HOW PSYCHOLOGISTS IN IRAQ HELP SOLDIERS COMBAT STRESS

SCIENTIFIC AMERICAN
MIND
THOUGHT • IDEAS • BRAIN SCIENCE
www.sciammind.com

Does Your Pet *Really* Love You? What studies say

FEBRUARY/MARCH 2006

INNER VISION

Insights about **mental imagery** may reveal how we think

Sexuality and Choice

Science of Meditation

Train Your Brain

The Halle Berry Neuron

Fighting Parkinson's

Page Intentionally Blank

SCIENTIFIC AMERICAN
MIND
THOUGHT · IDEAS · BRAIN SCIENCE

COVER IMAGE BY KENN BROWN

Mind Field

When you think of this morning's breakfast table, what exactly appears in your mind's eye? How sharp is the image? Do you "see" the colorful bits of cereal floating in the bowl, the glinting steel spoon on the napkin, the half-full coffee mug—or do you just "know" they are there?

More than a century ago Francis Galton, the famous anthropologist and statistician, asked numerous colleagues and friends to recall their breakfast spreads and was startled by how varied the answers were. Some people said their mental view was as vivid as reality; others reported their internal images were faint or even nonexistent. What brain mechanisms could account for such differences? Physician and science writer Thomas Grueter synthesizes the latest research on the topic in his article "Picture This," starting on page 18.

The everyday picture for soldiers in Iraq can be disturbingly uncertain. Service members must be alert for surprise attacks anyplace, anytime. The emotional and psychological effects of such conditions can be devastating. Writing from Iraq, psychologists Bret A. Moore and Greg M. Reger, two U.S. Army captains, describe their work to maintain the well-being of service members. Their article, "Combating Stress in Iraq," begins on page 30.

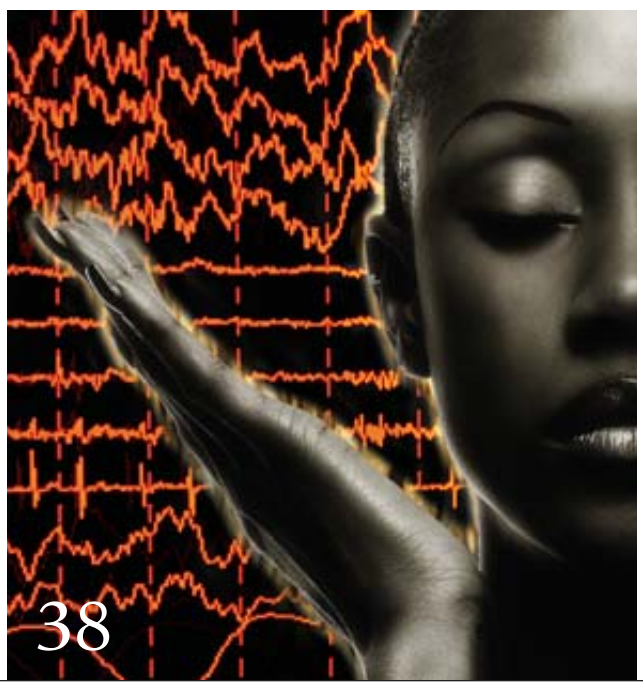
An entirely different battlefield is the one being fought for understanding. In "Do Gays Have a Choice?" psychologist Robert Epstein discusses the science behind the controversy of sexual "preference" (a term he disdains as judgmental). As it turns out, the answer is not black or white: rather human sexuality exists on a spectrum. Turn to page 50 for more.

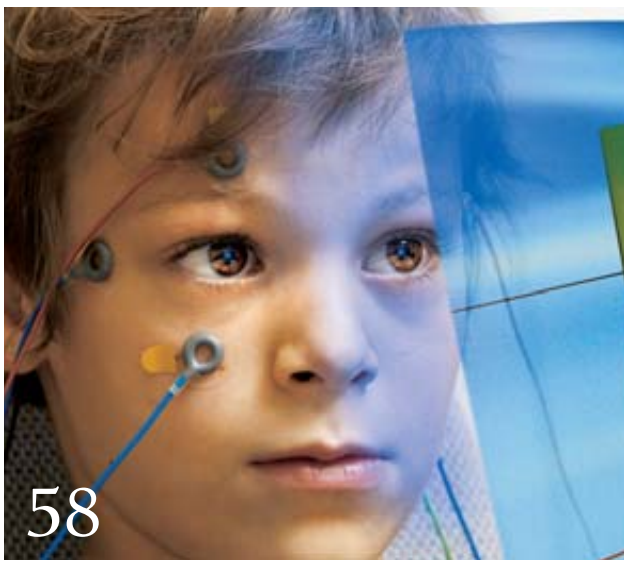
One distinctive feature of *Scientific American Mind* is that such insights about the workings of our brains frequently come straight from the expert researchers who are at the front lines of their fields. To tap even more of that kind of authoritative wisdom, we have created a board of scientist advisers. Their names appear in the masthead, to the left of this column, and their expertise will help shape our coverage in the coming months. We hope you like the results.

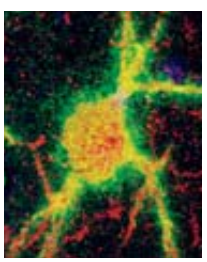
Mariette DiChristina
Executive Editor
editors@sciam.com

SCIENTIFIC AMERICAN MIND
Volume 17, Number 1, February/March 2006

FEATURES





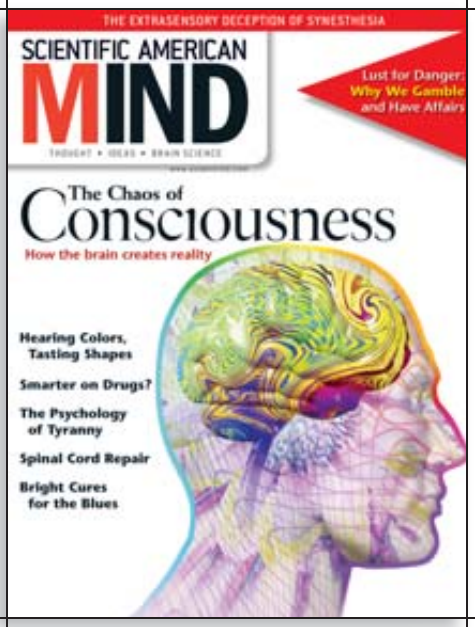


DEPARTMENTS

Scientific American Mind (ISSN 1555-2284), Volume 17, Number 1, February/March 2006, published bi-monthly by Scientific American, Inc., 415 Madison Avenue, New York, NY 10017-1111.

Periodical Postage paid at New York, NY, and additional mailing offices. Canadian BN No. 127387652RT; QST No. Q1015332537. 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. SAMIND06, 415 Madison Avenue, New York, NY 10017-1111. Inquiries: 212-451-8890 or fax 212-355-0408. Printed in U.S.A.

BLEARY-EYED EDITORS can always get a pick-me-up from the mailbag. As usual, letters about Vol. 16, No. 3, offered insightful commentary. Bob Sitze, director of hunger education at the Evangelical Lutheran Church in America, in Chicago, penned one of our favorites: "I have been a student of brain science for about 30 years now and as an educator and ecclesiologist (church guy) have found continual applications of neurological findings to the day-to-day workings of the people that I serve. I write and lecture on the subject (neuroecclesiology?) and gain courage from your magazine, if only to keep at this sometimes lonely subject. In the church, sadly, science is considered an unknown and unknowable body of knowledge." Keep the faith, Bob.



BEYOND CONSCIOUSNESS

Christof Koch's analogy between visual consciousness and "The Movie in Your Head," while a distinct improvement on the famous "magic theater" metaphor dating back at least as far as Hermann Hesse's *Steppenwolf,* is still rather unsatisfactory for a number of reasons. Although the moving picture metaphor usefully postulates a frame-by-frame rather than a smoothly continuous "showing," it suffers from the implication that a preset sequence of stored images exists that is then projected.

A more apt analogy would be the screen of a TV monitor, which, for the most part, is continuously receiving information about a person's immediate environment via the available optical receptors. Recognition of such images as reflecting real-time reality—as opposed to memories, predictions and other fantasies of times gone by or yet to come—is based on the usually greater intensity and "solidity" of the *currently* occurring mental events.

For any screen metaphor whatsoever, the objection has been raised that it implies an infinite regression of homunculi to serve as viewers of whatever is on display. I believe that this misunderstanding derives from overlooking the fact that all the "qualia" of consciousness, including any feeling that someone is watching, are themselves part of the imagery that is *being* observed.

Indeed, the question of the mechanism by which the mind creates a sense of identification with a restricted portion of the sensory data making up our subjective experience, so that it becomes subdivided into "me" and the outside world, is one of the major challenges for future neurophilosophical investigation. Once he/she/it has been relocated *beyond* conscious experience, then, "the observer" can be thought of as simply constituting all those regions of the brain to which the neural substrate for consciousness (in all likelihood the cerebral cortex) anatomically projects.

Michael A. Corner
(professor emeritus)
Netherlands Institute for Brain Research
Royal Academy of Sciences, Amsterdam

RESEARCH TYRANNY?

I am disturbed about "The Psychology of Tyranny," by S. Alexander Haslam and Stephen D. Reicher. The article claims to examine issues of power but fails to take into account the power wielded by the experimenters and the ways their expectations were communicated to the participants. It is not surprising, for example, that the guards were reluctant to exercise authority when the experimenters undermined their authority by making arbitrary rules ("prisoners can earn the right to be guards") and changed those rules a few days later—as if to be certain that the participants got the message about who was *really* in charge.

The consequent actions of the participants reminds me of normal teenage behavior with authoritarian parents: they seem to have systematically tested their boundaries. When eliminating the guard/prisoner roles failed to get a rise from the authorities, *of course* the participants talked about violence.

Sheryl Hill-Tanquist
Corvallis, Ore.

ALTERNATIVE TO LUST

In "Lust for Danger," Klaus Manhart suggests that we have only two ways of coping with our innate risk taking: setting limits in advance and choosing pseudo thrills such as horror films, roller coasters and video games. Unfortunately, the high levels of naturally produced (addictive) dopamine by thrills easily weaken resolve.

I would like to suggest another way: balancing brain chemistry from within. Meditation, prayer, yoga, martial arts, selfless service and even Taoist lovemaking all naturally moderate danger-seeking urges while offering profound well-being. Such disciplines apparently work by sustaining higher

levels of oxytocin—a neurochemical that counters dopamine imbalance symptoms such as addiction, anxiety and inappropriate risk taking.

Why feed our thrill addictions with empty activities that produce uncomfortable cycles of highs and lows? (When dopamine goes too high, it is followed by a neurochemical crash, or hangover.) In contrast, balance offers zest for life, greater contentment and sound judgment.

Marnia Robinson
Ashland, Ore.

SMARTER ALREADY

I completely agree with author Michael S. Gazzaniga of "Smarter on Drugs." Why not take a drug that has the potential to make us more effective and productive in our individual and collective societal pursuits?

Think of the other reasons Americans use drugs. We take drugs to make us happy, to wake ourselves up, to put ourselves to sleep. An ever increasing number of children are chemically treated for ADHD (attention-deficit hyperactivity disorder). They take Ritalin and other substances that promise to deepen their focus on scholastic activities, thus increasing their test scores and, theoretically, their intelligence. It would seem we are already taking drugs to make ourselves smarter.

J. Taylor Aue
Chicago

UPSETTING ARTICLE

I was disappointed by "Upsetting Psychotherapy," by Jamie Talan. First, it continually uses the terms "psychotherapist" and "psychoanalyst" interchangeably. It is true that psychoanalysts are indeed psychotherapists of a sort, but because there is little mention of other forms of psychotherapy, this presents the notion, far too often held by most consumers, that all psychotherapists will have you sit on a couch, free-associate and want to talk about your mother. Psychotherapy moved beyond the couch a long time ago.

One issue not discussed is the lack of empirical support for psychoanalytical techniques—one of the main concerns about the efficacy of psychoanalysis. This fact, in addition to its disproportionately long duration, may also be a reason that psychoanalysis is not very third-party-payer-friendly. Further, few patients can afford the price. Becoming a psychoanalyst generally requires about six additional years and up to $150,000 of postdoctoral training. Money may not be the reason all analysts become analysts, but the cost of the training is a fact of the matter.

Finally, the article failed to even mention behavior therapy, which is focused on addressing a patient's current symptoms without regard to earlier childhood experiences and is perhaps the psychotherapy that is most amenable to short-term intervention.

The fact is that the most frequently used forms of psychotherapy are generally time-limited and are routinely subjected to scientific evaluation in an effort to modify and refine them and to make them more effective.

Patrick Kerr
Grand Forks, N.D.

SNIFFING OUT DANGER

Regarding "Judging Amy and Andy," by Katja Gaschler: sizing up people and the resultant negative or positive first impressions that we derive may also be a product of less obvious factors. In his 1999 book, *Jacobson's Organ,* biologist Lyall Watson suggests that whereas our sense of smell has weakened during evolution, it may be sufficient to detect chemical inputs that warn us of potentially dangerous situations. Certain scents act subliminally on unusual nasal sense cells located near the opening of each nostril. What cops often call a "gut instinct" and others refer to as "intuition" might well be a combination of incoming data from visual *and* olfactory sources.

B. A. Brittingham
Three Oaks, Mich.

ALAN POWDRILL *Photonics/Getty Images*

Can we trust our first impressions to be accurate?

MORE SOLUTIONS

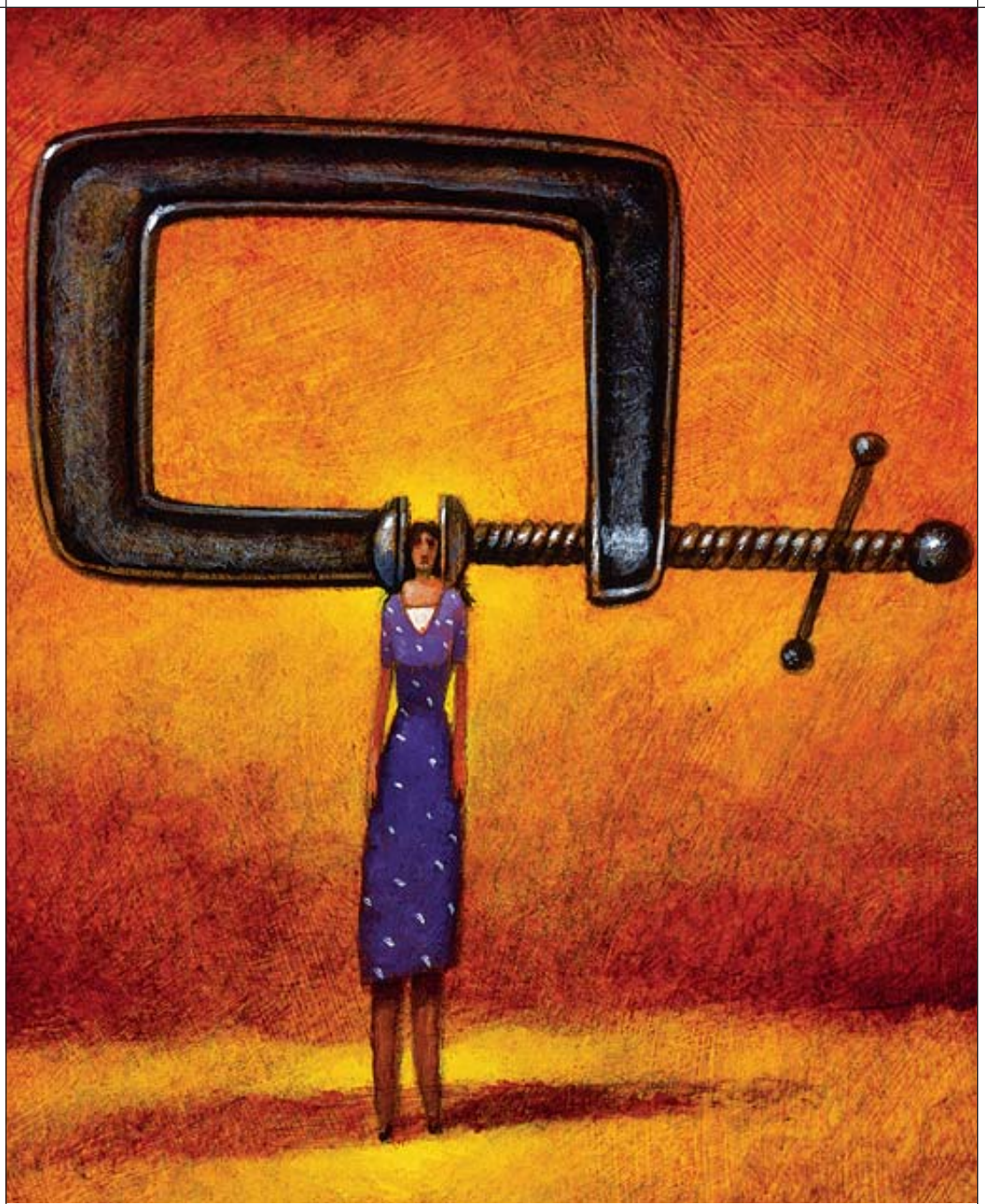
Puzzle 10 in "Head Games," by Abbie F. Salny, has multiple answers besides the given answer of "Charles is 4; Pat is 11." According to the information given, Charles could also be 1, 2 or 3, and Pat would be correspondingly 5, 7 or 9.

Lloyd Miller
via e-mail

Salny could have picked an alternative answer to question 8: Canada—the only word not to contain a letter distinctly absent from the other three words ("F" in "France" is unique to all four, as is "I" in "Iceland" and "t," "h" and "s" in "Netherlands").

Paul Talvitie
Burlington, Ontario

Head Lines



IMAGES.COM *Corbis*

Migraine, Not Sinus

According to recent data, American doctors routinely misdiagnose migraines as "sinus headaches"—as if pressure from clogged sinuses is causing the pain. Then they prescribe antibiotics, which do nothing, notes Mark Green, director of the Columbia University Headache Center in New York City. "Medically," he says, "there is no such thing" as a sinus headache.

Migraines are an inherited form of recurring headaches, in some cases accompanied by auras: perceived noises or flashing lights. Patients who go untreated for too long may incur structural changes in their brains, so they should insist on proper therapy, which may involve drugs similar to those used by epileptics.

Some confusion in diagnosis occurs because neurons in the brain stem can activate the sinuses during a migraine, causing them to secrete a clear fluid. Yet this discharge differs from the cloudy fluid produced by a sinus infection. Taking unneeded antibiotics can kill harmless bacteria, helping antibiotic-resistant strains to flourish. Green advises doctors to consider migraines more seriously and to look for eye tearing and clear nasal secretions as symptoms. —*Kaspar Mossman*

Optimism Prolongs Life

Mounting research shows that optimism could extend your life. The latest study comes from Wageningen University in the Netherlands. For 999 elderly Dutch men and women, agreement with statements such as "I still have many goals to strive for" was highly predictive for longevity. When subjects were traced nine years after being surveyed, death rates of optimistic men were 63 percent lower than those of their pouty peers; for women, optimism reduced the rate by 35 percent.

The Dutch study also begins to map out causality. By controlling for dietary factors, smoking habits, obesity, physical activity and alcohol dependence in participants, researchers isolate optimism's protective influence. Some of that influence drives healthy behavior. "Optimists will try to avoid and escape bad events," explains Martin E. P. Seligman, a psychologist at the University of Pennsylvania not linked to the Dutch team. For example, they are more likely to follow prescribed medical routines.

Fortunately, pessimists can learn to look on the bright side. In a study by Seligman, pessimistic college students randomly assigned to optimism workshops subsequently had fewer visits to their school's health services department and had lower rates of depression and anxiety than classmates who had no happiness classes. Positive self-talk can help, too. For example, says Robert C. Colligan, professor emeritus of psychology at the Mayo Clinic, "a student with a bad grade should replace 'I'll probably fail all of my other courses, too' with 'It'll go better next semester.'" *—Lisa DeKeukelaere*

Good for Business

Employers who provide for mental health care may cultivate a better balance sheet as well as a happier lunch room. Rising health insurance costs and harsh social stigmas cause many employers to overlook workers' mental health needs, but ignoring the problem may cost more than addressing it.

Researchers at the Johns Hopkins School of Medicine recently reviewed 103 studies covering mental health and factors such as health care dollars spent; worker productivity, retention and absenteeism; and workplace morale. Certain studies showed that health insurance claims of workers with both mental and physical disorders were 1.7 times higher than those of workers with physical disorders alone.

One factor in the hike may be that many of those suffering from depression and anxiety seek remedy for physical symptoms, leading to expensive tests and treatments. Several other studies found that employees experiencing depression are seven times more likely to be less effective and 2.5 times more likely to miss work than colleagues, depressing a company's bottom line.

