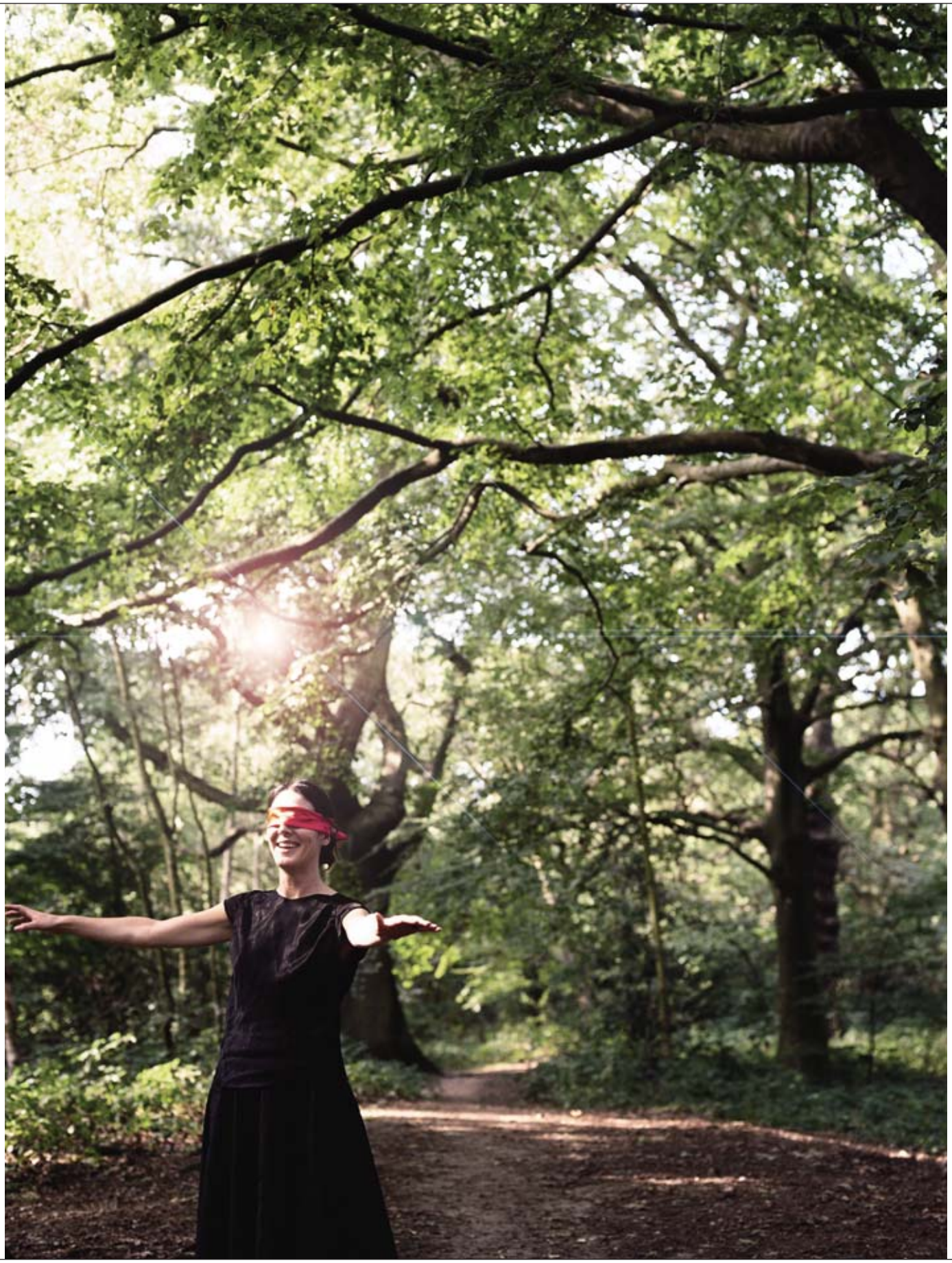
For now, many researchers emphasize that the relationship between a therapist and a patient is the most important element of psychotherapy. "Personal conversations cannot be replaced by electronic media," opines psychologist Rainer Richter of the University Medical Center Hamburg-Eppendorf in Germany.

Nevertheless, a 2002 survey of 60 well-known psychotherapists suggests that the various so-called cybertherapies will become more popular over the next few years, in many cases displacing traditional techniques. "Whether by video feedback, e-mail or simulation software, classical therapy will increasingly be supplemented by new media-supported forms," Kuntze forecasts. In this way, today's therapists may propel the talking cure into the digital age. M

(Further Reading)

- **Virtual-Reality Therapy.** Hunter G. Hoffman in *Scientific American,* Vol. 291, No. 2, pages 58–65; August 2004.
- **Is Severe Obesity a Form of Addiction? Rationale, Clinical Approach, and Controlled Clinical Trial.** G. Riva, M. Bacchetta, G. Cesa, S. Conti, G. Castelnuovo, F. Mantovani and E. Molinari in *Cyberpsychology & Behavior,* Vol. 9, No. 4, pages 457–479; August 2006.
- **Cybertherapy in Practice: The VEPSY Updated Project.** G. Riva, C. Botella, G. Castelnuovo, A. Gaggioli, F. Mantovani and E. Molinari in *Cybertherapy: Internet and Virtual Reality as Assessment and Rehabilitation Tools for Clinical Psychology and Neuroscience.* Edited by G. Riva, C. Botella, P. Legeron and G. Optale. IOS Press, 2004, 2005, 2006.
- Download Giuseppe Riva's VR environment and learn about the uses of VR in clinical psychology at **www.neurovr.org**
- Learn about commercial virtual-reality treatments for phobias and other anxiety disorders at **www.virtuallybetter.com**
- Learn about the virtual-reality technologies in Hunter G. Hoffman's laboratory at **www.hitl.washington.edu/projects/vrpain/**

CHRISTOPH WOELK *University of Osnabrueck*



FELIX CLINTON *Getty Images*

Tracking a FINER MADNESS

Many believers in psychic phenomena are also inventive—a fact that may help bridge the gap between creative genius and clinical insanity

By Peter Brugger

The experimental setup is simple: a six-foot-wide, 60-foot-long corridor with a straight black line running along the floor. A blindfolded subject attempts to walk the line, and a researcher records any wobbles to the right or left. Christine Mohr, now a lecturer in experimental psychology and neuropsychology at the University of Bristol in England, designed the study for her doctoral dissertation at the University of Zurich. Before the study participants walked the line, Mohr asked them about parapsychology—specifically, their belief in so-called psi phenomena, including telepathy, clairvoyance and psychokinesis (using mental imagery to move objects).

How could there be any connection? In fact, the results were incontestable. Among some three dozen subjects, Mohr found that the more strongly an individual believed in extrasensory experiences, the more likely he or she was to stray to the left side of the line. This drift was slight—the subjects themselves were unaware of it—but Mohr's calculations proved it. Further experiments at the University of Zurich revealed other trends among psychic devotees: on word association tests, they were apt to make more connections more quickly than skeptics were; they had far more notions about what a murky ink blot might resemble; and they were faster at identifying meaningful shapes among randomly generated patterns.

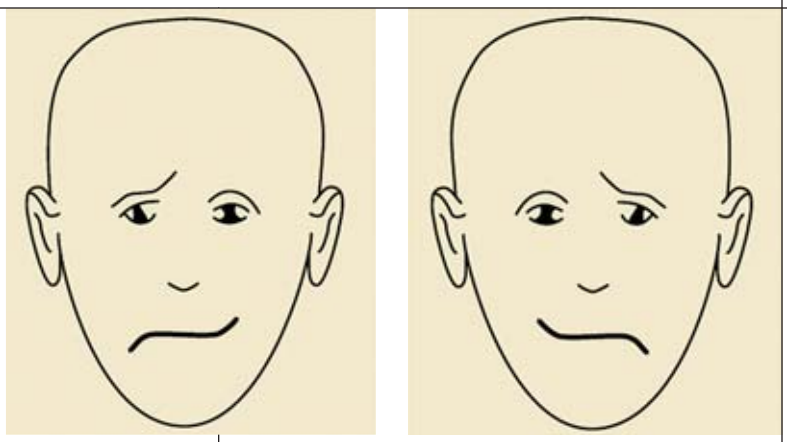
In fact, various indices suggest that believers in the paranormal tend to be "right-brained." It is this right-hemisphere dominance that explains their leftward drift in Mohr's experiment and the greater creativity they demonstrate on psychological tests. The aptitude for drawing meaning from seeming abstraction must also inform psychic believers' worldview, which is so often colored by magical thinking and heightened spirituality. Of interest, these same associative abilities taken to an extreme characterize people with schizophrenia, who also show leftward-veering proclivities. Along the spectrum from skeptics to schizophrenics, psychic enthusiasts fall somewhere in the middle—benefiting from increased creativity within the bounds of normalcy. Studying these people may afford insight into the neuronal sources of innovation and help neuroscientists explore the borders between artistic inspiration and pathological ideation.

Right of Way

Just as each brain hemisphere controls almost exclusively the movements of the opposite side of the body, our perceptions—by eye, ear or touch—are also organized primarily on a crossover basis. In most people, particularly those who are right-handed, the left hemisphere is the speech-dominant half, whereas the right hemisphere takes a lead in solving spatial and nonverbal problems. Because of this division of labor, a majority of individuals tend to place slightly more weight on information presented to them in the left visual field. To ESP believers, images from the left seem to bear even greater significance than they do among right-handed skeptics.

(The Author)

PETER BRUGGER is head of the neuropsychology department at University Hospital Zurich in Switzerland. He has researched the belief in paranormal phenomena for more than 10 years.



Which face seems happier? If you said the one on the right, the right hemisphere of your brain probably dominates your visual processing, leading you to pay slightly closer attention to information in your left visual field.

To study such asymmetries, neuropsychologists sometimes use images of chimeric faces, composites in which one corner of the mouth may arch up while the other corner curves down [*see illustration above*]. Many interpret chimeric faces as somewhat ambiguous, but whether a person regards such a face as slightly happy or slightly sad depends on which side draws more of his or her attention—and thus which hemisphere dominates that person's visual processing. As expected, most right-handed people view the face on the right as just a bit happier than the one on the left. Those with a pronounced psychic bent perceive the difference between the two faces as even greater. This preference for information on the left also extends to spatial reasoning, as demonstrated by another study in which blindfolded subjects felt a rod and attempted to identify the midpoint. The right-handed control subjects drifted slightly toward the left, whereas the more psychically inclined among them placed the middle even farther left of center.

In addition, there seem to be left-right asymmetries in mental imagery. Try to answer the following question without calculating: What number lies halfway between 15 and 3? Such estimation tasks are generally solved using a kind of internal number line, which in our culture generally extends from left to right, from lower to higher numbers [*see box on opposite page*]. Patients who have had a stroke on the right side of their brain tend to estimate high. Healthy right-handed people, in contrast, more frequently err lower (or toward the left). In keeping with the other experiments, those who believe in parapsychology tend to produce even lower guesstimates.

Psychic Ability

Spatial tasks aside, various studies have found that people who believe in the paranormal also show an above-average involvement of the right hemisphere in word association tasks. Contrary to received wisdom, the right hemisphere appears to dominate some aspects of speech processing, including the formation of silent associations and the interpretation of intonation and vocal stress. Moreover, the right hemisphere seems to trump the left in spotting indirect interrelations. Patients who have suffered damage to the right hemisphere, for instance, can often form associations only within narrow limits; irony and metaphor typically escape them. In comparison, those with a penchant for extrasensory phenomena draw quick metaphorical links, and schizophrenics make associations that soar well beyond normal perceptions.