According to the reports, the best prescription is "raising awareness and creating a workplace where signs and symptoms are recognized," states Alan M. Langlieb, professor of psychiatry at Johns Hopkins, who led the review. He recommends education programs for employees and supervisors, "much like what is in place for combating high blood pressure and obesity. If we can break down the stigma associated with mental disorders," he says, employees will come forward more readily and health care professionals will be able to set up evaluations and treatment plans. *—Lisa DeKeukelaere*

RICK GAYLE STUDIO *Corbis (top)*; BILL VARIE *Corbis (bottom)*

Shrekking Off Stress

Tension from activities as simple as watching a suspenseful movie or reading a speech in front of others is enough to interfere with problem-solving skills. A common beta blocker medication might provide an antidote. A pair of studies supporting this assertion was unveiled in November 2005 by Ohio State University neurologist David Q. Beversdorf, who led both tests. "When you are relaxed, you have more ready access" to problem-solving powers, he observes.

In the first study, student volunteers watched 20 minutes of *Saving Private Ryan,* a graphic depiction of the World War II invasion of Normandy. After the movie clip, they had to complete a word-association task. The volunteers also saw 20 minutes of the animated comedy *Shrek.* The cartoon watchers' test scores were 39 percent higher. Beversdorf concludes that the induced stress of the violent movie impaired mental flexibility.

The second investigation compared volunteers who had to give speeches in front of a panel of cold-looking "judges" with others who simply had to sit in a room and read. Some of the subjects were given the beta blocker drug propranolol, which is used to treat high blood pressure and migraines and which counteracts the stress hormone norepinephrine. Mental and physical tests administered after the activities indicated that the people taking propranolol experienced less stress and displayed greater cognitive flexibility than the other study volunteers.

A treatment for thought-impeding stress could hold great promise for people who suffer from serious anxiety disorders. For everyone else feeling pressed, a cartoon may be enough.

—Kiryn Haslinger

Odd Gait

Broken spirits, not bones, may be the worst result of falling down. Many older people fall, but for some, the experience makes them so afraid of toppling again that their mind impairs their ability to walk without trembling or losing balance. They quickly make themselves dependent on canes or wheelchairs. Roger Kurlan, a neurologist at the University of Rochester, has seen about 30 cases of what he calls "fear of falling" gait.

The condition may also make individuals vulnerable to dangerous misdiagnoses. One 76-year-old woman was seen by a doctor who noticed her tremor and inability to walk unaided and prescribed medication for Parkinson's disease. After subsequently talking with her, Kurlan managed to get her out of her wheelchair, and she was soon walking securely around his office. He is now encouraging physicians who spot such symptoms to ask patients about recent falls, instead of assuming a neurological problem and prescribing unnecessary medication, physical therapy or even institutionalization.

—Jonathan Beard

DREAMWORKS LLC/KOBAL COLLECTION (*top*); SUPERSTOCK/AGE FOTOSTOCK (*bottom*)

Half-Asleep

Bees, birds and iguanas do it, but no one is sure why animals sleep. "Every animal studied engages in some form of sleep or sleeplike behavior," says Steven L. Lima, a biology professor at Indiana State University and an animal sleep expert. Lima and most researchers believe sleep "has some sort of critical maintenance or restorative effect on neural tissue." But the unconscious state has a cost: it makes animals vulnerable to predators. Lima has found that in some birds, therefore, only half the brain rests at once. The other half stays alert, and the eye it controls stays open. The list includes pigeons, ducks, domestic chickens and a few other birds.

Most mammals cannot pull off the trick (dolphins can), Lima says, yet "humans are frequently subjected to situations—combat, travel and other stressful environments—where they need to decide when and how much to sleep." The best we can do is cater to our sleep "architecture," he explains. "The first two to three hours of deep sleep seem to be the most vital," Lima says, "while we can do without much of the REM [rapid eye movement], or dream, sleep that comes later in the night—at least over the short term."

—Jonathan Beard

The Shape of Alzheimer's

Researchers are a step closer to understanding how Alzheimer's disease takes shape—literally.

A hallmark of Alzheimer's is the presence of protein aggregates in the brain known as plaques. They are made up of various lengths and conformations of the beta amyloid protein. The proteins link end to end, forming long, threadlike structures called fibrils. Now Roland Riek and his colleagues at the Salk Institute for Biological Studies in San Diego, working with scientists at the University of Lausanne in Switzerland and the F. Hoffmann–La Roche company, have constructed a three-dimensional model of the fibrils based on their own experiments and earlier data published by others.

Riek says the model will help investigators to understand protein structure, which could lead to better targeted drugs. For example, molecules could be engineered to act as protein binding partners, thus interfering with fibril formation. Such a sticky molecule could also be used to diagnose the disease early. The model work might lend insight to other neurological disorders that involve fibril formation, such as Parkinson's disease.

David B. Teplow, a neurology professor at the University of California, Los Angeles, not involved in Riek's work, states that the model, as it stands, may not fully represent fibrils as they exist in a patient's brain. But Teplow praises the effort, noting that it could form the basis for further structural modeling studies of other beta amyloid peptides. Riek says his group will extend the three-dimensional work to other variations of the amyloid protein, because it undergoes many conformational changes on its way to forming a fibril. "We need to try to trap them in these intermediate states," he explains.

Ribbon model shows the three-dimensional structure of the protein that causes Alzheimer's plaques.

—Nicole Garbarini

BRIEFS

- **Sex among teens** occurs less frequently in tight-knit communities. An examination led by Ohio State University of more than 900 teens in 80 Chicago neighborhoods reveals that kids were less likely to have sex and had their first sexual experience at an older age if they lived in neighborhoods where adults kept a close eye on their own and other parents' children. The pattern prevailed regardless of a locality's racial or income profile. Such supervision leaves kids with the impression that it is hard to hide their activities.

- **Light exercise** helps to keep brains healthy, at least in rats. University of Florida scientists tracked active and sedentary rats, then examined samples of their brain tissue. The active critters had less of the oxidative damage thought to result from aging and implicated in various dementias. Mild exercise is enough; the healthier rats had access to a spinning wheel, which they used occasionally every day, although they were not forced to run. The sedentary rats had no source of exercise.

- **Violent video games** desensitize people to brutality, according to a University of Missouri at Columbia study released in December. Researchers measured the P300 brain waves of college students who were shown violent and nonviolent images. The waves indicate levels of arousal. P300 waves were diminished in students who regularly played more barbaric games, compared with students who did not.

D. ROBERT AND LORRI FRANZ *Corbis (top)*; COURTESY OF ROLAND RIEK, SOURCE: LUHRS ET AL., *PNAS*, VOL. 102, NO. 48, NOVEMBER 29, 2005 (*bottom*)

Old vs. Young

Much work on aging brains has focused on their failings, but two new studies look at how they succeed. In both a University of Michigan at Ann Arbor report on which brain regions respond to challenging tasks and a Johns Hopkins University look at older rats, researchers found that aging brains function differently than young brains.

Cindy Lustig of Ann Arbor used functional magnetic resonance imaging to observe the brains of young adults (aged 18 to 30) and seniors (65 to 92) as they tackled simple and difficult mental exercises. For the easy tasks, brain activity was very similar, but tougher challenges prompted differences. The seniors activated several frontal brain regions that the others did not. In addition, the younger people "turned off" parts of the brain not used during the tasks, but the elders kept those regions active. Lustig concludes that "older adults' brains can indeed rise to the challenge, at least in some situations, but they may do so differently."

Michela Gallagher of Johns Hopkins compared the brains of six-month-old rats with those age two (old by rat standards). Her team also divided the elder rats into age-impaired and age-unimpaired groups. When Gallagher compared the synapses—the tiny gaps between neurons where intercellular connections are made—she found that the impaired rats had lost the ability to adjust the activity of synapses appropriately but that the unimpaired rats had not. These connections are how memories are formed and preserved.

—Jonathan Beard

For complex tasks, aged brains call on more structures for help.

A Pacemaker for Depression

Treating depression could change significantly given the results of a small Canadian clinical trial that culminated in 2005. Pacemakerlike electrodes stimulating a deep-brain region called the subgenual cingulate freed several patients from heavy depression that had resisted medication, talk therapy and even electroconvulsive (shock) treatment. Study coauthor Helen S. Mayberg, who began the work at the University of Toronto before moving to Emory University, cautions that any trial so small—just six patients—must be considered provisional. Yet four of the six subjects felt dramatic and lasting effects.

University of Toronto neurosurgeon Andres Lozano implanted battery-powered, pacemakerlike devices underneath a patient's clavicle, then ran flexible, hair-thin electrodes to the subgenual cingulate, a well-buried cortical area that Mayberg had previously found active in depressive or sad states. The electrodes delivered pulses of four volts, 130 times a second. Mayberg hypothesized that in badly depressed patients the subgenual cingulate acts like a switch left open, allowing depressive circuits to run amok.

Her results suggest that the regular stimulation might moderate that activity. The four improved patients felt the effects right on the operating table. "They would say, 'The noise is gone,'" Mayberg recalls. "Or 'The void has disappeared.' This was not just mood elevation. It was relief of an agonizing state." In 2005, after a year of living with the continuous impulses, the four patients had lowered their scores on the Hamilton Depression Rating Scale from the soul-deadening high 20s to between one and eight—quite healthy.

Mayberg is trying to organize larger trials. She is also searching for the exact curative mechanism. "We're turning off something right in the operating room," she says. "Now we need to find out what."

—David Dobbs

GETTY IMAGES (*top*); IMAGES.COM *Corbis* (*bottom*)

Adopted toddlers seem to have trouble producing oxytocin.

Bonding Hormone

Scientists have already established that the hormone oxytocin is a trigger for love and affection. Now they have discovered that babies raised for their first two years in orphanages do not produce the same levels of oxytocin as children raised by their biological parents.

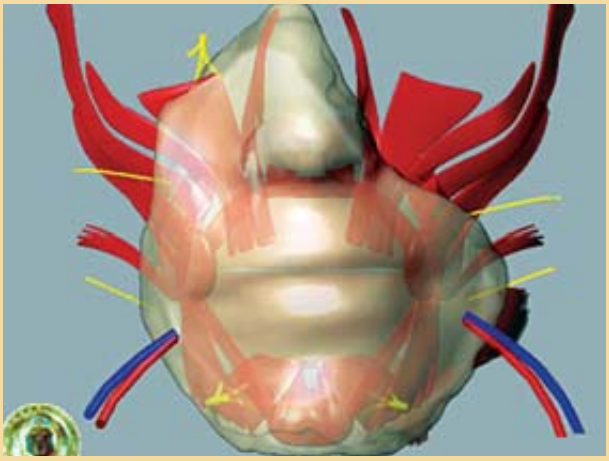
In a test designed to elicit cuddling and affection, Seth D. Pollak and his colleagues at the University of Wisconsin–Madison recruited 18 toddlers adopted from places such as Russia and Romania and an equal number of children with biological parents. Each toddler sat on his or her mother's lap while playing an interactive game with instructions such as "tickle your partner's tummy" and "hug your partner." The children completed the same game on the lap of a friendly female stranger. The biological children showed a rise in oxytocin after playing with their own mother but not after playing with the female stranger. Yet the adopted children showed no rise in either case.

Pollak does not want to alarm would-be adoptive parents but wants to inform the early childhood field so that measures can be found to help adopted children bond early on. "These are children who start their lives in some very horrendous conditions, and within a day, their world changes," Pollak says. "It may be that the child's comfort system isn't kicking in." Psychiatry professor C. Sue Carter of the University of Illinois at Chicago says there are ways to improve bonding, adding that hormones "are not destiny." —*Jamie Talan*

Facing a Transplant

As soon as surgeons in France had performed the first partial face transplant (*below*) late in November, psychologists began to question whether the patient was mentally stable enough to handle the stressful, high-risk procedure. The unidentified woman's face had been mauled by her dog, and doctors had said the damage was too severe for reconstructive surgery. Evidence suggested the woman was suicidal or at a minimum traumatized, but surgeon Jean-Michel Dubernard of Edouard Herriot Hospital in Lyon told the media that the woman had undergone thorough psychological testing that showed she was ready for the transplant's challenges.

Since then, experts have begun to discuss how any analyst could fully know if an individual were "ready" for such a novel procedure. Some psychological readiness criteria exist for patients who seek elective plastic surgery, but there is little literature about the mental attributes that make someone a good candidate for reconstructive surgery, much less a highly visible transplant.



Critics of the French operation say that in addition to needing the mettle to follow postsurgical procedures and stick with anti-tissue-rejection medication and side effects, the woman will have to withstand intense public scrutiny, and they wonder if she is up to it. But Elaine Walker, professor of psychology and neuroscience at Emory University, notes that from the patient's perspective, "the stresses may not trump the stress of living with the original disfigurement."

Walker points out that the patient essentially had to choose between three psychologically challenging options: live with a terrible disfigurement that would very likely instill in her significant social anxiety, attempt a protracted series of reconstructive surgeries that doctors said might not succeed, or undergo the risky face transplant. "None of the alternatives would be free of psychological stress," she observes. —*Mark Fischetti*

LWA/DANN TARDIF *Corbis (top)*; CHU LYON *AP Photo (bottom)*

Purple Shoes or Blue?

Why do we agonize over so many choices? More important, how do we find peace of mind once we choose? BY STEPHANIE HUEGLER

GETTY IMAGES

BORED WHILE WAITING at the bus stop, Kate sticks a cigarette in her mouth just as she notices a billboard across the road. The small print reads, "Warning: Smoking causes lung cancer, heart disease, emphysema and may complicate pregnancy." Kate stops for a moment. "How many have I had already today?" she asks herself. But then she lights up. "I don't smoke that much," she reasons, to quiet her conscience. "And anyway, I exercise and eat pretty well."

Every day we wrestle with opposing viewpoints that battle it out in our minds—a tension known as cognitive dissonance. Social psychologist Leon Festinger developed the concept in 1957, from the assumption that human beings fundamentally strive for harmony in their thinking. In the face of contradictory paths, our minds attempt to restore internal peace. We strive for the reconciliation of two conflicting thoughts, even if we must resort to a third to attain it, such as, "Gramps smoked a pack a day, and he lived to be 90."

Since Festinger's time, numerous researchers have shown how we attempt to reduce mental tension. To become truly content, it seems, we should favor smart choices over emotional ones, but even then, we may need to fool ourselves into thinking we have made the right decision.

The Torture of Choice

Imagine you are looking to buy a used car. Two models stand out—a practical little sedan that does not use much gas and a stylish, fuel-guzzling

To overcome **buyer's remorse**, revel in your new car's attributes and exaggerate the rejected car's faults.

sports car. After a good deal of back-and-forth, you decide on the sports car. But as soon as you have driven it off the lot, you get an ill feeling in your stomach. Shouldn't you have purchased the more efficient model?

Consumers call this feeling buyer's remorse. Psychologists call the tension that occurs after such decision making the regret effect. But cognitive salvation comes quickly. "Don't be an idiot," you tell yourself. "You'd be too cramped driving in that little thing. And the sports car has side air bags. And a CD player." The good features of the chosen car get bumped up in estimation, whereas the bad features of the rejected one get exaggerated. Internal harmony is restored.

Festinger's legendary field study involved a sect in a small American town. Sect members were firmly convinced that the world would be destroyed by a massive flood on a certain day. They would be saved, however, by extraterrestrials that would swoop down in flying saucers and whisk them off to another planet, where they would start a new life. Needless to say, doomsday passed uneventfully. But instead of giving up their delusion, the sect members quickly embraced the belief that God had spared the world one more time thanks to their steadfastness.

For the sect members, social support among themselves provided a way to cope with internal contradiction. Others do the same. When forced to act against our conviction, we often adjust the conviction after the fact. We adapt our attitude to our actual behavior, restoring internal balance.

Researchers are finding more and more examples of cognitive dissonance. In 2003 and 2004 studies by Michael I. Norton, now at Harvard Business School, and Benoît Monin of Stanford University unveiled a vicarious form of the phenomenon. In one exercise, students who were waiting to participate in an experiment overheard a staged conversation in which an investigator convinced a student to present an opinion during discussion time that would contradict what he believed: he was to speak in favor of tuition increases. Students who heard the coercion and later were part of the discussion voiced less skepticism about tuition hikes than they had previously. Apparently, the knowledge of their classmate's presumed internal conflict caused cognitive tension in them as well. The easiest way to restore equilibrium was to agree with their friend's stated position.

The potential for artificially inducing such attitudinal change is limited, nonetheless. Social psychologists Fritz Strack of the University of Wuerzburg in Germany and Bertram Gawronski of the University of Western Ontario found in a 2004 study of social groups that although we may change our conscious attitudes to justify contradictory behavior, our basic unconscious thoughts and feelings are not easily remolded—even clearly impugned social views such as prejudice. Our personal opinions can be strongly influenced by automatic mechanisms, which may trump deliberate, mature reflection.

Deeds over Words

The question at hand, then, is what actually needs to happen for us not merely to adapt our attitudes to our actions but to act in accordance with our convictions? Social psychologist Robert-Vincent Joule of the University of Provence in France discovered one prescription.

Joule conducted an experiment during the 2002–2003 school year with children aged nine and 10 from 700 families. The goal was to turn the children into environmental activists who would then win over their parents to a more ecologically aware way of life. The students listed behaviors that could change at school and at home. Together with their parents, they filled out a long questionnaire on the topic of energy conservation and pasted an environmental sticker on their refrigerator.

Finally, each child wrote an essay with his or her mother or father about what environmentally harmful practices the family would like to overcome, such as letting the television drone on when no one was watching instead of turning it off. The project culminated in a big environmental fair at the school. In most classes, 100 percent of the students and parents took serious steps to reduce their daily energy consumption.

Joule drew two significant conclusions: To achieve long-term behavioral change, we must first reinforce the desired new attitude by seriously grappling with the topic. Then we have to find a way to acknowledge the new position publicly.

If Kate really wants to stop smoking, she should make a list of all the benefits. Then she should explain her intention to quit to as many acquaintances as possible. She will have examined the reasons for ending her habit and will have committed to them in front of other people. As long as she avoids too many tempting situations to smoke, her chance of making the tough choice permanent—and achieving peace of mind with it—will be much greater. M

To convince yourself to quit smoking, list the benefits, then **commit to the decision** in front of friends.

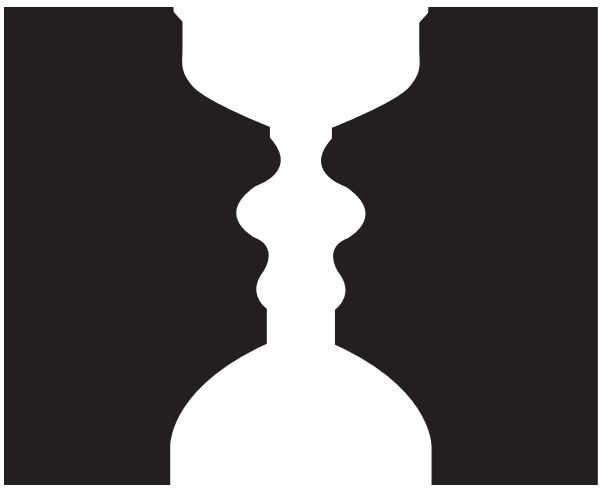
STEPHANIE HUEGLER is a sociologist, psychologist and freelance journalist in Heidelberg, Germany.

Stability of the Visual World

When your eyes scan a room, why doesn't the world appear to bounce like the real image on your retina? BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

WHY IS THE STUDY of perception so appealing? One reason is that you can gain deep insights into the inner workings of your own brain by doing relatively simple experiments that any schoolchild could have done 100 years ago. More on those in a moment.

Your sensory experience of the world does not involve faithfully transmitting the retinal image to a screen in the brain so that it can be "seen" by some inner eye. One piece of evidence for this fact is that your perception of an object (*a;* two faces or a goblet?) can change radically even if the image on the retina is held constant, which implies that even the simplest act of observation involves judgment by the brain.



a

Less obvious, but equally important, is the converse. Your perception of the world—or an object in it—can also remain stable if the image is changing rapidly on the retina. One example is how you take in a scene when you move your eyes around. Every time you glance around a room, the image dances around the retina at warp speed, hundreds of feet per second. Yet all appears rock steady. Why?

Now, at first you might think the world does not appear to lurch because all motion is relative. The clouds glide in the twilight sky, but we assume they are stable and attribute the motion to the smaller object, the moon.

A simple experiment demolishes this idea. Close one eye—let us say the left. Then, keeping the right eye open, use the right index finger to displace the right eyeball, rocking it side to side slightly in its socket. (Gently!) You will see the world jump as if in an earthquake, even though there is no relative motion on the retina.

Why do we see a stable world when we swivel our eyes naturally but not when we jiggle an orb manually? The answer came from the great 19th-century physician, physicist and ophthalmologist Hermann von Helmholtz. He suggested that when the command to move the eyes is sent from the frontal lobes to the muscles of the eyeballs, a faithful copy of the command (like a "CC" for an e-mail) also goes to visual motion–detecting centers in the back of the brain. As a result, they are tipped off ahead of time: "You are going to get some motion signals, but they are not caused by real movement of the world, so ignore them."