Such associations lie at the heart of all creativity. In 2005 Bradley S. Folley and Sohee Park of Vanderbilt University compared the creative potential among normal test subjects, people with schizotypal tendencies—who, like psychic believers, typically give credence to magical ideas and explanations—and schizophrenic patients. On one task, subjects had to think up as many uses as possible for particular objects, such as an eraser. Participants with schizotypal characteristics showed by far the greatest creativity. As measurements of brain activity using near-infrared optical spectroscopy demonstrated, the creative challenge activated areas in the frontal lobe of both hemispheres—or, more precisely, the pre-

FAST FACTS

Reading the Minds of Psychics

1» On psychological tests, believers in the paranormal very often display above-average creativity: on word association tests, they make more connections more quickly than skeptics do; they have more definite ideas about what ink blots might resemble; and they are faster at identifying meaningful shapes among randomly generated patterns.

2» These same associative abilities taken to an extreme characterize people with schizophrenia. Along the spectrum from skeptics to schizophrenics, psychic enthusiasts fall somewhere in the middle. Studying these individuals may help neuroscientists explore the borders between artistic inspiration and clinical insanity.

3» The transitions from the rejection of parapsychology all the way to the experience of hallucinations are fluid. The assumption of a continuum is important for neuropsychology. Unfortunately, present-day psychiatry is based on a one-sided understanding of pathology. Studying healthy subjects offers an often missed chance to exclude variables such as medications, hospitalization and the effects of social stigmatization.

GEHIRN & GEIST

Test Your Brain

What number is in the middle?

Read the following pairs of numbers to a friend and ask him or her to guesstimate the number halfway between each pair. Spend no more than two seconds on each one. It does not matter if your friend makes mistakes.

2, 8 15, 3 17, 7 3, 11 5, 17 14, 2

Got them wrong? No worries. Healthy right-handed people generally misestimate to the left—that is, their incorrect answers are a shade low. Individuals who believe in telepathy, clairvoyance and other magical associations drift even farther left than skeptics do.

What word connects sand and time?

Correct: clock! Write the word that connects the other two in the pairs listed below. If you can't think of anything quickly, skip ahead. Then read the solution printed upside down in this box.

worm, sofa	___	box, photo	___
lightning, noise	___	dog, mouse	___
hometown, reader	___	effect, brother	___
hunger, passion	___	onion, sadness	___
pitcher, flight	___	oatmeal, fur	___
fish, fire	___	bean, tea	___
thorn, bride	___	stall, flag	___
anvil, nail	___	youth, pension	___

Solution: Only every other pair consists of two words that are indirectly related. The most common answer for lightning and noise, for example, is thunder. For every other pair thereafter, the common answers are thirst, water, hammer, cat, tears, coffee, age. But there are certainly other conceivable answers. Were you able to think up a semi-plausible response to an unrelated pair of words? Congratulations! It speaks to your creativity.

frontal cortex. The more magical a person's thinking, however, the more the areas on the right side were involved.

Some of this activity may be attributable to neurochemistry. In a separate experiment, my colleagues and I tested 20 self-confessed paranormal believers and 20 skeptics by asking them to try to identify real faces or real words among images of either scrambled faces or made-up words. In general, psychic believers were more likely to see real faces and words when there were not any, and the skeptics more often missed the real faces and words when they did appear. Then we gave the subjects L-dopa, a drug that increases levels of the neurotransmitter dopamine in the brain. Both groups made more mistakes under dopamine's influence, but the skeptics also became less skeptical, more often interpreting scrambled information as meaningful. The dopamine system is thought to help the brain prioritize important information, and higher levels of this messenger substance may enable individuals to see patterns where none are obvious.

Scryer or Skeptic?

Seeing paranormal relationships in everyday coincidences is not at all the same as the distinctive denial of reality that characterizes schizophrenia. Nor should we confuse a belief in telepathy with the delusion that hidden unknown persons are tapping into one's thoughts. We must also avoid lumping a belief in extrasensory phenomena with pathology per se. After all, people with psychic predispositions are not the only ones who are capable of making extraordinary associations. And isn't that precisely what we so value in artists—the facility to interpret what is familiar in ways that are surprisingly new?

In truth, the transitions from the unimaginative rejection of parapsychology all the way to the experience of florid hallucinations are fluid. The assumption of a continuum is important for neuropsychology. Unfortunately, present-day psychiatry is based on a one-sided understanding of pathology. The possibility of learning about psychological disturbances from the systematic study of healthy individuals is foreign to most researchers. This approach, however, offers the often missed chance to exclude variables such as medications, hospitalization and social stigmatization. **M**

(Further Reading)

- **From Haunted Brain to Haunted Science: A Cognitive Neuroscience View of Paranormal and Pseudoscientific Thought.** Peter Brugger in *Hauntings and Poltergeists: Multidisciplinary Perspectives.* Edited by James Houran and Rense Lange. McFarland & Company, 2001.
- **Magical Ideation Modulates Spatial Behavior.** Christine Mohr, H. Stefan Bracha and Peter Brugger in *Journal of Neuropsychiatry and Clinical Neurosciences,* Vol. 15, No. 2, pages 168–174; Spring 2003.
- **Verbal Creativity and Schizotypal Personality in Relation to Prefrontal Hemispheric Laterality: A Behavioral and Near-Infrared Optical Imaging Study.** Bradley S. Folley and Sohee Park in *Schizophrenia Research,* Vol. 80, pages 271–282; August 24, 2005.

The Best Medicine?

How drugs stack up against talk therapy for the treatment of depression

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

IMAGINE a treatment for depression that possesses the following properties: It is as effective as antidepressant medications but lacks their side effects. Its therapeutic results last longer than those of antidepressant medications after treatment has ended. Its benefits generalize to many domains of life. It causes changes in the brain in processes associated with depression. It usually needs to be administered only once a week. It generally costs the same or less than medications. Sound too good to be true? In fact, such a treatment has been around for decades, although many people do not know about it. It is called psychotherapy.

Why are so many people unaware of these facts? One reason is that pharmaceutical companies have huge advertising budgets to aggressively market antidepressant medications to the public and to the physicians who write prescriptions. In contrast, psychotherapists have little or no budget for marketing. In this column, we will try to level the playing field by providing a scorecard of how antidepressants compare with psychotherapies.

Antidepressants: Pros and Cons

Although a number of different classes of antidepressants exist, we will focus on the most commonly prescribed class today: SSRIs, or selective serotonin reuptake inhibitors [*see box on opposite page*].

People who take antidepressants usually do not show improvement for two to four weeks. For any given individual, some antidepressants work better than others; no one antidepressant has been shown to be more effective than any other at a group level. Many people undergoing treatment for depression try two or three SSRIs (or other antidepressants) before they find one that works and that has tolerable side effects. Studies find that about 50 to 70 percent of those who take SSRIs are responders, showing a 50 percent or greater reduction in symptoms. For some clients, depression is better but still present, whereas others become symptom-free. Residual symptoms after treatment are problematic because they signal a significant risk factor for a repeat depression.

After therapeutic effects appear, clients are usually told to continue on the drug for at least an additional six to 12 months to prevent relapse. If patients have had several previous episodes or if their depression is severe,

Imagine a treatment for depression that is as effective as antidepressant medications but **lacks their side effects**.

COURTESY OF HAL ARKOWITZ (*top*); COURTESY OF SCOTT O. LILIENFELD (*bottom*); GETTY IMAGES (*illustration*)

Some studies have shown that combining psychotherapy and medications is **more effective than either alone** for adults.

they may be told to remain on the drug longer to avoid recurrence of depression. Using antidepressants for maintenance in this way reduces the relapse rate as compared with a placebo. Save for Prozac, antidepressant therapy has *not* been shown to be effective for children and adolescents and may not be safe for a small percentage of people younger than 24 years old, as we discussed in our last column, "Can Antidepressants Cause Suicide?" [Scientific American Mind, August/September 2007]. In addition, antidepressants can cause fetal damage, so pregnant women are strongly advised not to take them.

In most drug trials, all patients receive the same antidepressant. In the real world, however, psychiatrists often try a different medication if one prescription does not work. A recent study by A. John Rush of the University of Texas Southwestern Medical Center and his colleagues more closely approximated how SSRIs are used in practice. The researchers presented depressed patients with a four-step set of options to be used if necessary. All subjects started on the same antidepressant (Celexa). At each of three subsequent steps, those who either did not respond or could not tolerate the side effects got a menu of options, which included changing medication, adding medication, or adding or switching to cognitive-behavior therapy (CBT). This study yielded an overall remission rate of 67 percent, far superior to that of most studies that show remission rates (excluding improvement rates) of closer to 33 percent.

Some studies of adults have shown that combining psychotherapy and medications is more effective than either treatment alone. Further, several studies with adults have found that drug therapy may be more effective than psychotherapy for severe depressions, although the evidence on this point is mixed.

The Scoop on Psychotherapy

Despite the voluminous research on psychotherapy as a treatment for depression, scientists have evaluated only a few types of psychotherapy. CBT has been the most extensively studied by far. Such therapies teach and encourage new behaviors and help people change excessively negative thinking. Interpersonal psychotherapy (IPT) has the second greatest amount of supporting data. Research on other therapies, such as short-term psychodynamic therapy, client-centered therapy and emotion-focused therapy, has just begun, but outcomes in these few studies have been positive [*see box below*]. In the remainder of this column, our discussion of psychotherapy refers to those practices that have been supported by research.

Antidepressants and Common Side Effects

Selective serotonin reuptake inhibitors, or SSRIs, can relieve depression but can have drawbacks.

Trade name	Chemical name
Paxil	paroxetine
Prozac	fluoxetine
Lexapro	escitalopram
Celexa	citalopram
Zoloft	sertraline

Common Side Effects of SSRIs

- **Short-term** (lasting a few weeks): nausea, diarrhea, nervousness and insomnia
- **Long-term** (lasting months or longer): low sexual desire or sexual dysfunction (in 50 to 75 percent of patients) and sedation

Research-Supported Psychotherapies

Scientists have evaluated only a few types of psychotherapy. The most supporting data exist for cognitive-behavior therapy and interpersonal psychotherapy, which have been shown to be effective in treating depression. Only a few studies have examined the performance of the other three therapies listed below, but their outcomes are encouraging.

Name	Approach
Cognitive-behavior therapy	Teaches and encourages new behaviors to help people change overly negative thinking
Interpersonal psychotherapy	Focuses on the social difficulties and conflicts associated with depression
Short-term psychodynamic therapy	Emphasizes understanding and correction of problematic interpersonal patterns
Client-centered therapy	Emphasizes the therapeutic potential of the therapist-client relationship
Emotion-focused therapy	Builds on client-centered therapy by adding a focus on increasing awareness of thoughts and feelings and resolving persistent and problematic emotional reactions

The findings regarding the efficacy of CBT are remarkably similar to those of most SSRI studies. Approximately two thirds of patients who undergo 12 to 16 sessions of CBT show improvement or remission. (The reason therapy costs the same or less than medications is largely because people are usually on antidepressants far longer than they are in psychotherapy.) So far most comparisons among different therapies have shown them to be about equally effective. As of this writing, however, no studies of psychotherapy have adopted the multistage approach used by Rush and his colleagues with antidepressants; in practice, psychotherapists often switch strategies if the one they are using is not working. Because psychotherapy studies use only one approach for purposes of experimental control, they may underestimate the efficacy of psychotherapy for depression, although that conjecture awaits formal research.

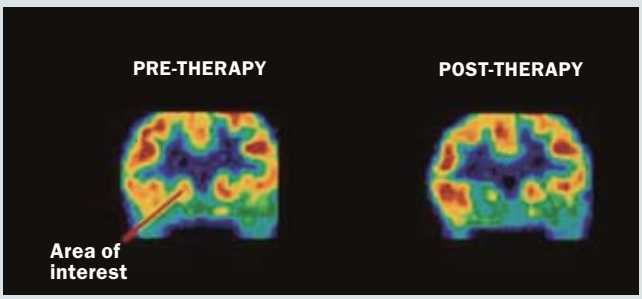
Numerous studies have demonstrated that after treatment has ended, patients treated with medication alone relapse at *twice* the rate of those treated with CBT alone. Further, dropout rates for antidepressant treatments are two to three times as high as those for CBT, with one large-scale study finding a 72 percent dropout rate for antidepressants by 90 days of use. Recovered patients who had received antidepressants and continued on them for maintenance showed relapse rates roughly equivalent to those who had completed CBT with no further treatment. These findings suggest that CBT may address some of the underlying causal processes better than medication does or that it may provide patients with coping skills that let them deal better with life events. In contrast, antidepressant treatments may be more palliative, suppressing symptoms for as long as the medications are taken. Even so, approximately half of those who respond to CBT relapse within two years, suggesting that we psychologists still have our work cut out for us. CBT researchers are working on ways to further reduce post-treatment relapse. For example, recent studies have found that an eight-session group booster treatment known as mindfulness-based cognitive therapy given to recovered depressed patients during the year after the end of initial treatment reduces relapse for those who have had three or more episodes of depression.