We can speak of two independent systems in the brain, either of which can signal a sensation of motion. Richard L. Gregory, emeritus professor of neuropsychology at the University of Bristol in England, calls these the image/retina system (caused by image movement on the retina) and the eye/head system (generated by sensing the movement of the eyes). Ordinarily, the brain subtracts one signal from the other. When you move your eyes around, these two motion signals cancel each other out and the world remains stable.

We know that the image/retina system exists because of the experiment in which you jiggled your eye with your finger. But how do we know the eye/head system can independently evoke a motion sensation? Think about what happens when your eyes track a glowing cigarette tip moving across a completely dark room. You correctly see it moving several feet, even though the cigarette image does not move much at all on your retina. Instead your eyes are making a big excursion. So the brain "concludes" that the cigarette must have moved an amount equivalent to the eye movement. Again, we can speak of the final movement perceived as resulting from the subtraction of image/retina signals (close to zero because you are tracking it) from eye/head signals (large, because the eyes move a large distance to keep the cigarette's image on the fovea). The net result is that you see the glowing orange spot moving several feet.

Even the simplest act of observation **involves judgment** by the brain.

If you now strobe the room, every time you move your eyes your friend will appear to **jump around**.

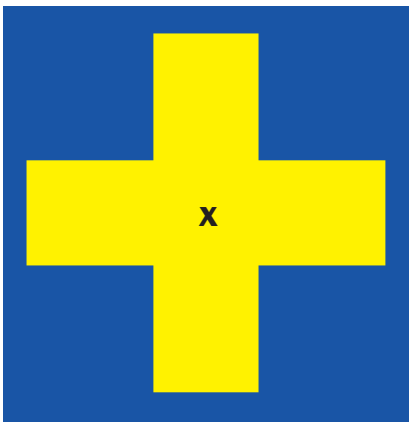
You can produce a more striking version of this effect by having a friend take a photograph of you while you look directly at the flash. The result is a persistent afterimage of the bulb caused by continued activity of the receptors long after the light burst is gone. This flash image is "glued" to your retina; it cannot move even a tiny bit. Yet if you go to a dark room and move your eyes around, you see the afterimage moving vividly with the eyes. The eye/head system is signaling a large value, but the image/retina signal is zero—so as a result of the subtraction, you see the afterimage moving even though it is fixed and stationary on the retina.

You can create a similar fixed afterimage without a flash by staring for 30 seconds at the central "X" in the image in *b;* you will see the afterimage when you shift your gaze to a blank sheet of paper. (Blink your eyes to refresh the image if necessary.)

Forward and Back

Next question: What is the source of signals generated by the eye/head system? One possibility, called feedforward, is that a copy of the command from eye-movement centers is delivered to the sensory motion–detecting centers so that they will expect—and thus cancel—spurious image/retina signals. A second option, called the feedback theory, is that receptors in the eye muscles themselves sense the degree of eye movement and send the "cancellation" information to the sensory motion–detecting centers. Which is correct?

To find out, Helmholtz performed a heroic experiment. He paralyzed his eye muscles using a local anesthetic instilled around the eyeballs. Every time he then tried to move his eyes (unsuccessfully, of course), the world appeared to move in the opposite direction—even though neither the image nor the eyes were moving. He concluded that the feedforward model was correct. You cannot be using feedback, because the eye muscles are not moving. It is as if a copy of the intention to move the eyes is sent (feedforward) to the motion-sensing areas to be subtracted from the expected image/retina movement. But because there is nothing to subtract, the net result is motion perceived in the opposite direction.



b

Another bit of evidence. Create an afterimage on one retina using a flash (keep the other eye closed). What happens if in a dark room you now jiggle the eyeball with your finger? The answer is … absolutely nothing. You do not see the afterimage jiggling. The reason is that in the dark when you jiggle the eyeball the afterimage remains perfectly still on the retina. So there are neither image/retina signals nor any command signals from the eye-movement motor centers. Subtract zero from zero, and you get zero. The experiment is also indirect evidence for the feedforward theory and against the feedback theory (because when you push your eyeball around, stretch receptors in the eye muscles are activated—albeit not in a coordinated manner).

Now consider an extreme example. Create an afterimage of a flash in one eye. Now imagine (do not actually try it!) that you pluck the eye from its socket, keeping the optic nerve undamaged. Holding the eye in your hand, turn it so it is looking behind your shoulder. Where do you think you would see the afterimage? You would still see it in front even though the eye is pointing backward because there is no way the visual centers could know that the eye is pointing backward.

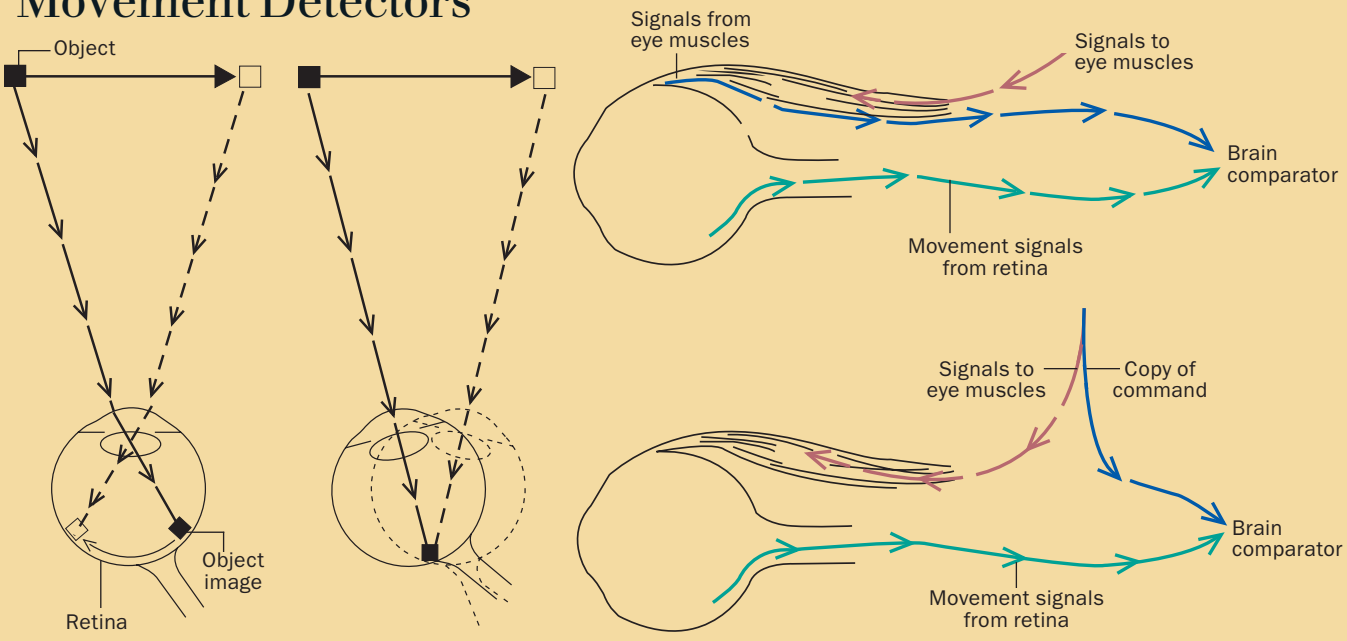
The Joint Is Jumping

Let us imagine another scenario. You walk into a discotheque lit by a strobe light. Given the right strobe rate, if you just move your eyes around, the entire world—including people and furniture—will appear to be jumping. When you move your eyes, the commands from the eye/head system go to the motion-sensing areas. Usually these messages would be canceled by image/retina motion signals. But your eyes in effect take static snapshots with each strobe, sampling the image. These samples behave effectively like afterimages. The ensuing failure to subtract retinal signals from commands results in a net perceived movement of the world.

Better still, have a friend hold a tiny luminous spot—like a lit cigarette or tiny-wattage penlight—motionless. Move your eyes, and it will, of course, look stationary. If you now strobe the room, every time you move your eyes your friend will appear to jump around, but the glowing point will remain exactly where it is. This is because the light, being self-luminous and continuously visible, generates image/retina motion signals that are canceled by eye/head commands. Yet the rest of the room and your friend, being "sampled" with the strobe, do not generate retinal motion and therefore appear to jump with the eye. The astonishing paradoxical perception you see is the penlight flying away from the person.

Our former mentor, the late Fergus W. Campbell, a physiologist at the Uni-

Movement Detectors



In the image/retina system (*left*), an object produces sequential firing of receptors as it moves along the retina while the eye is still. In contrast, in the eye/head system (*right*), the moving eye keeps an object stationary on the retina, but a person perceives movement because the brain monitors its own commands signaling the eyes to move.

To judge whether an object is moving, the brain subtracts signals from the image/retina and eye/head systems in one of two ways. The feedforward theory (*top*) posits that a copy of the command from eye-movement centers is delivered to the sensory motion–detecting centers, so they will expect—and thus cancel—spurious signals. The feedback theory (*bottom*) holds that receptors in the eye muscles themselves sense the degree of eye movement and send the "cancellation" information.

versity of Cambridge, found an ingenious practical application for this effect in a London nightclub. He had the cabaret women wear skimpy luminous bikinis as they danced in a strobe-lit room. When patrons moved their eyes around, they would see the luminous bikinis flying off tantalizingly, yet they revealed nothing. The illusion was a hit and was perfectly legal because there was no real nudity. We sometimes wonder whether science itself is the same way; each time you think you are unveiling the truth, all you get is a teasing glimpse of what turns out to be yet another veil.

The intelligent reader who has followed our reasoning so far will inevitably ask the following question: When I move my eyes intentionally, the "volition" signals get sent to the sensory motion areas to cancel out the spuriously produced image-on-retina motion. But why can't the same type of cancellation or subtraction occur when you voluntarily use your finger to jiggle the eyeball? Why can't you send "finger movement" signals to the visual image motion centers? After all, you *know* you are moving your eyeball.

The answer tells us something very important about perception. Even though it appears "intelligent" at times and can benefit hugely from high-level stored knowledge, it is by and large on autopilot, because it has evolved to do things quickly and efficiently. Even though you know you are pressing on your eyeball, no cancellation occurs because—unlike the eye-movement command centers—the finger-movement centers in the brain simply do not send the CC message to the motion-sensing areas. Our forebears apparently developed connections between eye-movement command centers and sensory-visual areas because we often do move our eyes. But our ancestors did not, we can be sure, walk around tapping their eyeballs with their fingers. Hence, there was never any evolutionary selection pressure to evolve such connections. M

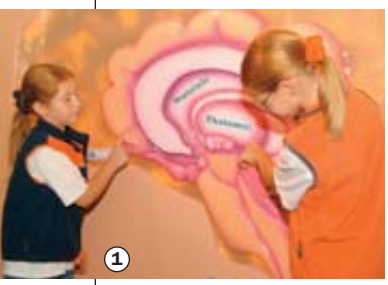
VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. Ramachandran is an adviser for *Scientific American Mind.*

(Further Reading)

- **Perceptual Stability of a Stroboscopically Lit Visual Field Containing Self-Luminous Objects.** D. M. MacKay in *Nature,* Vol. 181, pages 507–508; February 15, 1958.
- **Eye and Brain: The Psychology of Seeing.** Fifth reprint edition. Richard L. Gregory. Princeton University Press, 1997.

RICHARD L. GREGORY

(calendar)



EXHIBITIONS

Seeing
How does vision work—and do we really see things differently? This exhibit explores how we experience depth, color and motion. It also reveals how the context in which we look at images and items determines what we think we see.
Exploratorium, San Francisco
Permanent display
415-397-5673
www.exploratorium.edu/seeing/

1 Brainzilla
For an encounter with a mental giant that you will not likely soon forget, consider taking a tour of this gargantuan, interactive model of a human brain.
Explorium of Lexington, Lexington, Ky.
Permanent display
859-258-3253
www.explorium.com/

MEETINGS

Hot Topics in Humor
The members of the Association for Applied and Therapeutic Humor holding this meeting might prescribe a laugh box rather than a pill bottle for your medicine cabinet. Conference papers will address the latest on how to incorporate laughter and play to improve health and, dare we say, happiness.
Austin, Tex.
Feb. 16–19
512-514-5141
www.aath.org

Brain Conference
Scientists from a variety of backgrounds will come together in the Arizona desert to apprise one another of their work in understanding the brain and related systems.
Sedona, Ariz.
March 15–18
352-392-4081
www.springbrain.org

2 2006 International Conference of the American Creativity Association
Innovators in business, industry, education and the arts aim to foster the use of creative solutions to various problems.
Austin, Tex.
March 22–24
512-223-7074
www.amcreativityassoc.org

2006 Annual Meeting of the Society of Behavioral Medicine
Presentations will offer new perspectives on human behavior, health and illness as part of this year's theme, "Behavioral Medicine across the Lifespan." The annual meeting is the largest specifically devoted to behavioral medicine, typically drawing some 1,300 attendees.
San Francisco
March 22–25
414-918-3156
www.sbm.org/meeting/2006/

MOVIES/TV

A Scanner Darkly
Many addicts of Substance D, a widespread drug in future America, find themselves suffering from split personalities. One of the afflicted is an undercover cop named Fred (Keanu Reeves), whose other self, Bob, is a drug dealer whom Fred sets out to destroy. In animated form, Winona Ryder, Woody Harrelson and Robert Downey, Jr., lend their performances to this film adaptation of Philip K. Dick's cautionary novel about drug use.
Warner Independent Pictures
March 2006

3 Unconscious
Freudian psychoanalysis is at the heart of this period comedy set in 1913 Barcelona. Alma, married to a psychiatrist, is about to give birth when her husband vanishes. Alma and her brother-in-law search for clues in an analysis of female sexuality and "hysteria" written by her husband. Does Sigmund Freud's arrival in Barcelona have anything to do with her husband's disappearance?
here! Films
Spring 2006
www.heretv.com

WEB SITES

www.sciencemuseum.org.uk/exhibitions/brain/
Online exhibit from the Science Museum in Britain that explores aspects of the human brain. Highlights include how the brain developed language, how we store memories and why we have emotions.

www.doctorhugo.org/
Hugo Heyrman, a Belgian artist, aims to explore the connection between art and mind in his Museum of the Mind. The site includes paintings, writing and Net art experiments. It also has interesting links to museums around the world as well as sites that delve into synesthesia, a condition in which sensory input is blended.

www.ocfoundation.org/
Victims of obsessive-compulsive behavior feel as if they have "a case of mental hiccups that won't go away," according to the Obsessive-Compulsive Foundation. The site describes the many variations of this illness, suggests treatments and offers links to resources.

4 www.pacsci.org/education/sow/brainpower/onlineexhibits.html
An online permanent exhibit from the Pacific Science Center in Seattle that lets kids of all ages learn about their inner gray matter by investigating how different drugs act on the brain. Explore images of healthy and addicted brains, how drugs keep spiders from spinning successful webs, and more.

Send items to editors@sciammind.com

EXPLORIUM OF LEXINGTON (1); MARILYN MARTIN CONSULTING (2); HERE! FILMS (3); WWW.PACSCI.ORG (4)

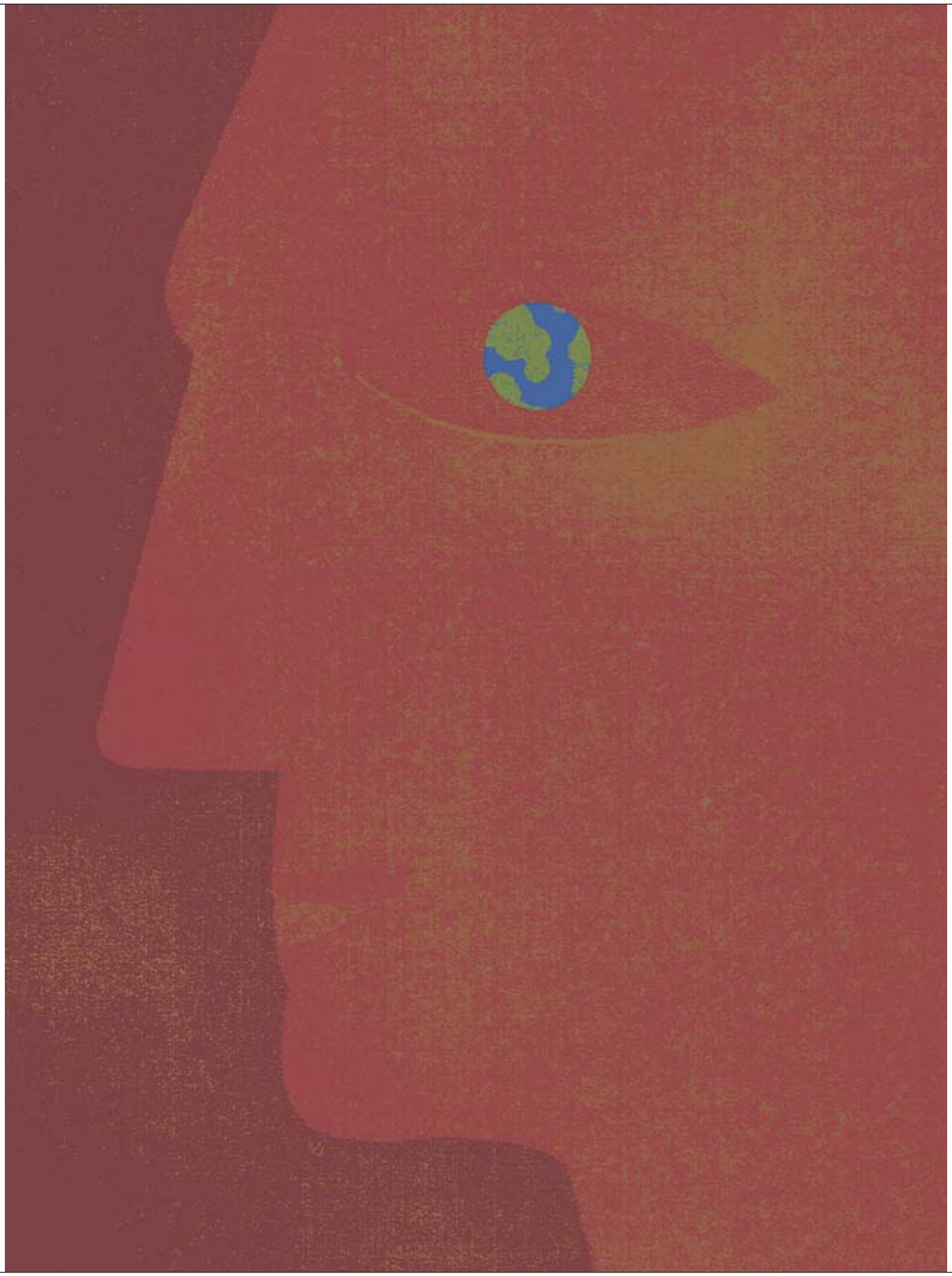
How does the brain create images in our minds?

Picture THIS

By Thomas Grueter

Which city is farther north—Portland, Ore., or Portland, Me.? Unless for some reason you recently committed to memory the latitudes of all large U.S. cities, you probably have only a rough map of the country in your head and can call up at best an approximate mental image of their locations. Or perhaps your mental picture is so precise that you know the right answer (Portland, Ore.). This ability to conjure internal images may seem matter-of-fact to you, but from a scientific perspective it is anything but.

How the brain generates and processes mental pictures has been a matter of much debate in the research community. The solution to the problem would illuminate an



IMAGES.COM *Corbis*

What are thoughts made of, and how are they represented in the brain?

important facet of our conscious experience [see "The Movie in Your Head," by Christof Koch; Scientific American Mind, Vol. 16, No. 4, 2005]. The core of the issue is an even more fundamental question that has occupied philosophers for millennia: What are thoughts made of, and how are they represented in the brain? As with many other areas of neuroscience in recent years, brain-imaging technology is providing some insights.

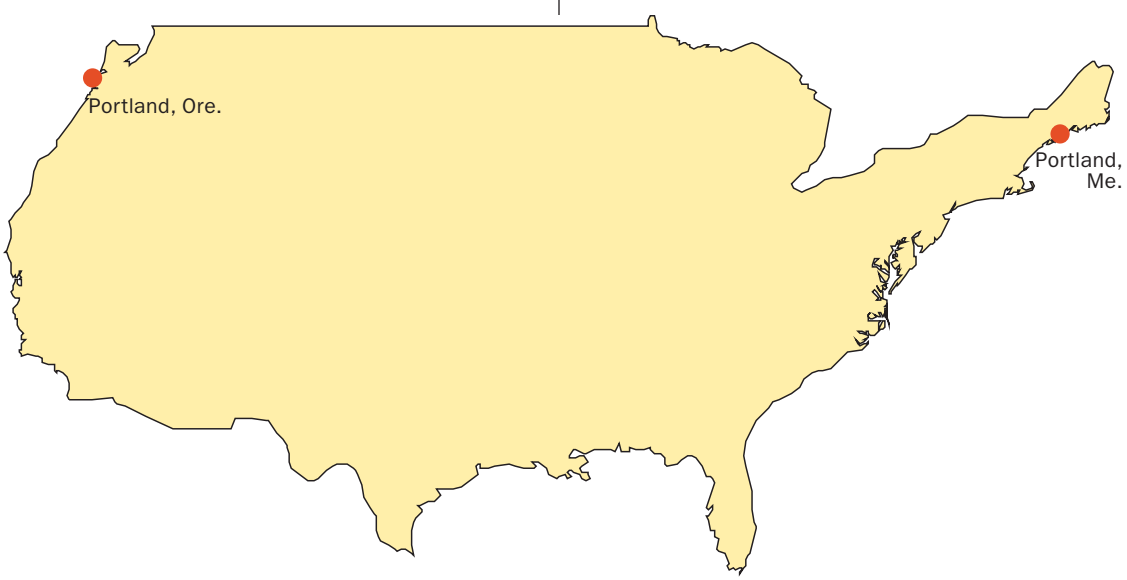
Sharp or Fuzzy

Philosophers have pondered the origins and purpose of mental imagery since ancient times. The first person to approach the problem using scientific methods was the renowned anthropologist and statistician Francis Galton, a cousin of Charles Darwin. In 1880 he published in the journal *Mind* the results of a survey he conducted among numerous colleagues and friends. The task he set was to have all respondents imagine the table at which they had breakfast in the morning. Galton was interested in the number of details his test subjects could recall and precisely how the image was constituted. In other words, how colorful and vivid was it? The results puzzled him: the quality of the images reported by his respondents fluctuated widely, and of all people, his fellow researchers overwhelmingly reported that their internal images were faint, obscure or simply nonexistent.

How could that be? Later investigators noted a methodological flaw in the way Galton posed his research question. One person's mental image simply cannot be compared with another's. What was missing in his question "How clear is your mental image?" was some kind of uniform reference point.

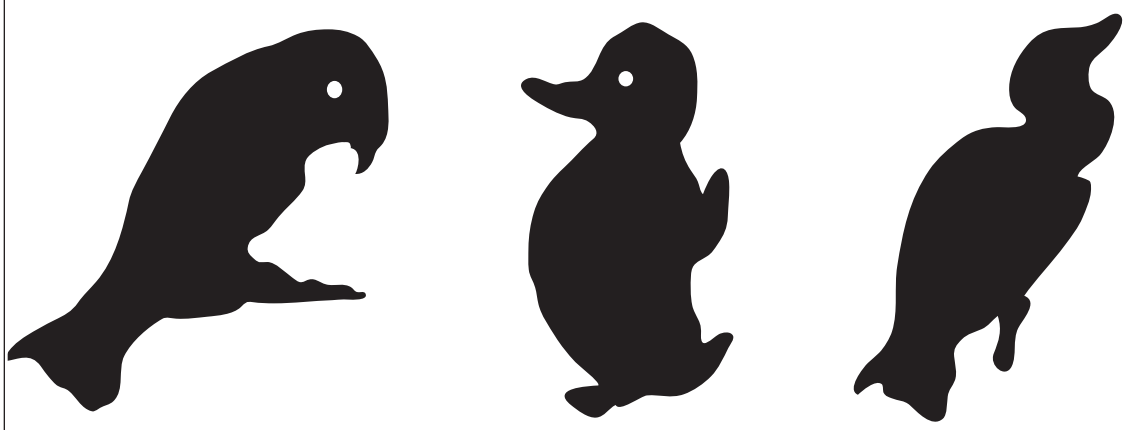
In 1973 English psychologist David F. Marks finally came up with a tool to find such a guide. Now at City University in London, Marks developed the Vividness of Visual Imagery Questionnaire (VVIQ), which is still the most widely used instrument for this purpose. The VVIQ asks respondents to compare the clarity of their mental imagery with the quality of their perception when actually looking at something. The test subjects are asked to imagine a variety of scenes and then to rank on a five-point scale how vividly they see their mental image. Answers range from 1 ("perfectly clear and as vivid as normal vision") to 5 ("no image at all, you only 'know' that you are thinking of an object"). Using this method, Marks discovered that a very small percentage of people claim to see no mental image at all, whereas somewhat more say they see "almost nothing."

Comparing the quality of mental images is one thing; understanding their foundations in the brain is another. Experts generally agree about verbal (that is, nonpictorial) representations. The current consensus is that such thoughts are made of so-called propositions—that is, links between an object and its attributes. For example, "round (ball)" implies that a ball is generally round. More complex thoughts are generated by linking many propositions to one another.



SAMUEL VELASCO

After studying this image, close your eyes and picture it: many people can retain only a rough approximation. Which Portland (*red dots*) is farther north?



Look at one of the three drawings. Then glance away and try to turn the image in your head clockwise by 90 degrees. What do you see? Now turn the page 90 degrees—what do you see? This test, designed by Peter Slezak of the University of New South Wales, shows that our ability to transform mental imagery is limited.

But when it comes to mental imagery, there is nothing like consensus: descriptionalists argue that internal images can also be represented in the form of such irreducibly simple statements. According to this theory, even mental imagery as complex as a wild windswept landscape is made of propositions, which gives us a subjective "as if" sensation that we are seeing an image.

In contrast, the various theories espoused by pictorialists hold that mental images are thoughts that are actually represented graphically in the brain and not in the form of propositions. In the 1960s researchers, particularly cognitive psychologists, began to claim that mental imagery was a fundamentally different kind of mental representation than other forms.

In 1971 Roger N. Shepard and Jacqueline Metzler of Stanford University had demonstrated that the greater the angle by which an object had to be rotated in the inner eye, the longer it took to rotate it. A plausible conclusion is that objects are represented in image form in the brain—and perhaps even in three-dimensional form. You can test another example yourself. Imagine the capital letter D and rotate it counterclockwise by 90 degrees. Now take the capital letter J and stick it into the middle of the lower edge of the D that you just rotated. What do you see? The most frequent answer is a line drawing of an umbrella. What this means is that people are able to attribute new meanings to objects in their inner eye—just as they can with real images. This would hardly be possible if the imagery consisted simply of individual propositional linkages.

The best-known representative of the pictorialist approach is Harvard University psychologist Stephen M. Kosslyn. His model assumes that visual memories are stored in propositional form or are similarly coded—analogously to the way that digital cameras compress image data to store them. Memory then transfers the data to a system that Kosslyn calls a "visual buffer." Here the propositional information contained in the image is transformed and graphically represented in a manner that is akin to the way digital cameras display images in the viewer.

Exactly what this visual buffer consists of was long unclear. Kosslyn now thinks that he knows what part of the brain may be responsible: nerve cells in the visual cortex whose spatial arrangement mirrors that of the light receptor cells in the retina. According to this idea, a checkerboard pattern of light falling on the retina stimulates cortical neurons that are arranged in a comparable pattern—in other words, the nerve cells graphically make an image of what has been seen. When we see images in our mind's eye, we are actually seeing them; however, the input to our visual center is coming from memory, not the sense organs.

If this theory were correct, the imagery in the inner eye would have to pass from the visual cortex through the usual processing steps necessary for seeing. Experiments using fake maps indicate that this may well be the case. Kosslyn used a drawing of a small island on which he marked various points such as a beach, light tower, tree and elephant. The test subjects were asked to memorize this map, particularly the position of the points and objects. They were then asked to imagine the beach itself and to tell the technician when they saw a mental image. Shortly thereafter, they were given the name of another point. The study subjects were then asked to search their mental map for this new site and to press a button when they had "found" it—that is, had a mental image of it.

Over the course of this experiment and similar tests, Kosslyn repeatedly found that the far-

(The Author)

THOMAS GRUETER is a physician and freelance journalist living in Muenster, Germany.

The primary visual cortex seemed to be activated during the process of imagination.

IMAGES.COM *Corbis*

ther apart these two points were on the fictive map the more time his test subjects needed to perform this action. He concluded that the map must be represented as an image in the brain and that they had to "scan" the image with their inner eye to find the point in question—exactly the same as would occur when looking at a real map. If, on the other hand, knowledge of the position on the map were in propositional form, the speed of response would always be approximately the same, according to Kosslyn.

As impressive as the empirical evidence presented by Kosslyn and other pictorialists may be, their critics, the descriptionalists, are not about to give up. In particular, psychologists Zenon Pylyshyn of Rutgers University and Peter Slezak of the University of New South Wales in Australia have for many years been analyzing critically the experiments of the pictorialists. Pylyshyn has advanced what he calls a "null hypothesis," seeking to prove that the widespread theory of a quasi-pictorial processing of mental imagery is not consistent with the known facts.

He claims that the findings of the pictorialists result from the fact that the test subjects know how actual seeing occurs. Kosslyn and his colleagues merely instruct their test subjects to use this "tacit knowledge" and to treat their own propositional image representations as if they possessed the characteristics of actual images. To prove this assertion, Pylyshyn posed the following experiment. He instructed his test subjects to memorize a map in which the individual points were marked with small lamps, only one of which was on at any given time. They were then asked to throw an imaginary switch, whereupon that light went off, and another one went on—that is, it took no time whatsoever to jump from point to point. When his test subjects roved mentally around the map, the time it took for changes to take place was independent of the distance between any two points.

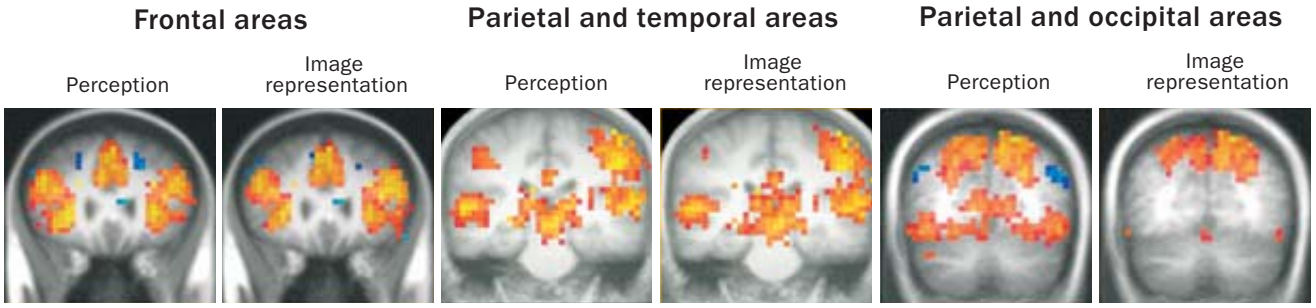
For Pylyshyn, this is evidence that the map has to be represented propositionally, because although the test subjects were supposedly using their image representations, there was actually no indication that they needed to scan the map in their minds to switch from point to point. According to Pylyshyn, the objects in the inner eye and the things that we actually see obey entirely different laws [*see illustration on preceding page*]. "Images on the retina/cortex have yet to be interpreted, while mental images *are* the interpretation," he writes.

Other researchers support this position with case studies of brain-damaged patients such as M.D. After suffering brain damage, M.D. was no longer able to identify objects that he saw in the real world. He continued to be able to imagine them in his inner eye, however, and he could still draw them accurately—although he was then unable to recognize what he had just drawn. Deficits such as this are almost impossible to reconcile with the notion of uniform processing of mental and real images.

Has empirical evidence brought us any closer to a resolution of the 30-year-old debate over

Seen or Imagined?

In an experiment, Stephen M. Kosslyn of Harvard University discovered that mental imagery and images that we actually see are largely processed in the same areas of the brain. Below are averaged-out functional magnetic resonance scans of the brains of 15 people.



how mental images arise? Perhaps. Over the past decade, new imaging technologies have begun to hold out the prospect of closure.

A Look Inside

If Kosslyn is right, visual representation and actual vision must activate the same areas of the brain. And this is exactly what Kosslyn found in 1997. In a study using positron-emission tomography (PET), two thirds of the areas stimulated by visual representation *and* actual vision corresponded. The primary visual cortex in particular, which Kosslyn considers to be the origin of our mental images, seemed to be activated during the process of imagination.

Still, several other research teams have been unable to replicate Kosslyn's PET results. Isabel Gauthier and her colleagues at Vanderbilt University demonstrated that the centers involved in object recognition show no particular activity when test subjects are asked to rotate geometric bodies in their heads—but there is such activity when they actually look at those objects. Instead areas of the parietal lobe that balance visual information and the spatial position of the body are activated during rotation.

In addition, shouldn't we find it difficult to distinguish between mental and external images if the information takes the same pathway from the visual cortex? Wouldn't these images constantly interfere with one another? And by extension, shouldn't we be able to make mental images more distinct if we minimized that interference? Many people, however, see mental imagery better with their eyes open than when they are shut. This was the finding of psychologist Stuart J. McKelvie of Bishop's University in Quebec, when he subjected the results of a large number of experiments on image representation to a meta-analysis.

One aspect of mental imagery has been more or less neglected in all the discussion: the connection between visual representations and memory. According to Kosslyn, mental snapshots decay relatively quickly. Nevertheless, all of us are aware of counterexamples. Scenes described in certain books can leave extremely vivid visual representations in our minds. Later, sometimes years later, when a film version is made, we may be disappointed because the scene on the screen is nowhere near as intense as the one in our heads.

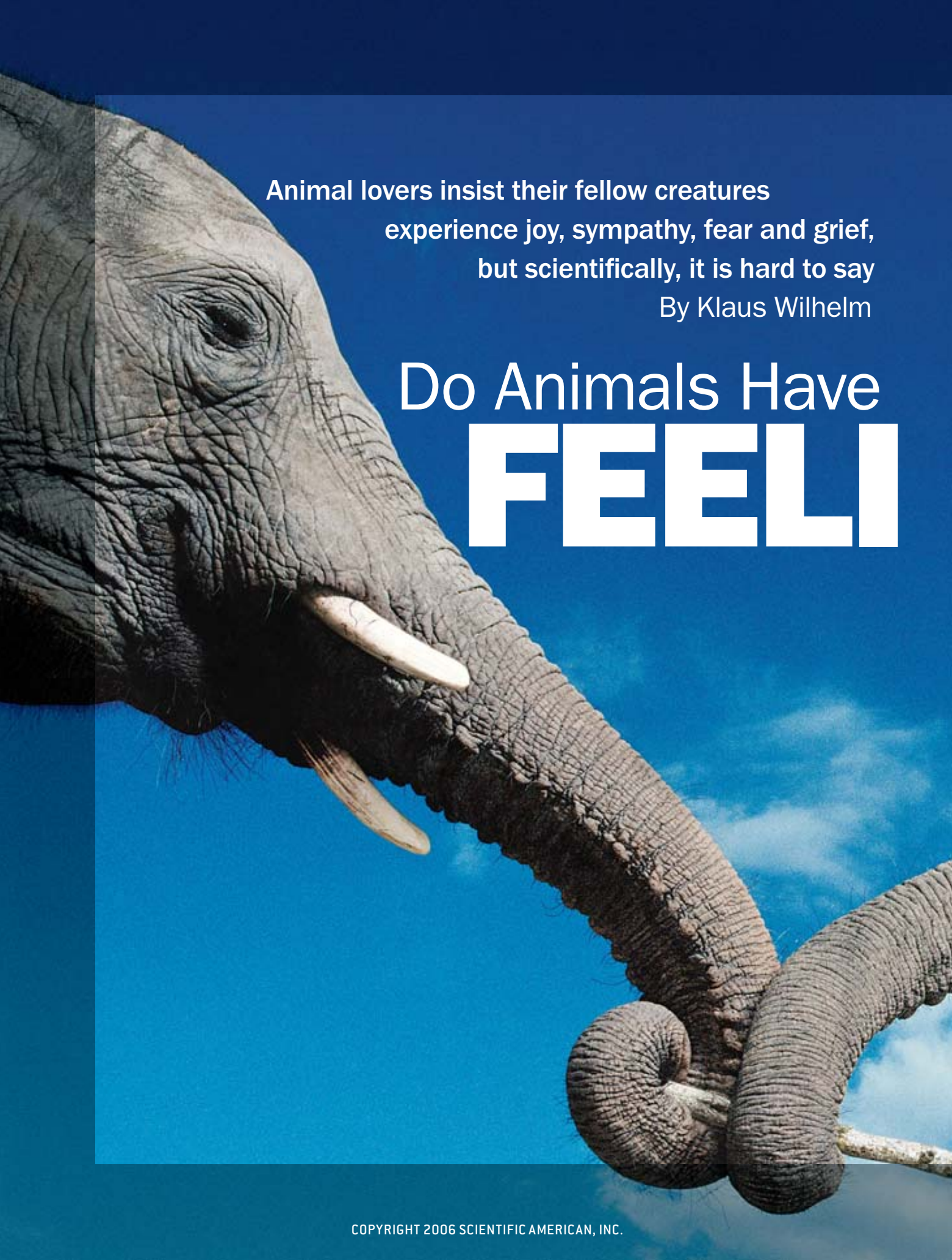
Imagined details do sometimes intrude on our memories of real events. Numerous studies have been conducted on this phenomenon. Psychologist Elizabeth F. Loftus and others at the University of Washington discovered that after reading a booklet that described recollections of being lost in a supermarket, many subjects suddenly reported recalling how they, too, had gotten lost as children. Before reading, they reported being unable to recall such scenes—afterward, they unknowingly smuggled images from the book into their own memory base.

One thing is certain: the final word on mental imagery has not yet been uttered. Kosslyn and Pylyshyn presented their divergent views in 2003 in the journal *Trends in Cognitive Sciences*, having at each other with barely disguised animus. The search for experimental proof—a knockout punch—continues unabated. M

(Further Reading)

- **Image and Brain: The Resolution of the Imagery Debate.** Stephen M. Kosslyn. MIT Press, 1996.
- **Return of the Mental Image: Are There Really Pictures in the Brain?** Zenon Pylyshyn in *Trends in Cognitive Sciences*, Vol. 7, No. 3, pages 113–118; 2003.

GIORGIO GANIS ET AL., ELSEVIER, 2004



Animal lovers insist their fellow creatures experience joy, sympathy, fear and grief, but scientifically, it is hard to say

By Klaus Wilhelm

Do Animals Have FEELI

On the dusty horizon, two troops of elephants emerge 100 yards apart and walk toward each other. The beasts trumpet loudly, flap their ears and turn in circles. They seem to know one another—the whole event appears to be a family reunion.

Anyone who travels the African savanna is apt to have witnessed such a meeting. In her decades of fieldwork, Joyce H. Poole, research director for the Amboseli Trust for Elephants in Kenya, has watched similar encounters many times. "These elephants," the biologist says with conviction, "are happy to see their old friends and acquaintances."

Investigators have also watched as a herd gathers around a stillborn calf. The pachyderms repeatedly touch the dead infant with their trunks, as if to rouse it. Then for days they stand vigil, with drooping ears. At other times, when a herd member is sick or wounded by a hunter, they caress the victim, offering support, and care for it until it is restored to health or dies.

Other animals seem to show emotions. Roughhousing chimpanzees emit sounds characteristic of joy and laughter. Dogs yelp to spur other dogs to play, and researchers who have played recordings of these sounds in kennels and shelters have shown that the noise can reduce stress levels in the animals there. Even laboratory rats make seemingly delighted chirps above the range of human hearing when tickled, some experts say.

Individuals who claim animals have feelings are usually accused of anthropomorphism—ascribing human traits to nonhuman beings. But after years of ignoring or discounting what pet lovers have long maintained, scientists are finally beginning to believe that mammals, at least, have some form of emotions—and investigating them is now a hot topic.

Anxious about Emotions

Some eminent scientists have boldly explored the riddle of animal emotions. Charles Darwin, the English naturalist and father of evolutionary theory, wrote an entire book entitled *The Expression of the Emotions in Man and Animals*. No one can deny that animals have emotions, he concluded, given the striking similarities between human and animal behavior. But in the century that followed the book's publication in 1872, a reductionist view took hold: bees, frogs, cats and all animals are merely organisms that follow hardwired, instinctual behavior patterns. They are devoid of feelings.

Recently, however, a more nuanced view has begun to gain credence, sparked by the question of what survival advantage humans, or animals, gain from emotions anyway. According to Darwinism, every organism has one overriding goal: to reproduce, as well and as often as possible. For worms, insects or jellyfish, following a predetermined pattern of behavior in pursuit of this goal might be sufficient to achieve it. But for fish, reptiles, birds and vertebrates, behavior is less routinized. Ultimately, mammals are extremely flexible, and as such their activity cannot just result from hardwired templates. How, then, do rats, goats, apes, elephants and humans know which actions will best guarantee survival and reproduction? Among other cues, they may use emotions.

This statement, that an animal may "use emotions," only demonstratively means that its brain reacts to certain events in certain ways—a net-

(The Author)

KLAUS WILHELM is a biologist and freelance science writer in Berlin.