In depressed children and adolescents, only one of the antidepressants

Psychotherapy and the Brain

Drug company marketing suggests that depression is caused by a "chemical imbalance" in the brain. For example, an advertisement by the maker of the selective serotonin reuptake inhibitor (SSRI) Zoloft states: "While the cause is unknown, depression may be related to an imbalance of natural chemicals between nerve cells in the brain. Prescription Zoloft works to correct this imbalance." The imbalance to which the SSRI ads refer is a deficit of the neurotransmitter serotonin at receptor sites in the brain. Such advertising is misleading, however, and does *not* reflect scientific findings. There is no clear scientific evidence that neurotransmitter deficits cause depression or that there is an optimal "balance" of neurotransmitter levels in the brain. Moreover, medications that primarily affect chemical messengers other than serotonin are as effective as SSRIs.

Undoubtedly, antidepressants are helpful in alleviating depression. But there is a form of circular reasoning that goes: if SSRIs are helpful in alleviating depression, and if they do change the "chemical imbalance," then depression must be caused by that imbalance. Inferring causality from the success of a treatment is frequently a flawed endeavor: aspirin is effective for headaches, but no one would seriously claim that headaches are caused by a deficiency of aspirin.



PET images of a patient with obsessive-compulsive disorder before (*left*) and after (*right*) successful psychotherapy show decreases in glucose metabolic rates. Such brain changes have also been found in depressed patients who have received therapy.

In addition, biological treatments are not unique in their ability to cause changes in the brain. Using neuroimaging techniques, many studies have shown significant brain changes in patients treated with psychotherapy alone. One study with depressed patients demonstrated that cognitive-behavior therapy led to decreased activity in the frontal regions of the brain, some of which may be related to rumination, a common feature of depression. Some studies have found brain changes identical to those caused by antidepressant medications, whereas others have found different brain changes. These findings support the idea that psychotherapy produces measurable changes in the brain, although these modifications may sometimes differ from those produced by medication.

—H.A. and S.O.L.

SOURCE: LEWIS R. BAXTER, JR., ET AL.

(Prozac) has been shown to help, whereas several different types of psychotherapies have proved beneficial. In both cases, however, treatment effects have been only moderate. The results of studies on the combination of drug therapy and psychotherapy for these populations show either no advantage or a slight advantage for the combination over either single treatment.

Although results are somewhat mixed, most of the evidence suggests that combined psychotherapy and drug treatments are more effective for adults but not necessarily for children and adolescents. One well-designed large-scale study in chronically depressed adults compared a non-SSRI antidepressant medication, a modified form of CBT that emphasized changing interpersonal relationship patterns and negative thinking, as well as their combination. Whereas response rates for each of the single treatments were comparable to those usually obtained in depression treatment studies, the response rate for the combination treatment was a dramatic 85 percent!

Putting It Together

Antidepressant medication and certain forms of psychotherapy are reasonably effective for the treatment of adult depression, but there is considerable room for improvement in initial response rates and relapse rates. Response rates (improvement or remission) for both treatments average at around two thirds. This means that many people are helped but are left with some depressive symptoms, whereas others are not helped at all. The combination of psychotherapy and drug therapy may yield better outcomes for adults but little or no added benefits for children and adolescents. Although psychotherapy leads to half the relapse rate of drug therapy over a two-year follow-up period, relapse rates for both remain disturbingly high.

Psychotherapy, drug therapy and a combination of the two are all helpful for adult depression, but effects are weaker in children and adolescents who are depressed. Drug therapy may be better for some people, psychotherapy for others, and the combination for others still. We do not know which people will respond best to any given treatment. Moreover, many other important questions remain unanswered. Would longer psychotherapeutic treatments such as those typically used in clinical practice lead to better initial outcomes than those that result from the short-term psychotherapies that have been researched so far? Would a sequential strategy such as that used by Rush and his associates for drug therapy improve psychotherapy outcomes? What can we do to further reduce or eliminate relapse? Are some treatments better for some types of people and depression than for others?

So, to the bottom line. We have learned that psychotherapy and drug therapy are both fairly effective. We know that psychotherapy prevents relapse better than drug therapy does when treatment is discontinued, that there are few, if any, negative side effects of psychotherapy, and that psychotherapy is a safe and moderately effective treatment for depressed children and adolescents. It also can change the biology associated with depression [*see box on opposite page*]. CBT and IPT (the two best empirically supported therapies for depression) and possibly other psychotherapies with some empirical support should be seriously considered for a depressed person seeking treatment. If the response to psychotherapy is not adequate, other types of psychotherapy may be tried or a drug regimen may be added. Although the combination of psychotherapy and drug therapy may be somewhat more effective than either alone, drug side effects can be problematic.

We hope that the information we have provided will counter some of the mistaken impressions fueled by the marketing strategies of some drug companies and that it will encourage readers to think of psychotherapy as a viable treatment for depression that has several advantages over drug therapy. M

Many studies have shown significant **brain changes** in patients treated with psychotherapy alone.

HAL ARKOWITZ and SCOTT O. LILIENFELD serve on the board of advisers for *Scientific American Mind.* Arkowitz is a psychology professor at the University of Arizona, and Lilienfeld is a psychology professor at Emory University. Send suggestions for column topics to editors@sciammind.com. The authors thank Steve Hollon of Vanderbilt University for his invaluable help with this column. Any statements made in the column, however, are solely the responsibility of the co-authors.