TIM FLACH Getty Images (*preceding pages*)

Joy is a primary emotion, along with anger and sadness.

Young mammals play to learn skills. But it is the fun that ensures that they play.

work of neurons fires, initiating a predictable behavior. An animal will avoid situations that, in the past, made it feel threatened. Likewise, a creature that associates a positive experience with a certain action will seek the same one in the future. So far, so good. But does that animal feel in the course of things? This point is where the experts disagree.

A basic part of the discussion turns on the definition of emotion and feelings. Psychologists and neurologists do not even concur for humans, much less for animals. In his 2003 book *Looking for Spinoza,* influential neuroscientist Antonio R. Damasio of the University of Iowa lays out an increasingly popular scheme that distinguishes between primary, almost instinctive emotions; social emotions that help an individual mesh with a group; and feelings, which stem from self-reflection.

Primary emotions include fear, anger, disgust, surprise, sadness and joy, and Damasio ascribes them to many animals. Even the primitive sea slug *Aplysia* shows fear. When its gills are touched, its blood pressure and pulse go up and it shrivels in size. These are not reflexes, Damasio says, but elements of a fear response—complex, mutually dependent reactions. He emphasizes, however, that such organisms do not produce feelings. To Damasio and many others, emotions are physical signals of the body responding to stimuli, and feelings are sensations that arise as the brain interprets those emotions. In humans and sea slugs, heart rates increase and muscles contract when the organisms are afraid of something, but an organism registers the feeling of fear only after its brain becomes aware of the physical changes.

For social emotions, Damasio lists sympathy, embarrassment, shame, guilt, pride, envy, jealousy, gratitude, admiration, contempt and indignation. These are not limited to humankind either. Dominant gorillas swagger around to demand respect from their peers. Low-ranking wolves in packs make gestures of abasement. Dogs reprimanded by their owners for doing something wrong show clear signals of embarrassment. Yet even in such cases, as with primary emotions, some neuroscientists say these actions

Indignation is a social emotion, as are jealousy and pride.

DANIEL J. COX *Getty Images (top)*; DANIEL DAY *Getty Images (bottom)*

Nothing to Fear but Fear Itself

The pharmaceutical industry assumes that animals can feel fear in the same way people do. Otherwise it never would have spent millions of dollars on mouse experiments in the search for drugs to combat anxiety. Fear has been better studied than any other animal emotion.

The degree of fear mice feel can be quantified using the "elevated plus maze test." A pole about a yard high has four arms extending out horizontally, each one at a right angle to the next (*photograph*). Two of the arms have walls to prevent falling, but the other two arms are open. If a mouse makes a false step on an open arm, it will fall hard. Most mice placed at the middle of the maze will choose to move out along a protected arm. If mice are given a drug that reduces anxiety in people, however, they will readily move out along the open arms. —*K.W.*

JUNZO KAMEI *School of Pharmacy and Pharmaceutical Sciences, Hoshi University*

are largely automatic and inborn and count them among the routinized mechanisms animals use to help them survive.

Ancient Reflection

Feelings, in contrast, well up from the analytical mind. Someone who "feels good," who experiences joy, is aware of her body being in a particular state. The perception of such a feeling requires processing by several somatosensory brain regions in the cerebral cortex that map parts of the body and their condition and, simultaneously, brain activity that assesses what those conditions mean. In essence, this processing constitutes self-reflection, which can occur either slowly or very fast.

It is difficult to prove that animals possess the capacity for self-reflection. Damasio theorizes that pygmy chimpanzees, for example, may be able to show the social emotion of pity for other animals but that they do not realize they are exhibiting pity. Given this inability to confirm what is happening in an animal's head, Damasio is reluctant to imply that it possesses feelings.

Other experts are willing to entertain the notion. Jaak Panksepp, a renowned behavioral scientist at Bowling Green State University, agrees that only humans can think about their feelings, thanks to their highly developed neocortex. And only humans can manipulate and feign feelings, as politicians and actors do. But he does not believe feelings arise only from reflection.

Panksepp postulates that the roots of emotions lie in brain regions such as the limbic system that are much older in evolutionary history and that we share with all mammals. He points, for example, to a recent research study led by Naomi I. Eisenberger of the University of California, Los Angeles. Eisenberger used functional magnetic resonance imaging (fMRI) to monitor the brain activity of subjects who felt socially excluded. Volunteers were asked to take part in a virtual ball game on a computer screen and told that two other participants hidden from view were also playing. In reality, the two "others" were simply icons controlled by a computer program. In the game, the three players were to toss a virtual ball back and forth, but the two computer-controlled "people" passed only to each other, ignoring the live person watching them on the screen. The volunteers later told the researchers that the experience of being excluded had felt hurtful.

The fMRI scans taken during the snubbing showed significant activity in several brain regions, especially the anterior cingular cortex. Previous studies by others have indicated that people placed in situations that made them sad showed unusual activity in the thalamus and the brain stem. These regions play key roles in the limbic system—the area of the brain that produces and regulates emotion.

Joy and Play

Interestingly, young guinea pigs that are prematurely separated from their mother exhibit heightened activity in the same brain system. In Panksepp's view, the feeling of being alone and vulnerable, and the stress it creates, reflects an-

cient mechanisms that are the foundation for the feeling of sadness experienced by humans. The limbic system is an ancient brain structure, and its central role shows that emotion is an integral part of animal life.

Biologists who have long observed signs of joy among animals agree. In the rain forests of Sumatra, orangutans swing from branches and splash their hands into pools of water with no other apparent purpose than just for the fun of it. In Alaska, ravens lie on their backs and slide down snow-covered rooftops, for no utilitarian reason. Buffalo in North America roar loudly as they deliberately slide across frozen patches of grass. Young macaques on the Japanese island of Honshu make snowballs in winter and play.

It is well accepted that young mammals have an inborn drive to play, because the interaction helps them sort out social opportunities and limits. They learn skills that will be important to their later survival. But what motivates them to goof around in the first place? Marc Bekoff, a biologist at the University of Colorado at Boulder who has researched the topic extensively, says it is the fun itself that ensures that animals will play.

ARNE PASTOOR Getty Images

Feelings, such as happiness, arise from the mind's awareness of bodily emotions.

Animals don't have to have the same feelings humans do. They can be happy in different ways.

Studies of brain metabolism provide evidence that animal feelings may not be very different from those in humans, because similar physical brain processes underlie those experiences. Experiments show, for example, that the neurotransmitter dopamine has an especially important part in the processing of emotions such as joy and desire in humans—and in other mammals.

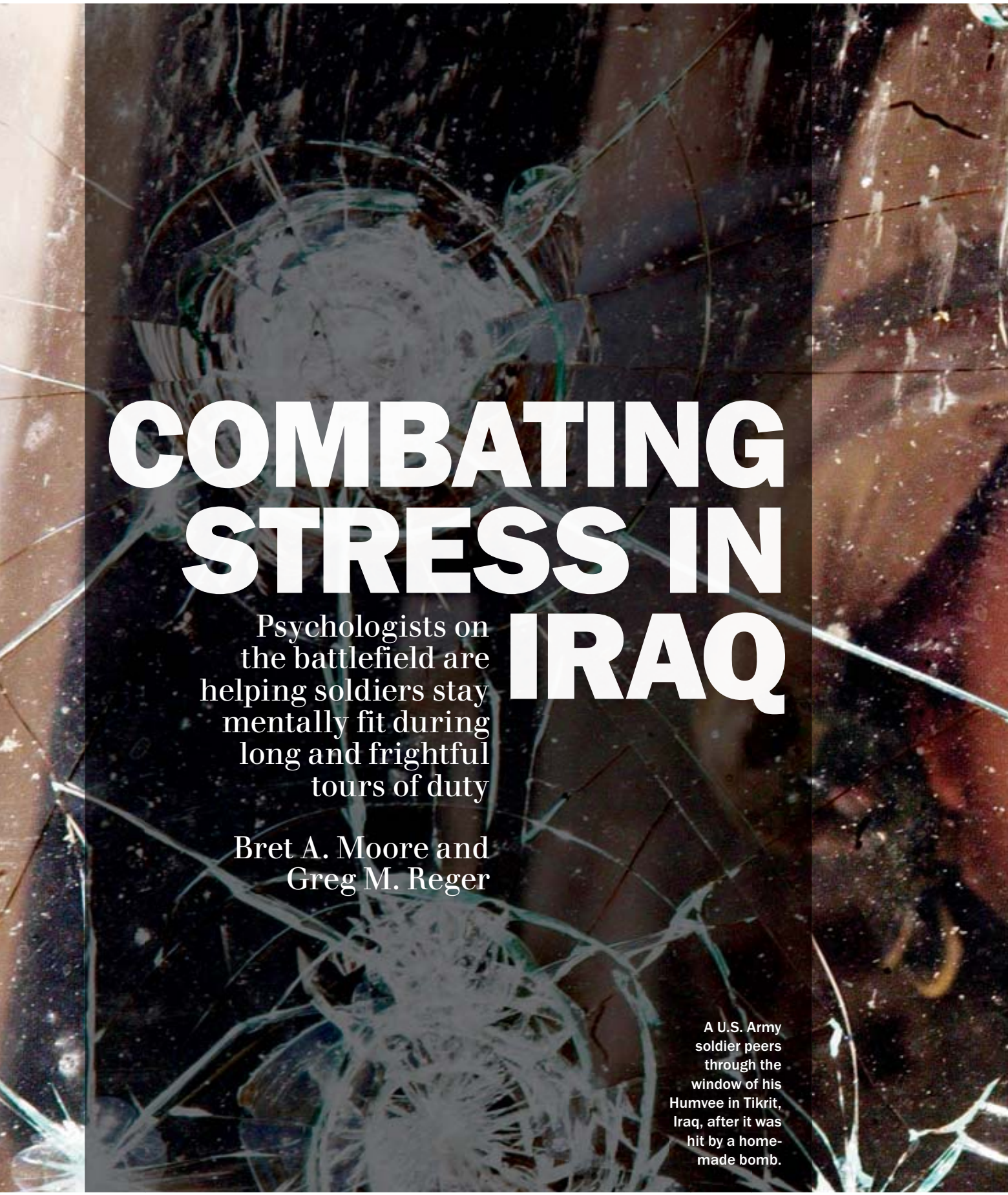
In the end, it is not possible to prove through observation whether an animal possesses conscious feelings—no more than we can be sure about what another person is truly experiencing inside. We know from lab work that some animals, at least, are indeed self-aware, so it is not much of a stretch to think they could be cognizant of their emotions, too. Bekoff emphasizes that when we talk about animal feelings, they do not have to be the same kind that people have. Humans can be happy in ways that vary from person to person. Animals likewise could be happy in different ways from humans.

Animals and humans could indeed share pride, joy, grief and shame, too. Psychologist Marc Hauser of Harvard University once surreptitiously observed a male rhesus monkey that, after copulating with a female, paraded around—until he tripped over an uneven patch of flooring and fell down. The monkey immediately and anxiously looked around before he got up—seemingly embarrassed about his stumble. Only when he was sure that no one had seen him did he get up and strut off—with his back straight and head held high—as if nothing had happened.

For Bekoff, the new research findings have not just a scientific message but also a social one: if animals are capable of feeling emotion, then we have yet another reason to seriously consider how well we treat them. M

(Further Reading)

- **The Smile of a Dolphin.** Marc Bekoff. Discovery Books, 2000.
- **Minding Animals: Awareness, Emotions and Heart.** Marc Bekoff. Oxford University Press, 2002.
- **"Laughing" Rats and the Evolutionary Antecedents of Human Joy.** Jaak Panksepp and Jeff Burgdorf in *Physiology and Behaviour,* Vol. 79, No. 3, pages 533–547; 2003.

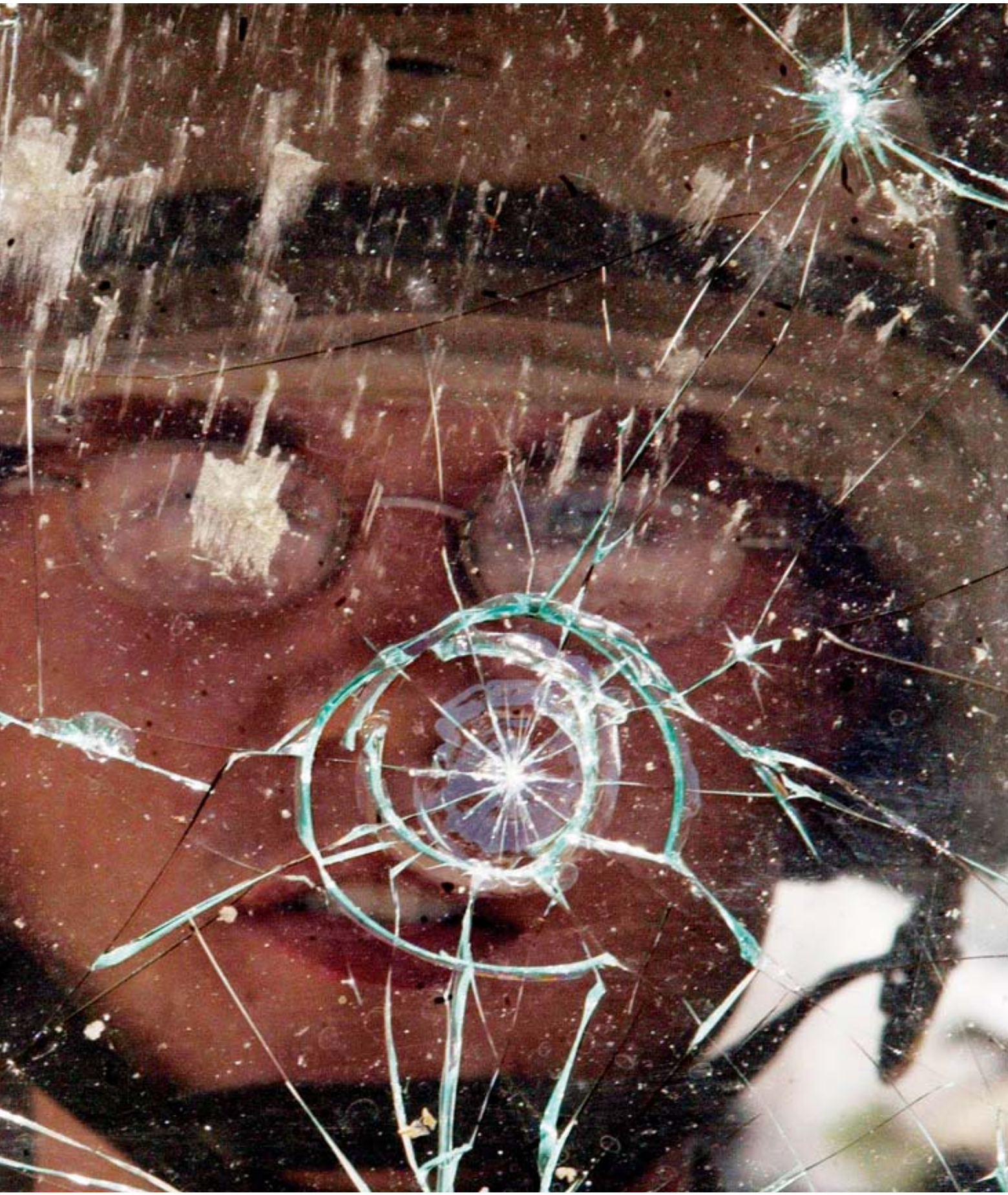


COMBATING STRESS IN IRAQ

Psychologists on the battlefield are helping soldiers stay mentally fit during long and frightful tours of duty

Bret A. Moore and Greg M. Reger

A U.S. Army soldier peers through the window of his Humvee in Tikrit, Iraq, after it was hit by a homemade bomb.



During a routine patrol outside a small village in eastern Iraq, a four-vehicle convoy was suddenly blasted with an improvised explosive device (IED). Michael (not his real name), a 22-year-old combat medic who was riding in one of the vehicles, lost consciousness for several moments. As he regained his senses, he saw that the gunner had been thrown from the turret. Michael immediately scrambled out of the mangled vehicle and began to apply first aid. After stabilizing the injured soldier, Michael proceeded to the next truck ahead to see if there were further casualties. As he approached, a second IED detonated. Michael was knocked out again. When he came to, he saw that the driver was seriously injured. Michael gave him CPR and struggled over him for 10 minutes, but the man died in his arms.

Two days later, as part of the routine follow-up to such an incident, a psychologist with the unit's combat stress control team conducted a debriefing of the members of the convoy. Throughout the discussion Michael was quiet and reserved, showing no emotion. Then, six days later, he appeared at the psychologist's quarters and reported that he was having trouble sleeping, was experiencing nightmares, had lost his appetite and had an intense fear of going on future missions.

The psychologist promptly initiated treatment for Michael, assuring him that what he was experiencing was to be expected. The therapist taught him behavioral techniques that would help him sleep, facilitated a brief course of sleep medication, and educated him on the importance of maintaining a regular exercise and work routine. The psychologist also started Michael on daily therapy sessions, and he was placed on restricted duty for the next seven days. At the end of that time Michael reported that he could sleep better and was clear of nightmares. He regained his appetite as well as his confidence in his abilities as a soldier and a medic. The unit's commander placed Michael back on full-mission status, and he continued with his military duties.

Army psychologists are playing a critical role in maintaining the emotional and psychological well-being of service members in Iraq. Their ability to get to the troops quickly and treat them on the battlefield is making a difference in how well our fighting men and women are able to deal with the potentially disabling consequences of combat stress. Michael's story highlights the toll that combat exposure can take, and it illustrates how prompt and targeted intervention can mitigate the present and possible future effects of traumatic experiences. The case also illustrates the tactical and operational importance of the army psychologist in Iraq. Helping emotionally stressed service members return to their prior level of functioning is not only the best medicine for their mental health, it is key to a military unit retaining valuable soldiers, which is crucial to operational success.

Unable to Function

Traditionally, the human cost of war has been viewed primarily through physical lenses. Talk of combat casualties usually refers to physical injury or death on the battlefield. Yet the emotional and psychological effects of combat on service members can also be devastating. It can even be the critical factor in whether or not a military force is successful.

The first accounts of combat stress on warriors can be traced back to early mythology. But it was not until the 17th century that military leaders began to realize that the stress on soldiers could have a profound influence on the success of military operations. The condition was originally called "Swiss disease," because doctors and leaders in the Swiss Army noted that some men no longer had the motivation or ability to continue fighting. Many would just give up

ARKO DATTA *Reuters/Corbis (preceding pages and this page)*

JACK WHITE, ARMY STAFF SGT., 116TH BCT PUBLIC AFFAIRS (*top*); LEK MATEO, ARMY MASTER SGT., 56TH BCT PUBLIC AFFAIRS (*bottom*)

or become so incapacitated by fear that they could not physically function. Over the next centuries this phenomenon went through several name changes, including nostalgia, irritable heart, shell shock, battle fatigue and the current designation of combat stress reaction.

Combat stress may arise when an event, situation or condition in a fighting zone requires a soldier to alter his or her behavior in response to new demands. The change typically presents cognitive, physiological and emotional challenges. Such stress is a normal and expected experience for deployed personnel, and the vast majority of soldiers manage it effectively. Many actually perform better under reasonable levels of stress. But certain situations can place so much strain on an individual that he or she cannot maintain a normal level of functioning. Emotionally, a service member suffering from a combat stress reaction may exhibit sadness, worry, fear or even inappropriate euphoria. Cognitively, the person may experience disorientation, confusion, memory loss or inattention. And behaviorally, he or she may exhibit an increase in aggressive or suicidal behavior. In extreme cases, the service member could potentially engage in hostile behavior toward local civilians or enemy detainees.

We should note that the term "post-traumatic stress disorder," or PTSD, is often used to describe a service member's reaction to battlefield events. PTSD is a specific psychiatric diagnosis, however, characterized by emotional trouble months or years after trauma. A combat stress reaction may or may not lead to the development of this disorder.

Soldiers in Iraq are affected by the same problems that military personnel over the centuries have been forced to endure. Still, for the American troops currently deployed overseas, two important differences can further impinge on their psychological health. First, at no other

Author Bret Moore (*top center*) discusses stress with soldiers at their compound in Iraq. Author Greg Reger (*bottom*) stands before an armored vehicle that medical personnel use on the battlefield.

> The anxiety of knowing that an attack can occur anywhere, anytime, can be difficult to manage.

Personnel who cannot shake fear after being treated at their camp may be sent to a base that has more extensive therapeutic resources.

LEK MATEO, ARMY MASTER SGT., 56TH BCT PUBLIC AFFAIRS

time in American military history have service members been required to take such a defensive and reactive posture in combat operations. Although the initial assault on Baghdad in the early months of 2003 and the retaking of Fallujah in November 2004 were aggressive operations, much of the troops' time is spent patrolling villages, convoying between forward operating bases and searching for unexploded IEDs. The anxiety and fear of not knowing if or when an attack might occur can be difficult to manage. Second, everyone is in harm's way. The days of the soldier with the "gear in the rear" are over. There is no more "front line"; the linear battlefield has given way to self-supporting bases and camps strategically scattered throughout the region. Many support troops who would have been spared the emotional strains of combat in previous wars are now as vulnerable as the infantrymen. Consequently, larger numbers of combat stress casualties are possible. Fortunately, the military has recognized these changes and the potential problems that may arise. It has gone to great lengths to increase the number of mental health providers in Iraq. Army psychologists and combat stress control teams have become important operational assets.

Little Time to Talk

When asked to describe a psychologist, the public often imagines an older middle-aged man with a graying beard, probably with a cigar and

(The Authors)

BRET A. MOORE and GREG M. REGER are captains in the U.S. Army and met two years ago during training. Moore (bret.moore@us.army.mil) is a clinical and aeromedical psychologist with the 85th Combat Stress Control Unit, based in Fort Hood, Tex. He is currently deployed in Kirkuk, Iraq, where he is the officer in charge of a CSC preventive team. Reger is a clinical and aeromedical psychologist with the 98th Combat Stress Control Unit, based in Fort Lewis, Wash. He is deployed in Tallil, Iraq, where he is a psychologist with a CSC restoration team. Moore and Reger wrote a chapter on combat stress for the upcoming book *For Those Who Bore the Battle: Combat Stress Injury Theory, Research, and Management,* edited by C. R. Figley and W. P. Nash (Routledge, 2006). The views expressed here are those of the authors and do not reflect the official position of the U.S. Army, U.S. Department of Defense or U.S. government.

A Soldier First

To ascertain how stress is affecting behavior, psychologists take part in dangerous assignments and must therefore be reliable soldiers as well.

It was late on a Tuesday afternoon when the platoon sergeant stopped by my makeshift office. Because of a recent increase in activity among nearby Iraqi insurgents, the platoon would be conducting traffic checkpoints that night in a densely populated city in northern Iraq. Concerned about his men, the sergeant asked me, the psychologist deployed to support his platoon, to accompany the unit so I could observe his soldiers. He wanted to know if stress was adversely affecting their performance. I had been on missions before, but none with this much potential exposure to enemy contact. Nevertheless, I agreed to go.

After cordoning off an area in the heart of the city, the unit began to stop and inspect vehicles. Even with temperatures still hovering around 100 degrees Fahrenheit at 11:00 P.M., the traffic was steady and the streets were bustling with bystanders. About an hour into the mission, a small car carrying four young Iraqi men approached. One soldier was at the checkpoint gate with me, and several others were close by. While the soldier was checking identifications, he realized that one of the passengers in the rear seat met the description of a wanted insurgent. As he questioned the suspect, a verbal confrontation ensued, and the two men in the front seats began to exit the car. As instructed in my previous training, I raised my gun and directed it at the men in an aggressive posture. Within seconds four other soldiers from the unit surrounded the vehicle with weapons drawn. A full search turned up several illegal weapons and materials used to make improvised explosive devices. The men were detained and taken to the local Iraqi police station. I breathed a huge sigh of relief.

Unlike in past world wars, today's battlefields do not typically have clearly delineated front lines and somewhat safe support positions in the rear. Violence erupts anywhere at any time. Explosives can be hidden in seemingly innocuous items such as cars, roadside debris and even baby strollers and can be carried by insurgents dressed in civilian clothes. Given this ease of disguise, today's army psychologists may find themselves alongside combat troops in dangerous situations. As a result, the army is reemphasizing the importance of psychologists and all support professionals being proficient not just in their occupational skills but also as soldiers.

I certainly did not relish standing at that checkpoint. But it was necessary for me to observe how stress might be affecting soldiers' actions, and if I had not reacted quickly enough, or had overreacted, my inappropriate actions could have allowed or caused a deadly fight.

Later, I told the sergeant that although his men were experiencing elevated levels of stress, they were still performing their jobs competently and safely. To reach that conclusion, I had to be in the midst of an important tactical operation. Furthermore, by inserting himself or herself in harm's way, a psychologist achieves two other crucial goals. First, the soldiers in a unit may develop a greater sense of trust in the psychologist and therefore be less reluctant to participate in mental health services. And second, the psychologist is better able to appreciate the stress unique to a combat environment, thereby imparting a far deeper understanding of what soldiers experience. *—B.A.M.*

JOHN MOORE *AP Photo*

an Austrian accent, who quietly takes notes alongside a patient who is lying on a couch. This image is as out of place in the army as the Freudian theories associated with it [*see box above*]. Historically, mental health providers have treated patients from a variety of psychoanalytical or psychodynamic theories that generally conceptualized an individual's problem as stemming from unconscious, repressed thoughts or feelings. Clinicians intervened with long-term talk therapy that attempted to bring this hidden material into consciousness, in hopes of giving the patient insight into the supposed root of his or her symptoms or finding a corrective experience in therapy.

Even though army psychologists may continue to draw from these theories to conceptualize a soldier's difficulties, the realities of a combat zone make long-term talk therapy impractical. Soldiers' mission schedules are unpredictable. Troop movements and unit reorganizations occur regularly. Psychologists may have only brief access to soldiers traveling through a particular forward operating base. As a result, army psy-

A soldier in Baghdad mourns at a memorial service for a 19-year-old compatriot killed when the truck he was riding in was hit by a rocket-propelled grenade.

DAVID LEESON *Dallas Morning News/Corbis Sygma*

chologists rely on more recent therapeutic models of short-term treatment.

One approach often employed is cognitive behavioral therapy. This practice recognizes the important role that thinking has on an individual's feelings and behavior. Challenging a person's irrational, illogical or dysfunctional beliefs can alter his or her moods and actions. For example, a soldier who feels angry with other members of the unit may have vindictive thoughts and act in verbally aggressive ways toward them. By recognizing and altering how the person thinks about his or her peers, the intensity and duration of the anger may wane. Although psychologists certainly take into account a soldier's environment, background and family history, short-term, nonpharmacological interventions such as cognitive behavioral therapy are the backbone of treatment in a combat zone.

Immediate Attention

The mission of an army combat stress control (CSC) team is straightforward: provide prevention and treatment as close to the soldier's unit as possible, with the intent of keeping the soldier with the group. CSC teams are specialized mobile mental health groups that are typically deployed to distant battlefields. They may supplement existing mental health teams or function independently, depending on the need or battlefield configuration. The development of these unique teams springs from lessons learned from World War I: if combat stress cases were evacuated to the rear, they seldom returned to their units, but when soldiers were treated close to the front, they were more likely to return to duty and less likely to have ongoing mental health problems on their return home.

Among the military's diverse mental health providers—which include psychiatrists, psychiatric nurses, occupational therapists and social workers—psychologists play an integral role in CSC units. We operate under four basic treatment principles: proximity, immediacy, expectancy and simplicity, a scheme known as PIES. Proximity refers to treating the soldier as close to his or her unit as possible. Immediacy acknowledges the importance of intervening as quickly as possible, to mitigate the impact of traumatic events and ward off potential long-term problems. Expectancy means helping the soldier realize that symptoms such as being afraid to go on further missions after being hit with an IED are expected, or typical, reactions to an abnormal situation and that with time these feelings will subside and allow for a full return to duty. Finally, simplicity encompasses the short-term and evidence-based treatment techniques such as cognitive behavioral therapy as well as ensures that the soldier's basic needs of rest, food and hygiene are met.

Psychologists in a CSC unit serve in two main ways: prevention and restoration. Preventive teams are typically found in remote battlefield areas. Their primary responsibilities are working to ward off combat stress, triaging it and setting up short-term treatment if it occurs. A CSC psychologist educates personnel in a va-

riety of areas such as how to avoid acting on thoughts of suicide, handling conflicts and reducing stress. In triage, the psychologist may have to travel to an outlying camp that was subjected to a traumatic event to assess and identify soldiers who are having acute stress reactions. At this point, the psychologist can decide whether to initiate a regimen of short-term therapy or to refer someone to the restoration team for more extensive care.

Restoration teams are usually located at a base that has greater access to resources than the remote units do. Here a psychologist works with a soldier on a longer-term basis, which in the army may mean anywhere from three days to two weeks. In certain cases, treatment could extend for several months. The soldier may receive daily individual and group therapy and training on stress and anger management, relaxation, and ways to get a better night's rest. Furthermore, the psychologist can help coordinate medication for sleep problems, depression and anxiety, as well as utilize the unique skills of occupational therapists. Prevention and restoration work together:

On his weekly visit to a remote camp that housed several infantry units, a preventive team psychologist learned from a sergeant that three days earlier one soldier was killed and several were seriously injured after an enemy rocket hit the camp's crowded dining facility. The psychologist immediately brought together the personnel who were involved and held a crisis debriefing—a one-time group session that allows everyone to discuss and process what happened.

Over the next several days, the psychologist worked one-on-one with a number of soldiers who were still struggling with the attack. Through individual therapy, coordinating sleep medication with the camp's physician assistant, and placing some of the soldiers on restricted duty to ensure they received adequate rest and recovery, he helped most of the personnel regain the level of functioning that they had before the incident.

The psychologist did identify two soldiers who had begun to suffer panic attacks, develop intense fear and feel hopeless about their ultimate survival. He coordinated an air evacuation of the two men to a regional restoration team, where they received more intensive and comprehensive services. Six days later the soldiers were able to return to mission status with their unit. Although some residual fear remained, the two men and their providers judged that the lingering stress was not sufficient to prevent them from doing their job or to put them or other members of their unit at risk.

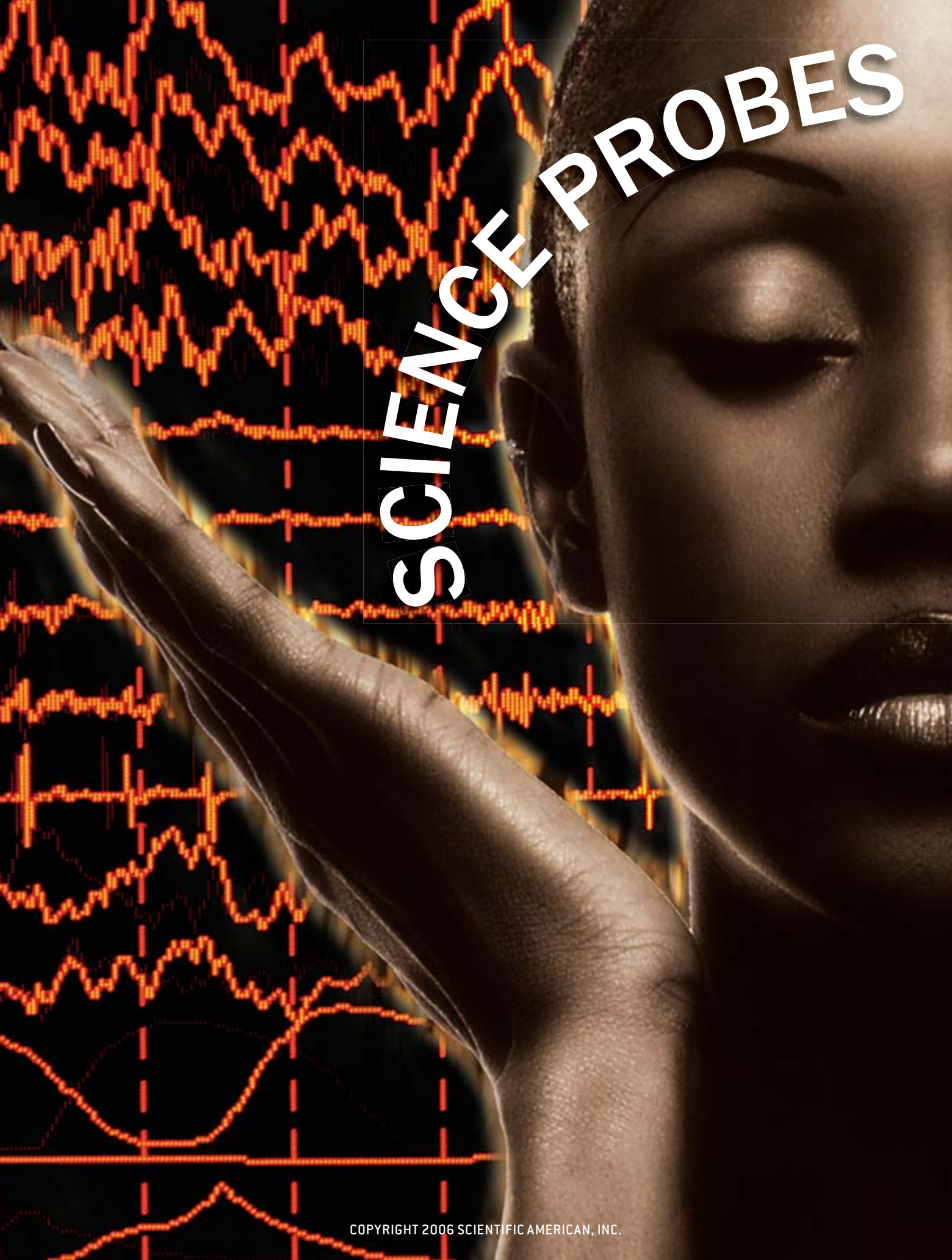
Psychologists may have only brief access to soldiers passing through. Treatment must be short-term.

The stress of war can have a tremendous impact on a service member. But with targeted and prompt intervention, a psychologist can help mitigate the acute effects of combat stress and, it is hoped, prevent the development of future mental health problems when the soldier returns home. Combat stress can also hurt a military unit as a whole. Without the appropriate level of manpower, the unit may be unable to function optimally, compromising an important military operation and placing many troops at risk.

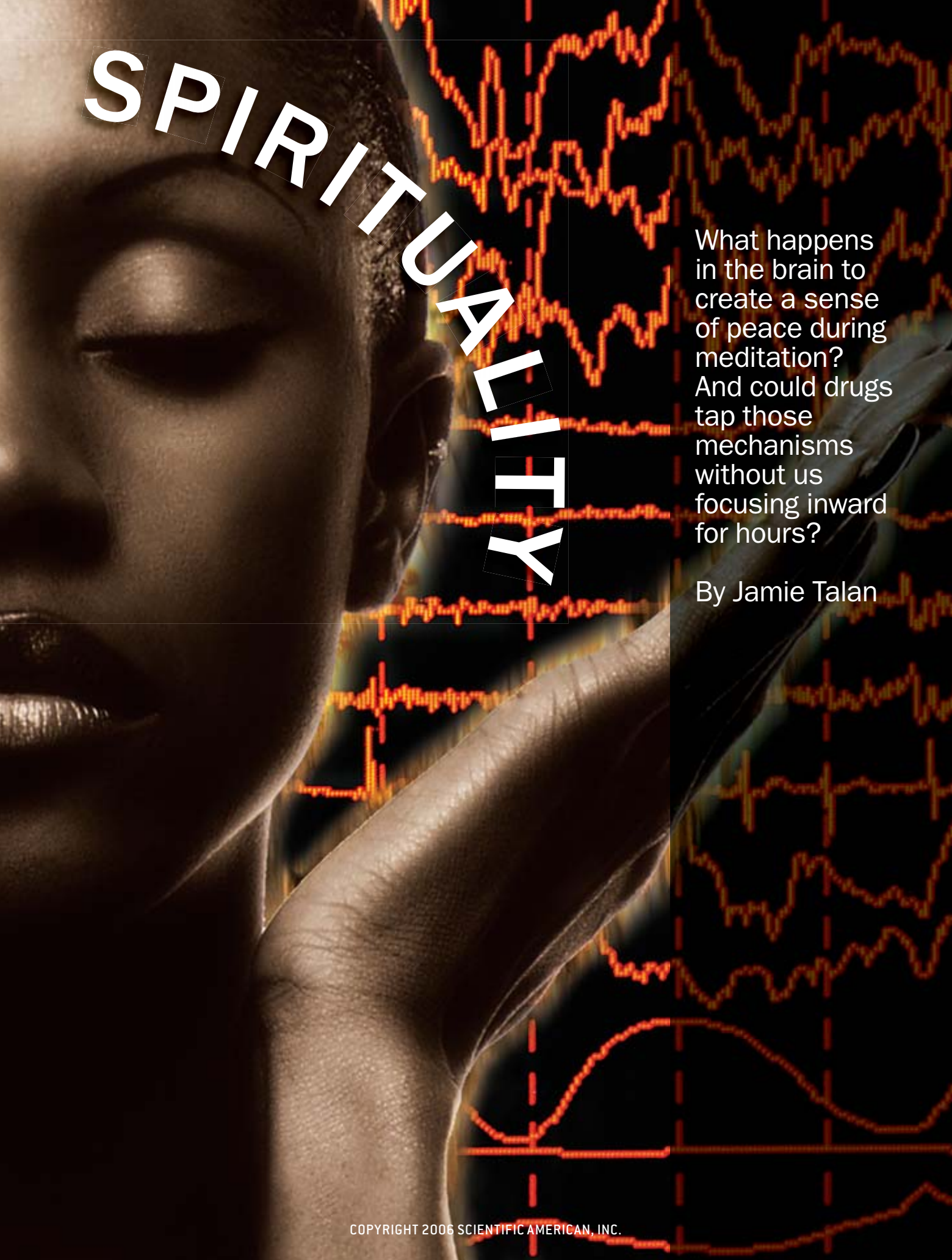
Fortunately, the military has recognized the importance of ensuring quality mental health care to its members. At a minimum, our country owes these brave men and women a return home to their loved ones and a future not plagued by emotional and psychological problems. We are not so naive as to believe that these warriors will be completely unaffected by their experiences. But by adapting psychological principles common in the civilian sector to the battlefield, psychologists and combat stress control teams can alleviate the damaging effects of the inevitable stresses of war. M

(Further Reading)

- **"Forward Psychiatry" in the Military: Its Origins and Effectiveness.** Edgar Jones and Simon Wessely in *Journal of Traumatic Stress,* Vol. 16, No. 4, pages 411–419; August 2003.
- **A Historical Overview of Combat Stress Control Units of the U.S. Army.** Bryan L. Bacon and James J. Staudenmeier in *Military Medicine,* Vol. 168, No. 9, pages 689–693; September 2003.
- **Stressed Out at the Front.** Rod Nordland and T. Trent Gegax in *Newsweek,* Vol. 143, No. 2, pages 34–37; January 12, 2004.
- **Clinician to Frontline Soldier: A Look at the Roles and Challenges of Army Clinical Psychologists in Iraq.** Bret A. Moore and Greg M. Reger in *Journal of Clinical Psychology* (in press).



SCIENCE PROBES



SPIRITUALITY

What happens in the brain to create a sense of peace during meditation? And could drugs tap those mechanisms without us focusing inward for hours?

By Jamie Talan

eople who meditate regularly feel an enviable sense of calm. Neuroscientists have shown that by altering brain-wave patterns, the discipline purges negative thoughts. Experienced meditators are calmer in their response to daily stress and perform better at tasks that require focused attention. A handful of researchers think the same brain changes could even confer physical benefits, such as lowering blood pressure and preventing disease.

Scientists, as well as practiced meditators such as the Dalai Lama, also want to know how much meditation is needed to achieve these gains. What if 20 minutes, twice a day, were enough? A person could add that to his or her daily routine of 30 minutes on the treadmill and achieve physical and mental harmony.

The number of clinical investigations into meditation is increasing, in part because the Dalai Lama himself has encouraged such analyses. Richard J. Davidson, a professor of psychology and psychiatry at the University of Wisconsin–Madison who practices meditation, was one of the first to record the brain activity of Tibetan monks during their altered state. Davidson's team has since conducted several creative experiments to test the possible neural benefits. Davidson is studying how electrical brain activity corresponds to emotional and behavioral reactions to the environment. He has shown that meditation triggers the high-frequency waves associated with attention and perception to a far greater degree in experienced practitioners than in novices.

Another meditator, Margaret E. Kemeny, a health psychologist at the University of California, San Francisco, is investigating ways to help healthy adults deal with negative emotions. She is following teachers she has trained to meditate, as well as a control group of untrained teachers, over a five-month period to see whether regular meditation for a few minutes each day alters the mind and body in positive ways. Her answer will be based on measurements of brain chemicals that regulate stress, as well as heart rate, blood pressure and mood ratings.

Clifford Saron of the University of California, Davis, has proposed a wild and intriguing research project. He wants to find 30 people who would put their lives on hold for one year, live on a beach on the Pacific coast and spend their days meditating hour after hour, only to be probed every so often by a slew of scientific devices, from brain scanners to blood analyzers. Saron hopes to determine whether meditation creates permanent biological changes, such as a wealth of new or altered brain cells that give people a sense of tranquillity. What is more, if he can identify a brain region that brings about inner peace, then pharmaceutical companies potentially could design drugs to create the same effect. To test whether the project is even feasible, Saron is first designing a three-month pilot study. At a recent meeting, a number of scientists indicated they might be willing to put aside a few months and volunteer, but no one was signing on for a year.