(Further Reading)

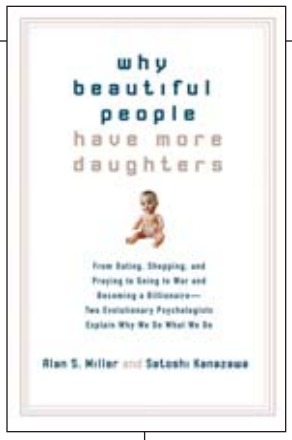
- **Psychotherapy and Medication in the Treatment of Adult and Geriatric Depression: Which Monotherapy or Combined Treatment?** S. D. Hollon, R. B. Jarrett, A. A. Nierenberg, M. E. Thase, M. Trivedi and A. J. Rush in *Journal of Clinical Psychiatry,* Vol. 66, No. 4, pages 455–468; 2005.
- **The Empirical Status of Cognitive-Behavioral Therapy: A Review of Meta-analyses.** A. C. Butler, J. E. Chapman, E. M. Forman and A. T. Beck in *Clinical Psychology Review,* Vol. 26, No. 1, pages 17–31; 2006.

Mind Reviews

> EVOLVING EXPLANATIONS

Why Beautiful People Have More Daughters: From Dating, Shopping, and Praying to Going to War and Becoming a Billionaire—Two Evolutionary Psychologists Explain Why We Do What We Do

by Alan S. Miller and Satoshi Kanazawa. Perigee (Penguin), 2007 ($23.95)



Evolutionary psychology, a school of thought whose influence has grown over the past decade, seeks to explain human behavior as if it were aimed at maximizing "reproductive fitness." In other words, we do what we do because it enabled our ancestors to have more offspring than others—and thus pass on the genes that predispose us to behave in such ways.

In *Why Beautiful People Have More Daughters,* Alan S. Miller and Satoshi Kanazawa, sociologists by training who have embraced evolutionary psychology, apply this viewpoint to matters ranging from dating and marriage to crime, employment, religion and war. (Miller, who taught at Hokkaido University in Japan, died in 2003; Kanazawa of the London School of Economics and Political Science finished the book alone.)

Adopting a question-and-answer format, the authors ask, for instance, why men are attracted to "blonde bombshells." Their answer is that because blonde hair darkens with age, men unconsciously use it as an indicator of women's youth and reproductive potential. Why are there many deadbeat dads but few deadbeat moms? Because, the authors say, men have less biological investment in any one child; it might not be theirs to begin with, and men can potentially have far more children than women can.

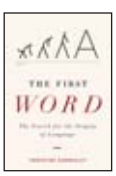
On the title question, the book contends that good-looking couples have more daughters because women benefit strongly from good looks in the reproductive game (and natural selection has geared families to have more children of the sex benefiting most from their lineage's inheritable traits).

Although many of these ideas are intriguing, the book takes an overly confident tone given the speculative nature of its arguments. Citing Bill Clinton as an example, Miller and Kanazawa assert that male politicians risk their careers on extramarital affairs because access to females is the very purpose of their careers, an imperative dictated by genes. Turning to Iraq, the authors suggest that insurgents have killed more Iraqis than Americans because of a subconscious drive to eliminate fellow Arab males as sexual rivals.

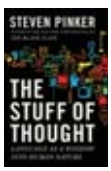
Whereas the authors acknowledge a few puzzling contradictions—for example, wealthier people tend to have lower reproductive rates even though they could afford to have more kids—they pay little attention to critiques of evolutionary psychology. Biologist Niles Eldredge of the American Museum of Natural History in New York City, for instance, argues that the gene-spreading impulse better explains the behavior of simple organisms than that of complex ones. Such counterarguments provide a different perspective on human evolution: maybe natural selection has endowed us with brains flexible enough to partly escape our genes' orders. *—Kenneth Silber*

> SOMETHING TO TALK ABOUT

The ability to speak is arguably at the root of humanity. Delve into the mysteries of language with these recent releases:



Fossils can tell us how our ancestors first walked upright and when we colonized the world, but they are unable to reveal how and when we learned to speak. In ***The First Word: The Search for the Origins of Language*** (Viking Adult), Christine Kenneally picks up where the bones leave off, exploring how language might have evolved and how scientists are studying this once taboo question using parrots, chimps and even robots.



The way we use language is a vivid glimpse into the way our brain manages information, according to Harvard University's Steven Pinker. In ***The Stuff of Thought: Language as a Window into Human Nature*** (Viking Adult), the best-selling author shows how tense, syntax, swearing and metaphor mimic our perceptions of the world—from space and time to social structure.

In a remote Israeli village where there is a high rate of deafness, an indigenous sign language arose—creating an unadulterated example of humanity's complex communication instinct. Margalit Fox trails an international team of scientists as they pick apart and piece together this unique and endangered dialect in ***Talking Hands: What Sign Language Reveals about the Mind*** (Simon & Schuster).

"We were never born to read," writes Maryanne Wolf, who nonetheless argues passionately for the importance of reading proficiency. In ***Proust and the Squid: The Story and Science of the Reading Brain*** (Harper), Wolf explains how the rule-based structure of the written word enhances our cognitive development as she laments the loss of analytical skills that she predicts will arise from modern "screen-reading" habits.

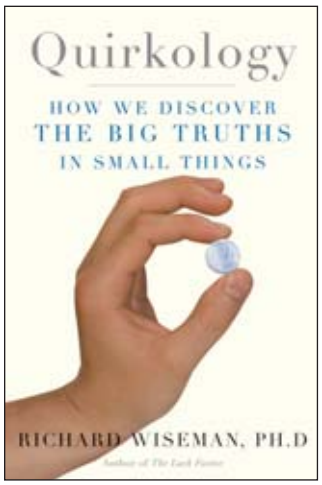
—Meredith Knight and Amelia Thomas

> CELEBRATING THE BIZARRE

Quirkology: How We Discover the Big Truths in Small Things

by Richard Wiseman. Basic Books, 2007 ($26)

The month of your birth can influence the way you behave. You might expect such a statement from someone in a foggy dungeon littered with star charts, but this one comes from a university scientist—and he has the facts to support that claim.



In his compilation of research aimed at explaining the more obscure aspects of human behavior, Richard Wiseman shows us, for example, that the ambient temperature on your birthday has a long-term effect on the development of your personality. People born during the summer months tend to be more optimistic and open to opportunities than those born in the wintertime.

Wiseman, a British psychologist, has been studying areas of human behavior "that have something quirky about them" for more than 20 years. In *Quirkology* he takes readers on a journey through the science behind curious aspects of life, ranging from luck to the paranormal. Although his findings do not reveal anything particularly deep about human nature, his fresh discourse makes for an entertaining and interesting read. Wiseman has unearthed studies showing that teachers award higher essay grades to children with likable names and that people with an extremely unusual first name, such as Oder or Lethal, are more likely to be diagnosed as psychotic than are people with a more common moniker. He also delves into the darker side of human nature and shows how certain types of superstition underlie prejudice, irrationality and even murder.

> "Women's personal ads would attract more replies if they were written by a man."

The book concludes comically with a list of factoids about human behavior, rated on their suitability to provoke interesting dinner party conversations. Wiseman's first choice: people would rather wear a sweater that has been dropped in dog feces and not washed than one that has been dry-cleaned but formerly belonged to a mass murderer. —*Nicole Branan*

> HIGHS AND LOWS

A Summer in the Cage

Produced and directed by Ben Selkow
Airing on Sundance Channel, October 15 at 9 P.M. EST

Everyone likes a happy Hollywood ending. But the unpredictable nature of bipolar disorder prevents this documentary from reaching that kind of uplifting conclusion. Filmmaker Ben Selkow follows former Division I basketball player Sam Murchison as manic depression transforms him from a successful money manager into an unemployed, medicated, 300-pound man, weighed down by depression and fearful of inheriting his father's suicidal fate. In one of the film's most disturbingly honest moments, Selkow rolls tape as mania sends Murchison wading into a pond in New York City's Central Park.

To explain Murchison's highs and lows, the film leans heavily on the expertise of Johns Hopkins Hospital psychologist Kay Redfield Jamison, who, along with an estimated 5 percent of the world's population, also suffers from bipolar disorder. The illness's high prevalence demands that it be better understood, she says. Yet the film's narrow lens on Murchison's experience leaves little room for a description of bipolar symptoms or how the disorder torments the brain. Regardless, Murchison's story is powerful. Even as Jamison imparts the importance of family and friends in the lives of people coping with the disease, Selkow's exasperation and the anxiety of Murchison's widowed mother show the difficulty of maintaining relationships with bipolar loved ones.

The film may leave viewers unsettled, but it gives rare insight into the suffocating reality that Murchison faces every day. "The disease is always there," he says. "It will never go away." —*Corey Binns*

> MINDING THE AIRWAVES

The Infinite Mind

Lichtenstein Creative Media, National Public Radio
To listen, check local listings or visit
http://lcmedia.com/mindprgm.htm

Why do we need vacations? What happens when we feel empathy? What are the roots of our phobias? These are just a few of the questions recently addressed on the award-winning public radio show *The Infinite Mind,* which explores a different neurological or psychological mystery every week.

The show, which premiered in 1998 and is hosted by psychiatrist Peter Kramer, tackles the world of the mind in an easily digestible, no-nonsense manner. The hour-long segments, broadcast in about 250 cities in the U.S. and Canada, feature interviews with scientists, doctors, historians and everyday people with moving personal stories. Despite how deeply the show delves into the workings of the mind, it manages to keep the discussion both simple and interesting—sometimes throwing in a dash of humor, too.

The end result is an hour that flies by quickly but leaves listeners with a coherent and nuanced understanding of a complicated subject. Not only will *The Infinite Mind* help you better understand your own brain, it will also provide you with a compelling argument for why your boss should really give you that extra vacation day. —*Melinda Wenner*

askthe**Brains**

Do deaf people talk to themselves?

—Amelia Thomas, Rochester, N.Y.

Cognitive scientist **Gregory Hickok** of the University of California, Irvine, and linguist **Carol Padden** of the University of California, San Diego, respond:

ABSOLUTELY. Just like hearing people, deaf people can mentally rehearse a speech, mull over a conversation in their head or simply ramble internally about the day's happenings, all in the form of mental images of signs. To get a sense of what talking to yourself in sign language might be like, imagine waving good-bye or blowing a kiss—you are "talking to yourself" in gestures. Now imagine knowing a whole language of signs complete with grammar that would give you the capacity to converse with yourself internally about anything you like. Deaf people who use any of the world's sign languages certainly have this capacity and indeed talk to themselves regularly in signs just as hearing people talk to themselves in speech.

Brain-imaging experiments have mapped the major circuits involved in what is often referred to as inner speech (or in the case of sign language, inner sign). A study by one of us (Hickok), for example, monitored neural activity in the brains of deaf signers who were asked to rehearse sets of signs mentally. Inner signing activated a network of regions that are known to be involved in the overt production of sign language, including areas of the frontal, parietal and temporal lobes. Some of these same regions, particularly those in the left frontal lobe, are also involved in the inner speech of hearing people. These frontal regions have long been associated specifically with speech functions, but their involvement in sign language and in complex motor behaviors beyond language has suggested a more general function, such as the selection or inhibition of complex action plans.

But why do we talk to ourselves in any language? And why do we get the feeling that we can "hear" our own inner speech (or "see" inner signs)? One possibility is that inner speech is the voluntary use of a mechanism designed to monitor our own language output for error-correction purposes. The brain formulates a motor plan for an overt utterance, but before articulation it feeds that plan back into its language *perception* system, which can detect potential errors and send a correction signal if necessary. Because we have this kind of internal sensorimotor feedback loop, what is to stop us from using it to mentally rehearse a speech or to rehash a conversation? And because this internal loop has links back to our perceptual system, we have the sense that we are hearing (or for signs, seeing) our inner dialogue.