The person who prompted Saron's initiative is Colorado businessman Adam Engle. While trekking in Nepal in the 1970s, Engle was taken by the warmth and compassion of the Buddhist lamas he met. A decade later he learned of the Dalai Lama's penchant for science and eventually co-

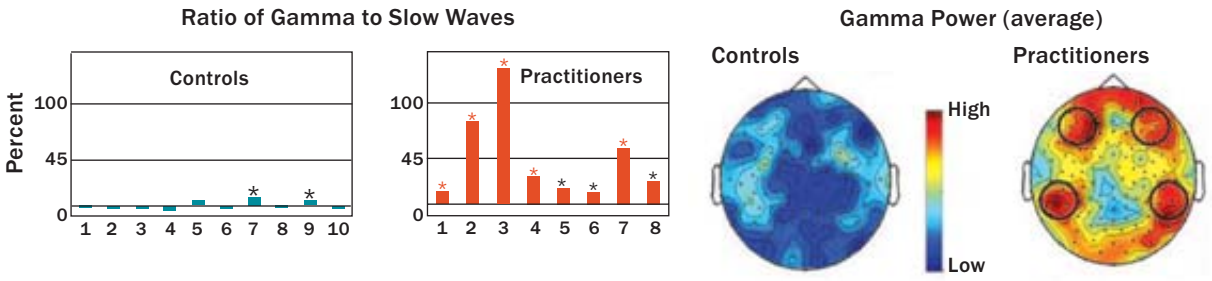
(The Author)

JAMIE TALAN covers neuroscience for *Newsday* and has written about psychotherapy and ethics for *Scientific American Mind*.

BRUCE TALBOT Getty Images (*woman meditating*); ROBERT J. HERKO Getty Images (*background ECG, EEG and CRT traces*) (*preceding pages and this page*)

Masters of Emotion

People can diffuse ill feelings by mastering emotions such as anger. Tibetan monks who are experts in meditation rid themselves of negativity by augmenting the brain's gamma waves, which can be measured in a lab (*right*). Richard Davidson of the University of Wisconsin–Madison tested eight monks (*right graph*) during meditation. They boosted their gamma waves to twice (*black stars*) or three times (*orange stars*) the resting level. A composite head diagram (*right*) shows regions of greatest gamma activity. Eight volunteers who had just been taught how to meditate and acted as controls (*left graph*) showed little gamma-wave gain.



founded the Mind & Life Institute, based in Colorado, with the late neuroscientist and Buddhist practitioner Francisco J. Varela. The institute's purpose, Engle says, is "to see if we can bridge the gap" between science and spirituality.

In 2000 the institute sponsored a meeting in India where neuroscientists met with the Dalai Lama and discussed ways to study Buddhist meditation practices. One attendee was Paul Ekman, a noted expert in facial expressions and emotion. In a subsequent study, Ekman, a professor of psychology at the University of California, San Francisco, found that lamas assessed the emotion shown in faces much faster and more accurately than did "thousands of people I have tested over the years, including lawyers, policemen and judges." He thinks meditation offers a way to strengthen brain circuits that regulate attention and emotion and believes the practice could help many people who suffer from mental diseases characterized by abnormal emotional reactions.

The opportunities for advancement are expanding. In 2003 more than 1,000 scientists gathered at the Massachusetts Institute of Technology to hear the Dalai Lama describe this new area of research. In November 2005, days before the Society for Neuroscience meeting where the Dalai Lama was to speak [see "Meditations on the Brain," by R. Douglas Fields, on page 42], the Dalai Lama and scientists met at Constitution Hall in Washington, D.C., to share results and discuss ways to study how meditation might alter disease states of the mind and body. Georgetown University Medical Center, Johns Hopkins School of Medicine and the Mind & Life Institute sponsored the meeting. Universities are taking this line of inquiry seriously, and a number of researchers are also finding federal money for these studies.

As the Dalai Lama blessed his audience of neuroscientists at the November event, he offered his hope that their efforts will pave the way to a healthier, happier world. M

(Further Reading)

- **Destructive Emotions: A Scientific Dialogue with the Dalai Lama.** Daniel Goleman. Bantam, 2003.
- **Genuine Happiness: Meditation as the Path to Fulfillment.** B. Alan Wallace. John Wiley & Sons, 2005.

Meditations on the Brain

BY R. DOUGLAS FIELDS

"I would be the first patient!" exclaimed the Dalai Lama before 14,000 neuroscientists who flocked to hear him speak at the Society for Neuroscience's annual meeting in November 2005 in Washington, D.C. The Buddhist spiritual leader's promise followed his comment that hospitals not only should aid the mentally ill but also should provide mind-altering brain surgery and drugs to control anger, hate or jealousy in everyday people. He added—only half-jokingly—that if a small electrical jolt to his brain could free him of negative emotion, he would have no need to spend hours meditating each day to reach a trouble-free state of mind.

The audience members responded to the Dalai Lama's proposal with nervous laughter, because they knew that the means already exist to tweak emotions. The checkered history of prefrontal lobotomy flashed collectively through their minds. But the high priest had already moved ahead to other similarly difficult questions. Is it ethical to take drugs such as antidepressants to find happiness? Yes, he replied, as long as critical faculties are not numbed. But should a patient in dire need be forced to take antidepressants? "Never forced," he said, although he quickly added that he thought troubled individuals could be persuaded. Where does a caretaker draw the line? "Some have the view that [ethics] must be based on religious beliefs. I don't believe that."

In this direct fashion, the Dalai Lama confronted the most critical issue of neurobiological research: How are scientists, and society, going to handle the explosion of information on the machinery of our thoughts? While scientists grapple with their own ethical dilemmas of applying brain research to treat the mentally ill, the Dalai Lama is probing an even greater philosophical challenge: how to utilize this science to make a healthy mind better.

LISA POOLE *AP Photo*

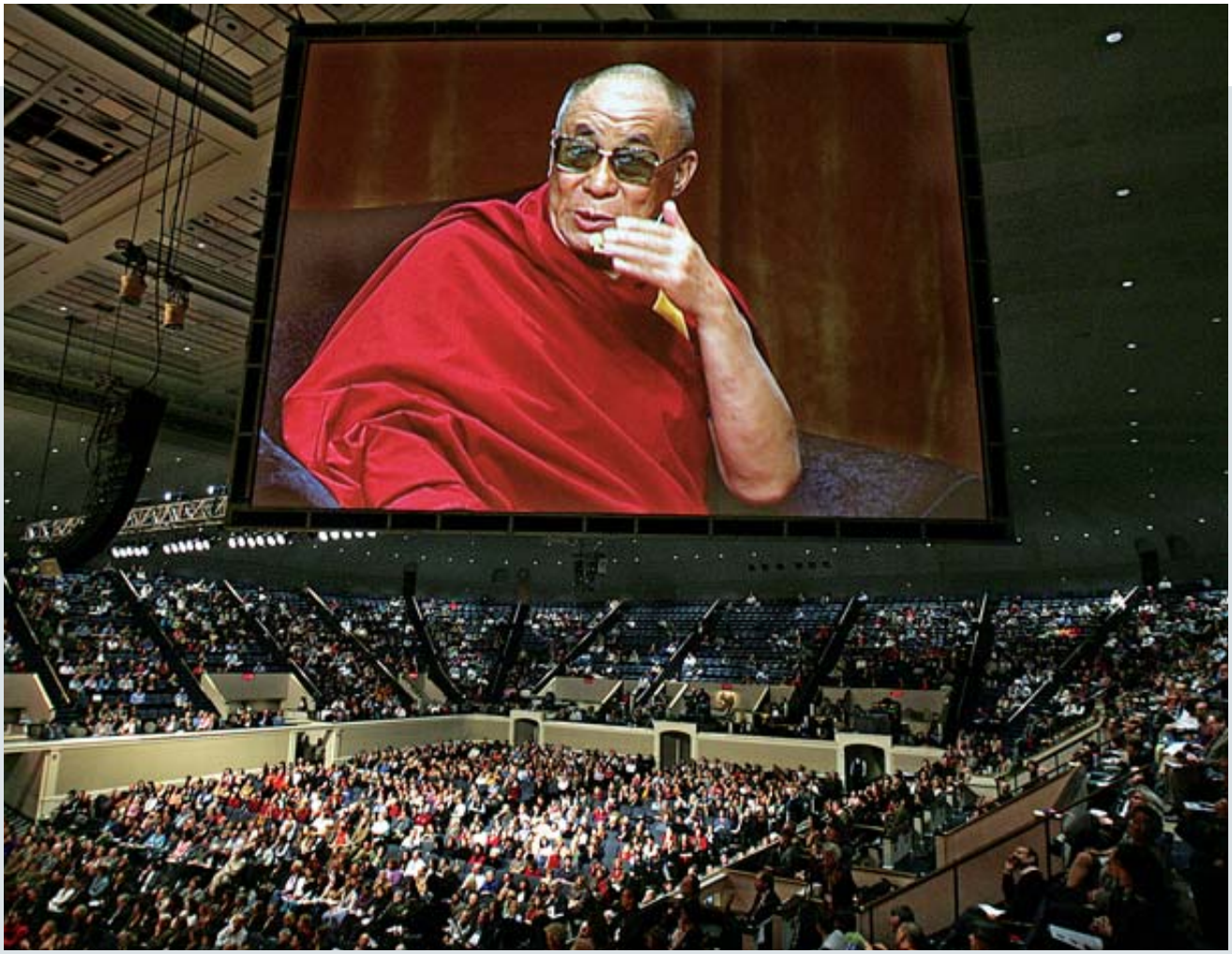
Rising above the Controversy

Science and society have drifted back and forth on ethical dilemmas presented by new treatments for brain disorders. For decades after its inception, prefrontal lobotomy was lauded as a breakthrough in easing the suffering of hopelessly ill schizophrenics. Egas Moniz was awarded the Nobel Prize in 1949 for introducing the surgical procedure. But later the technique was stigmatized as an unethical remedy, because it crippled parts of the patient's mind and personality in exchange for fewer horrifying delusions or catatonia. The treatment was also sometimes abused as an expedient method to control difficult individuals. More recently, the use of electroconvulsive (shock) therapy for treating depression has suffered similar swings in acceptance. Today psychotropic drugs, mood stabilizers, and antianxiety and antidepressant pharmaceuticals abound, and the same issue arises: When should they be used?

According to the Dalai Lama, securing human well-being and happiness is paramount. Audience members pressed the spiritual leader to elaborate on what appeared to be a prescription for abuse. They raised the specter of a society addicted to pills to treat nonexistent ailments, as many people now are addicted to alcohol and other drugs. He offered no simple answers, dogma, or "just say no" platitudes.

The monk's scheduled appearance at the meeting had been highly controversial. A petition demanding that the invitation be rescinded had been circulating for months and was ultimately signed by 500 neuroscientists. "What can the Dalai Lama teach me about neuroscience?" asked one of the petition movement's leaders. The co-signers stated that they objected to using science, or pseudoscience, to validate the Buddhist method of enlightenment through meditation. Many of them felt it was inappropriate for a spiritual leader to espouse his views at a scientific meeting, particularly in this time of heated debate over the government mandate in certain states that the religious concept of "intelligent design" be taught in science classes as an equivalent alternative to evolution.

The Dalai Lama's approach turned out to be surprisingly scientific, however. His intention is to unite Buddhist techniques with neuroscience techniques to control the mind. From his perspective, the mind is the root of all evil and unhappiness in the world. By openly considering how meditation and neuroscience can benefit humankind, he is struggling to make the wisest choices—in his case, about how to improve a medically healthy brain.



TIM SLOAN AFP/Getty Images

Seeking the best way to rid the mind of negativity, the Dalai Lama has engaged scientists at the Massachusetts Institute of Technology in 2003 (*opposite*) and at the Mind & Life XIII: Investigating the Mind 2005 meeting (*above*).

In this quest, the Dalai Lama is confronting the same ethical issues as neuroscientists. He did not come to the symposium with pat answers, and that confused some audience members. Most expected a religious leader to resolve difficult questions with doctrine, but he refused, replying at times with "I don't know." Coming from a scientist in a white coat, this response is reasonable and acceptable, but from a person in religious robes it seemed to clash with expectation. In objecting to the Dalai Lama's appearance, they revealed their own dogmatic view that science and religion must always be at odds.

Others in the audience may have experienced an epiphany, as I did, realizing that the Dalai Lama's approach and solutions are in harmony with their own. Like them, he is seeking to find principles for guidance and uses reasoning and compassion to make an ethical choice for the greater good. This is exactly what a neurosurgeon must do, because almost all brain surgeries and drug treatments come with a cost.

In addition, this leader surprised the audience by demonstrating qualities found in great scientists: open-mindedness combined with objective criticism. He laid bare his own cherished views on meditation to scrutiny and made plain his eagerness to exploit neuroscience to reach his goal of purging the mind of negative emotions. If Buddhist dogma conflicted with science, he was willing to shatter religious teachings in the name of verifiable facts.

How many scientists would act with such open-mindedness? The Dalai Lama's address suggests that leaving the comfort of dogma and using ethical principles for guidance, together with reason and compassion to choose correctly for the greater good, will lead to the most responsible application of science. The revered monk has traveled farther than any other religious leader to learn what science can reveal about the human mind. In exchange, neuroscientists may have gained new bearings to help guide them through the treacherous ethical dilemmas emerging from their discoveries.

R. Douglas Fields is an adjunct neuroscience professor at the University of Maryland and an adviser to Scientific American Mind.

MASTERY OF EMOTIONS

JOSEPH E. LEDOUX DISCOVERED HOW FEAR ARISES. NOW HE IS SHOWING THAT THE BIOLOGY OF EMOTIONS IS WHAT GIVES LIFE MEANING **BY DAVID DOBBS**

One of the biggest fears Joseph E. LeDoux had when he was growing up was of getting stuck in Eunice, La. His small hometown sits among creeks and rice fields, and its Cajun country roots give it a certain charm. It is hard to swing a possum without hitting a good gumbo restaurant. An old theater downtown hosts the weekly *Rendezvous des Cajun* radio show, a yipping version of *Prairie Home Companion,* only with dancing, and anyone can join the live studio audience for a mere $5.

But when LeDoux was coming of age in the 1960s, he found Eunice too sedate. He did some radio disc jockeying in high school, and the era's music, along with his own inquisitiveness, drew his attention to the wider world. His parents, however, told him they would pay for college only

RANDY HARRIS

if he studied business and only if he did not venture farther than Baton Rouge, 80 miles east. His father, a butcher, envisioned his son as a leading local businessman. The main interest Joseph had in butchering was that it allowed him to do his first neural explorations: digging through cow brains to extract the bullets that had killed the cattle, so his father could sell the brains as a delicacy.

Nevertheless, LeDoux dutifully enrolled at Louisiana State University. Now 55 and a leading neuroscientist specializing in the study of fear, LeDoux recently told me in his office at New York University that he did not care much for his business studies, yet they ultimately led him to brain research. "I studied marketing," he explained in an amiable voice that carries the slightest hint of Cajun. It was a bright day, and the Empire State Building gleamed in the distance outside his office window. "As I went along, the thing that interested me most was why people bought stuff they didn't really need."

N.Y.U. colleague Elizabeth A. Phelps has used fMRI images to show in human brains perception and emotion mechanisms that LeDoux discovered in rats.

RANDY HARRIS

LeDoux's interest in such "manufactured desire" led him to a course on learning and motivation with L.S.U. psychologist Robert Thompson. Professor and student hit it off, and Thompson urged LeDoux to go on to graduate school in neuroscience. LeDoux applied to 30 programs, but just one, the State University of New York at Stony Brook, accepted him and only, LeDoux says, because Thompson convinced his friend Michael S. Gazzaniga, then head of the school's neuroscience program, to take a chance.

Gazzaniga and LeDoux would both go on to stellar careers. Gazzaniga has become a prime leader in cognitive neuroscience, and this winter left Dartmouth College after a decade to direct the new Sage Center for the Study of the Mind at the University of California, Santa Barbara. His protégé, meanwhile, has turned an area of research that most neuroscientists were loathe to plumb—the biology of emotion, particularly of fear—into one of neuroscience's most revealing disciplines.

With remarkable tenacity and creativity over two decades, LeDoux has used simple fear conditioning in the rat to identify the neural pathways and processes through which the rodents acquire, act on and sometimes extinguish their fears. Because most of these neural networks operate similarly in humans, his findings have vastly expanded our understanding of how emotions affect our thoughts, moods, motivations, memory and behavior. His work is also aiding the development of drugs and other treatments for the millions of people who suffer mental disorders caused or aggravated by anxiety. "Joe has been the driving force," Gazzaniga says. "When he started, he was a long-hair ponytail, and maybe some wouldn't have thought him impressive. But there are people who walk in and you see right away that they have it. Joe was one of them."

Assess the Threat

Behind many a long, productive inquiry stands a simple method. For LeDoux, that has been the conditioned response. Like many of his colleagues, LeDoux has used rats, and his basic tool has been the pairing of a tone with a mild electric shock. He puts a rat in a cage, sounds a tone, then sends a mild shock through the metal cage floor. After a few repetitions, the mere sound of the tone, without the shock, makes the rat "freeze" in fear. Such conditioning has been a staple of mind research since Russian physiolo-

gist Ivan Pavlov published his dog studies in 1903. LeDoux's genius—first as a graduate student with Gazzaniga, then as a postdoc and professor at Cornell University from 1977 to 1989, and since then at N.Y.U.—has been to use this simple conditioned response to analyze ever more closely how the rat's brain creates the association of tone and shock and incorporates that learning into future behavior. Of particular interest is the amygdala, the almond-shaped structure near the center of the brain, long considered the seat of emotions.

Startle someone right after she has seen a menacing face, and her memory of that face will strengthen.

In one of LeDoux's first papers, written in 1985, he found that the primary neural pathway for emotional auditory memories—for example, tones or other sounds that instill fear—runs directly from the thalamus (the brain's receiving room for most sensory information) to the amygdala. This is a very quick path—the impulse completes the run in five milliseconds—that bypasses conscious awareness so it can instantly put the body on alert. LeDoux then isolated a second circuit, slower but more information-rich, that heads from the thalamus to the auditory cortex in the brain's "thinking" area (which helps to further define and interpret the sound) before continuing on to the amygdala. To the general alarm created by the first pathway, this longer path adds context from memories, other elements of cognitive awareness, and more complex learned responses.

Tinkering with those paths revealed some interesting phenomena. LeDoux found that if he cut the first pathway, a rat could not develop a new conditioned response; if a tone was paired with a shock, the animal would not learn to fear the tone. But if he destroyed the second, "smart" route in a conditioned rat, it would be unresponsive to virtually all sound, yet it would still freeze when the tone rang. Although the rat was not consciously aware of any noise, its ear passed the tone to its amygdala, which sounded the alarm. If this procedure were done to a human, the person would be functionally deaf but would still jump if a door slammed behind him. The amygdala's most basic reactions take place independent of awareness.

The second, slower loop adds all the information that allows us to identify and react appropriately to the alarming stimulus. This cortical pathway is crucial to what LeDoux calls emotional actions (rather than reactions) that are designed to help a creature avoid, escape or discount a threat. The simpler pathway makes your muscles tense and heart race so that they are ready for action when the smoke alarm in your kitchen goes off. The longer, cortical pathway gives you the assessment that sends you out the door in the case of a fire—or just across the room to turn off the alarm if bread is being singed in the toaster.

Along with defining these pathways, LeDoux has found functional regions in the amygdala that play different roles in communicating with other brain areas. The most vital of these other structures are the hippocampus (a kind of directory for memory storage), the prefrontal cortex (which incorporates sensory information into the "thinking" brain), and the hypothalamus (which in tense situations recruits the adrenal and pituitary glands to mobilize the body for response). By knocking out or isolating the various pathways among these regions, LeDoux has found that the amygdala plays a crucial part not just in acquiring emotionally laden memories but also in consolidating them. Startle someone a few seconds after she has seen a picture of a threatening face—while she is consolidating that memory—and her memory of the face will be strengthened. The memory will also be strengthened if she is startled when she is recalling that threatening face later.

Decide What Matters

LeDoux's earliest studies, then, helped to establish the surprisingly complex dynamics behind our seemingly simplest fear reactions. His subsequent work, and that of others who have built on his platform since the early 1990s, has shown that the amygdala figures heavily in the

(The Author)

DAVID DOBBS (www.daviddobbs.net) is author of *Reef Madness: Charles Darwin, Alexander Agassiz, and the Meaning of Coral* (Pantheon Books, 2005). This is his third profile for *Scientific American Mind*.

more complex human spheres of perception, attention and even social relations. As Ralph Adolphs of the California Institute of Technology, an expert on emotion, memory and social cognition, has put it, the amygdala "pervades the organization of thought and behavior at all levels."

Socially, for instance, patients with amygdala damage often overlook emotionally laden stimuli. They may not recognize an expression of fear on someone's face, and they find all faces more trustworthy and approachable than the rest of us do. They are slightly, happily naive. Similarly, monkeys with amygdala lesions approach other monkeys more quickly and openly than unaffected monkeys do.