Do we have a dominant eye?

—Alexandros Syriopoulos, Athens, Greece

Mark A. W. Andrews, professor of physiology and director of the Independent Study Pathway at the Lake Erie College of Osteopathic Medicine, replies:

JUST AS MOST people have a dominant hand, almost everyone has a dominant eye, defined as the primary eye used when viewing an object at a distance. Approximately two thirds of the population is "right-eyed," with most others being "left-eyed" and 2 to 4 percent having no discernible dominant eye. Most left-handed people are also left-eyed (and likewise for right-handers), but some individuals are cross-dominant.

Deaf people who use any of the world's sign languages talk to themselves regularly in signs just as hearing people talk to themselves in speech.

Although scientists do not yet understand why we have a dominant eye, they have uncovered some interesting properties related to this phenomenon. Evidence suggests that one eye is better at sighting targets, and input from this eye may appear larger and clearer than that received from the other eye. The dominant eye also provides visual input to control movement and posture through subconscious pathways, and it has even been shown to inhibit input to the central nervous system from the opposite eye.

Knowledge and use of one's dominant eye may be helpful in activities that require precise sighting—hunting, billiards and golf, for example. But although the idea has been proposed for years, there is no definitive evidence showing that cross-dominance is advantageous in sports involving side-on stances (such as golf or baseball).

To determine your ocular dominance, try the Porta test. Point an index finger at a distant object with both eyes open, then alternately close each eye to view the object with one eye at a time. The eye that views your finger as pointing directly at the object is your dominant eye. M

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

KAHIAU HOSODA (*Hickok*); VICTOR CHEN (*Padden*); COURTESY OF MARK A. W. ANDREWS

Head Games

Match wits with the Mensa puzzlers

1 WORD SLEUTH

A. I am a three-letter word.
If my second letter was "A," I would be a bird.
If my third was "B," I would be a chore.
If my first was "C," I would be timid.

What word am I? _ _ _

B. I am a four-letter word.
If my second letter was "A," I would not be able to walk.
If my fourth was "B," I would be up a tree.
If my third was "C," I would be itchy.
If my first was "D," I would be small change.

What word am I? _ _ _ _

C. I am a four-letter word.
If my second letter was "A," I could not bear children.
If my first was "B," I would be in your gut.
If my third was "C," I would squeak.
If my fourth was "D," I would be gentle.

What word am I? _ _ _ _

2 HINKY PINKY

What pair of rhyming words—one 12 letters long, the other 13 letters long, both with five syllables—makes a phrase that describes "a deeply satisfying feeling about the formal sanctioning of a treaty"?

3 MICRO CROSSWORD

A three-by-three box contains 10 three-letter words:

three horizontal	**two diagonally up**
three vertical	**two diagonally down**

Below are definitions of the words. Hint: The answers to the definitions are in alphabetical order.

listening device, month, encountered, floor cleaner, scull, soft touch, snoop, listening device, attempt, sweet potato

4 SCRAMBLE

Start with the "T" and move to adjacent letters one by one—horizontally, vertically or diagonally—to spell out a 13-letter word that is an important energy source in the body. You may return to letters to repeat them, but you may not "sit" on them to double them.

S	C	O	F
Y	E	R	H
L	D	I	T
U	G	N	A

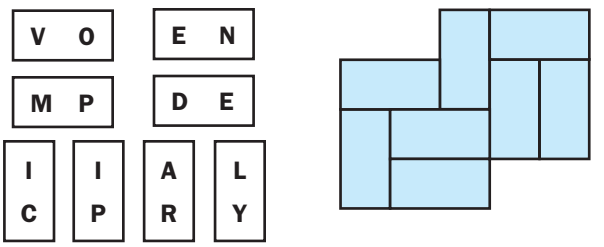
5 MISSING PIECES

Fill in the blanks according to the clues.

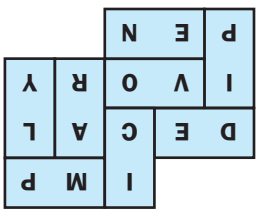
a)	**B _ A _ _ _ T**	**Completely lacking in subtlety**
b)	**_ _ _ B _ A T**	**Popular vessel in some urban parks**
c)	**_ _ _ B A T**	**A GI might get this type of training**
d)	**_ _ _ B A T _**	**The legal settling of an estate**
e)	**B A _ _ _ _ _ T**	**Tiny tub, often made of wicker**
f)	**_ B _ _ _ _ A T _**	**Sticking persistently to an opinion**

6 PIECES OF EIGHT

Fit the pieces into the frame to form common words reading across and down crossword-style. There is no need to rotate the pieces; they will fit as shown, with each piece used exactly once.



Answers



6.

4. Triglycerides.

5. a) Blatant
b) Rowboat
c) Combat
d) Probate
e) Bassinet
f) Obstinate

1. A. JOY (jay, job, coy).
B. LIME (lame, limb, lice, dime).
C. MILE (male, bile, mice, mild).

2. Ratification gratification.

3.

M	O	P
E	A	R
T	R	Y

Coming Next Issue

SCIENTIFIC AMERICAN
MIND
THOUGHT • IDEAS • BRAIN SCIENCE

Available in December 2007

ONLY AT WWW.SCIAMMIND.COM

Weekly Mind Matters seminar blog

Two features highlighted from every print issue

Neuroscience news

E-mail alerts for new issues

This Leg Must Go! ▼

Some people feel part of their body is superfluous or disturbing, and they demand the right to amputation. Is such surgery ethical?

Why We Get Bored ▲

Scientists are beginning to explore boredom—and they are finding its roots in the nature of consciousness.

The Sex of Science

Why are there so few female mathematicians? Are men innately better at science? A team of experts weighs in.

Evolution of Empathy

Animals show a surprising range of altruistic behaviors that may be the precursors of human emotions.

PLUS:

Ask the Brains Experts answer your questions.
Illusions Play tricks on your brain—and gain insights about mental functions.
Head Games Brain teasers and puzzles.

CORBIS (*left*); ANDREW MICHAEL Getty Images (*right*)