The amygdala's recruitment of memory, knowledge and association is also vital to deciding, amid the sensory din coming at us all the time, what matters. In addition to LeDoux's rat studies, high-resolution images of healthy and damaged human brains by N.Y.U. colleague Elizabeth A. Phelps and others, as well as behavioral studies, support this idea. Growing evidence indicates that the amygdala enhances and directs our perception and attention regarding emotions other than fear, such as pleasure or disgust. It makes key parts of our brains more responsive, as well as "stickier" in forming memories and associations.

> The amygdala attunes the brain to threats and joys: a snake on a path, the smile on your child's face.

By attuning the brain to all manner of threats and pleasures—not just the snake on the path but also the smile on your child's face—the amygdala helps to confer emotional significance on a wide range of experiences. The amygdala helps to give life meaning.

One implication is that the amygdala may play a leading role in establishing what consciousness researchers call "salience"—choosing which stimuli we prioritize and therefore of what we are conscious. This Oz-behind-the-curtain power has LeDoux convinced that the amygdala and its subcortical allies, rather than our consciousness, define who we are. "Consciousness may get all the focus," LeDoux notes, "but consciousness is a small part of what the brain does, and it's a slave to everything that works beneath it. I don't think that's what produces our selves." Rather, he says, our identities arise from the unique arrays of learned fears, desires, associations and expectations that are ingrained most fundamentally and broadly in our unconscious.

Attacking Anxiety

Even if the amygdala is not the fount of human experience, its function is certainly fundamental to a pleasant life. As LeDoux notes, fear and its more persistent cousin, anxiety, "are the root of almost all our emotional disorders." More than half of mental health visits in the U.S. every year are for anxiety or related conditions, including post-traumatic stress disorder (PTSD), generalized anxiety disorder, obsessive-compulsive disorder, schizophrenia and depression. Most often anxiety either drives these conditions or makes them unbearable.

Unlike fear, anxiety does not spring from an immediate stimulus; rather it is from our worries or memories, real or imagined. From a LeDouxian perspective, one can view anxiety as a mismatch in traffic capacity between pathways from the ancient amygdala (which appeared in animals that evolved earlier) and the centers of thought, imagination and planning (which humans have so recently developed). LeDoux and others have found many more neural routes running from the amygdala to the cortex than from the cortex to the amygdala. This imbalance may be why our anxieties often control our thoughts, whereas our thoughts have trouble quelling our anxieties. Our imagination easily amplifies and feeds the fears coming from the amygdala and hippocampus, but we cannot send enough controls back to dampen the anxiety. That is why we can seldom calm ourselves by telling ourselves to be calm.

LeDoux hopes that we will soon learn enough about anxiety's neural circuits to be able to correct with drugs or other therapies the truly debilitating conditions that result from this flaw. One neural dynamic that could be exploited is known as extinction—the apparent erasure of a learned fear. Researchers have known for decades that fears are extinguished not because they fade but because new, less threatening associations take their place [see "Can We Cure

Fear?" by Marc Siegel; Scientific American Mind, Vol. 16, No. 4, 2005]. If a rat conditioned to fear a tone subsequently hears the noise repeatedly without receiving any shock, a neutral association slowly replaces the fearful one; at some point the tone will sound and the rat will not react at all.

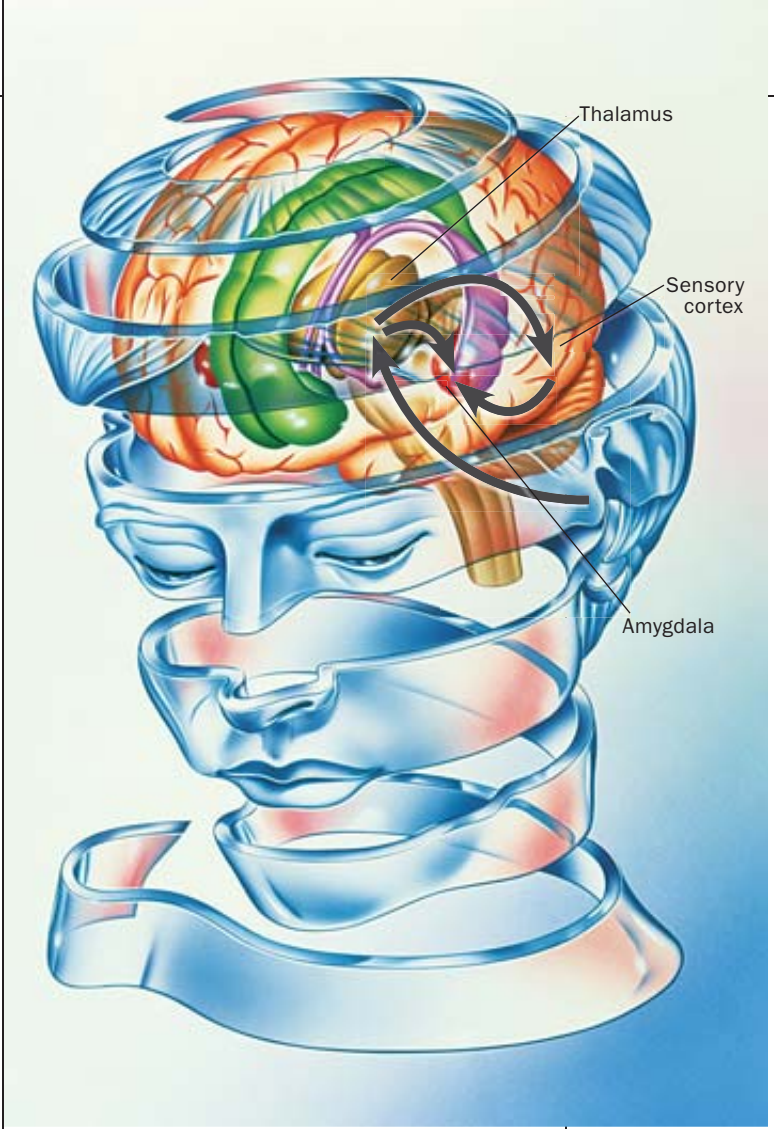
Researchers have recently found that this process relies on the medial prefrontal cortex calming the amygdala. If they can identify the particular neural, molecular or genetic switches for this process, they might be able to design drugs or other treatments that ease the pain of traumatic memories or even erase them. "Some people are uncomfortable with that idea," LeDoux notes, referring to concerns that such treatments could be used in Big Brother fashion to control people's minds or by criminals, say, to erase a victim's memory of a crime. "But they never seem to be people with PTSD. Few object to the idea of improving our memories," he says, nodding at the coffee I am drinking to enhance my own attention and cognition. "I don't see a big difference between improving your aunt's memory and removing a memory that she doesn't want."

As the study of emotions, memory and their implications expands, LeDoux seems certain to remain at the forefront of investigation and understanding. He possesses enormous energy and creativity. And as the director of the Center for the Neuroscience of Fear and Anxiety, which forms collaborative links among leading researchers at N.Y.U., the Rockefeller University, the Mount Sinai School of Medicine and Cornell Medical School, he is part of a network offering stunning resources and intellect.

Lately he has been investigating reconsolidation—the controversial but exciting notion that memories are vulnerable to change, or even erasure, when we recall them. Strengthening the synapses—the junctions between neurons—that hold long-term memories requires protein synthesis, and LeDoux and other researchers have recently found that if this process is disrupted while a long-standing memory is being recalled, the memory can actually be made fleeting [see "Erasing Memories," by R. Douglas Fields; Scientific American Mind, Vol. 16, No. 4, 2005].

Some fears, of course, are universal. Even a rat born from 40 generations of ancestors that were lab animals and had never seen a cat will freeze at the scent of a tabby. People fear the dark, a rattlesnake's rattle, snarling dogs, their own deaths and the deaths of people they love. These seemingly elemental fears rise partly from imagination and partly from foresight. But LeDoux, who has suffered his share of shocks and grief, feels these fears also affirm the things we live for.

"The backside of every positive emotion," he says, "is the fear that you'll lose what makes you happy. Not only do you love your wife, but you're also afraid of what life would be like without her. How much should you trust your positive emotions? How do you focus on and enjoy them and not give in to the fear? These are things we all wrestle with. I'm afraid fear is terribly basic." M



A direct pathway from the thalamus to the amygdala makes you jump when a smoke detector sounds. A secondary, slower path through the sensory cortex assesses if you should run from flames or pop up the burning toast.

JOHN BAVOSI *Photo Researchers, Inc.*

(Further Reading)

- **The Emotional Brain: The Mysterious Underpinnings of Emotional Life.** Joseph LeDoux. Simon & Schuster, 1998.
- **The Synaptic Self: How Our Brains Become Who We Are.** Joseph LeDoux. Penguin, 2003.
- **Contributions of the Amygdala to Emotion Processing: From Animal Models to Human Behavior.** Elizabeth A. Phelps and Joseph E. LeDoux in *Neuron,* Vol. 48, No. 2, pages 175–187; October 20, 2005.

ALAN SCHEIN zefa/Corbis

Do Gays Have a Choice?

Science offers a clear and surprising answer to a controversial question

By Robert Epstein

On a typical summer Saturday morning Matt Avery and his wife, Sheila (not their real names), cook breakfast with their two sons, ages five and eight. Then they get organized with towels, goggles and water wings and load the family into the car for an afternoon at the pool. "Weekends are all about family time," Matt says.

Matt and Sheila have been happily married for 11 years. "She's my soul mate," Matt says. "I wouldn't trade my life for the world."

But some people would claim that Matt's life is based on an illusion—that he could not possibly be a dedicated husband and father. Why? Because Matt used to be gay.

According to the National Gay and Lesbian Task Force and at least a few experts, gays do not have a choice about their sexual orientation. If a man or a woman is born gay, he or she will always be gay. Because Matt was gay for most of his young adulthood (ages 17 to 24), the thinking goes, he must *still* be gay. Pressured by a homomisic society—a society that dislikes and shuns gays—Matt has simply run back inside the closet. Gay activists favor this perspective at least in part because survey data show that people are more sympathetic to gay causes if they believe that sexual orientation is immutable.

The public disclosure by James McGreevey, who announced at an August 2004 press conference that he was resigning as governor of New Jersey, seems to support this view. With his beautiful wife at his side, McGreevey revealed that he was about to be sued by another male for sexual harassment. His announcement suggested, at least to some, that he had always been gay and that his two marriages and two children were somehow less than valid.

Does this perspective have merit? Or are religious conservatives correct in asserting that homosexuality is entirely a matter of choice? A wealth of scientific evidence provides an answer. It turns out that sexual orientation is virtually never a black-and-white matter. Rather it exists on a continuum, with both genes and environment determining where people end up.

Sexual orientation exists on a continuum, with genes and environment determining where people end up.

Biblical Proportions

It is difficult for most people to think objectively about homosexuality, in large part because biases against it are literally of biblical proportions. According to the book of Leviticus, homosexuality—at least when practiced by males—is prohibited, punishable by death. Thousands of American pulpits to this day repeat the old biblical injunctions, which fuel discomfort with homosexuality at every layer of our society.

Until recent decades, prejudice against homosexuality has persisted even in the mental health professions. In the 1970s most therapists still held that homosexuality was a psychological disorder, akin to a disease. In the 1968 edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*)—the indispensable diagnostic tool used by therapists—homosexuality appeared in the section on sexual deviations as an instance of an aberration in which sexual interests are "directed primarily toward objects other than people of the opposite sex."

It was largely gays themselves—understandably tired of being viewed as freaks of nature—who began to assert that their orientation was not pathological. A defining moment came on June 27, 1969, after a police raid on a gay bar in Greenwich Village in New York City provoked a riot. Crowds continued to gather at the site for another five days, protesting discrimination and preaching gay rights. Now called the Stonewall Riots (named after the Stonewall Inn, which was at the center of the melee), they galvanized the modern gay-rights movement in America and initiated a shift toward greater cultural acceptance of homosexuality.

A mere four years later, in 1973, the nomenclature committee of the American Psychiatric Association (APA) set about reassessing the profession's dark characterization of homosexuality. Leading the charge was psychiatrist Robert L. Spitzer of Columbia University [*see box on page 55*]. As a result of his committee's recommendation, the term "homosexuality" disappeared from the next edition of the *DSM*. That hardly settled the matter, however. In a poll of psychiatrists conducted soon after the APA's leadership voted to make the change, 37 percent said they opposed the change, and some accused the APA of "sacrificing scientific principles" in the service of "civil rights"—in other words, of giving in to pressure.

Changing "Truths"

Matt Avery had no doubt about his orientation when he first became sexually active in his teens. During college in the early 1980s, he worked at a gay bar and had hundreds of sexual partners. He also had a four-year relationship with a man. Matt considered himself "feminine." "I was 140 pounds, had long fingernails, a blond ponytail and wore an earring," he reminisces. "I was a sight to be seen."

But when he was 24 his partner returned from a weekend retreat with some incredible news. Be-

KEVIN FLEMING *Corbis*

The Stonewall Riots in Greenwich Village in 1969 initiated a shift toward greater cultural acceptance of homosexuality.

ing gay, his partner said, "wasn't a truth" for him. Matt was distraught. "My whole life," he says, "was defined by whomever I was with—whomever I could use to make up for my own faults." After their sexual relationship ended, they stayed roommates and friends. But then, Matt says, "he started dating this *woman*." This change was another blow, especially because Matt was still seeing multiple men at the time. He was shaken but also curious. "One day," he recalls, "I decided homosexuality might not be a truth for me either, and I went on a date with a woman. It was pretty good."

Within two or three years he found himself involved exclusively with women. He made the shift without therapy and without the influence of religious groups. He was supported, he says, by friends who helped him deal with "issues involving his father." They helped him learn to be comfortable with his masculinity. Matt got to the point where even his sexual fantasies about men disappeared. In that respect, he probably became straighter than many heterosexuals. Although Matt made the switch without professional assistance, others—sometimes under tremendous social pressure from family members or religious groups—seek out "reparative" therapists to help them become straight.

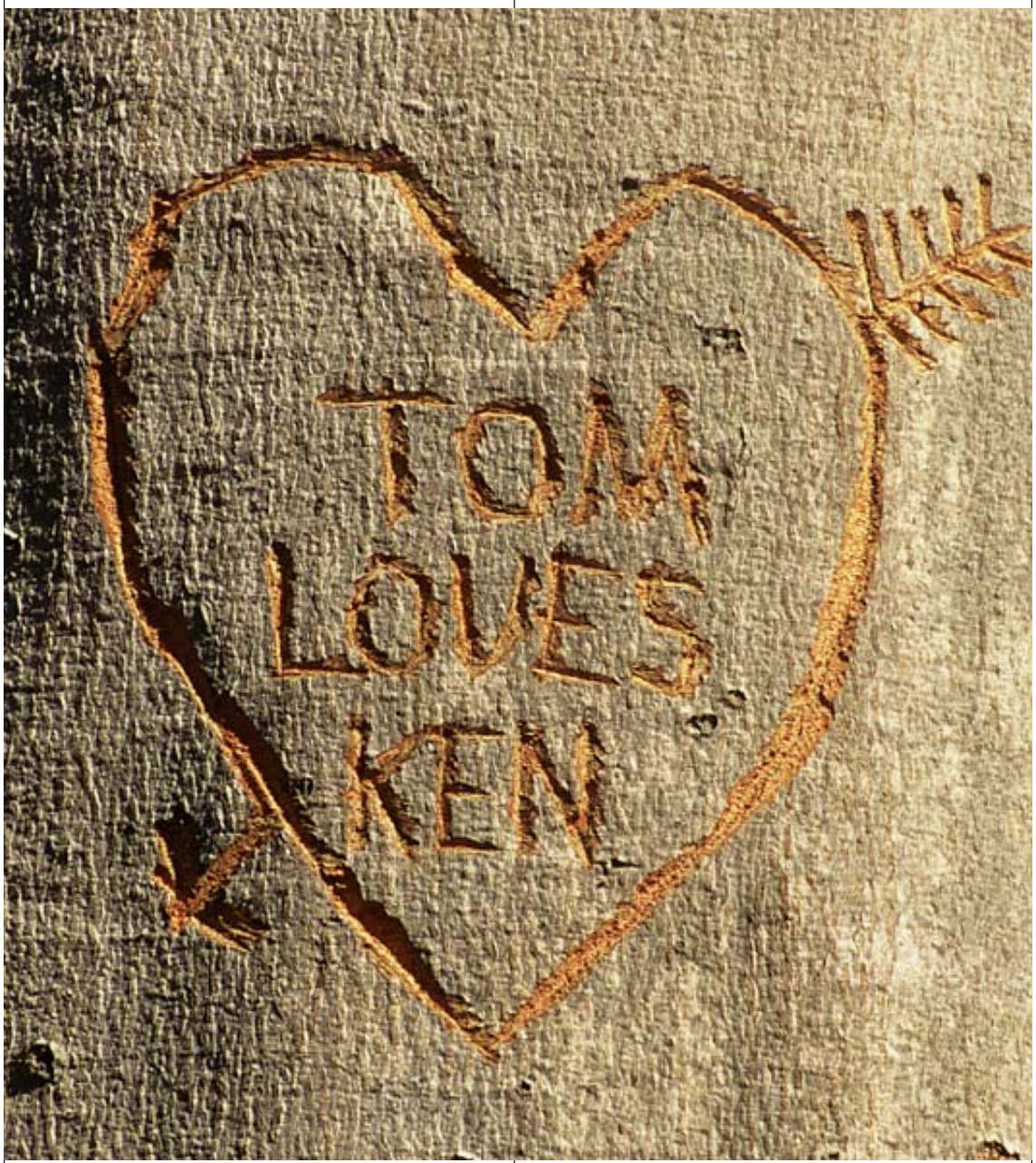
Floyd Godfrey—himself formerly gay—has been a reparative therapist in Arizona for six years. His office has five clinicians, and they see 30 to 40 clients a week, many of whom are men struggling to overcome homosexual tendencies. Godfrey says they come because they are depressed, anxious and unhappy. "They feel out of place," he says. "They don't feel like one of the guys. When people feel like they don't fit in, that can produce depression."

Some, he says, are young men whose fathers were abusive or neglectful. "Their dad was never available for them to bond with. Or sometimes mom was controlling or overprotective. The bottom line," Godfrey says, "is that there was a disruption during childhood of the bond that normally develops between father and son." Deficient upbringing, Godfrey claims, can sometimes lead to same-sex attractions.

Let us set aside the obvious question for the moment—whether the therapy works—and consider a more basic issue. Why is it called "reparative"? Doesn't this term presume that homosexuality is somehow invalid—that gays are like broken washing machines that need to be repaired? In other words, isn't this therapy a retrenchment to the old disease model of homosexuality that Spitzer and his colleagues dispatched more than 30 years ago?

It seems so. Those deeply entrenched notions affect even the way we talk about homosexuality. Even the common term "sexual preference" reflects bias, suggesting that orientation is entirely a matter of choice. As for the claim made by Godfrey and others that homosexuality is the result of poor parenting, there is simply no legitimate

As for the claim that homosexuality is the result of poor parenting, there is no scientific evidence.



AGE FOTOSTOCK

scientific evidence to support it. Whereas it is true that some homosexuals had poor relationships with their fathers when they were growing up, it is impossible to say whether those fathers produced homosexual tendencies in their sons by rejecting them or, instead, whether some fathers simply tend to shun boys who are effeminate at the outset.

As for the effectiveness of reparative therapy—referred to by some as reorientation therapy—initial studies such as a small one published in 2002 by New York psychologists Ariel Shidlo and Michael Schroeder suggested that such therapy worked poorly or only occasionally.

In a landmark study published in the *Archives of Sexual Behavior* in October 2003, however, Spitzer interviewed 200 men and women who once considered themselves homosexuals but who had lived their lives as heterosexuals for at least five years. Most of the participants had un-

Switching Sides?

Robert L. Spitzer was an ardent Trotskyite in his youth, and his father was a Maoist. At one point, he was even the vice president of the NAACP chapter at Cornell University. Maybe his background explains why, in 1972, when the psychiatrist first witnessed a gay protest at a psychology convention, it was he who approached the protesters, not the other way around. He saw social injustice, and he wanted to help.


Spitzer

He told the protesters he was a member of the nomenclature committee revising the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*) for the American Psychiatric Association and that he would ask its members to allow gay activists to present their views. Ultimately, the committee recommended that the term "homosexuality" be eliminated from the *DSM.* The governing board of the APA then voted 13 to 0 (with two abstentions) to accept the recommendation—an extraordinary leap for gay rights in America.

Today Spitzer, now at Columbia University, explains that neither he nor his committee ever meant to suggest that homosexuality was normal or healthy; such a conclusion would be "very wrong." "Just because something is not a mental disorder doesn't mean it's normal," Spitzer explains.

What is more, Spitzer says, the committee was careful to preserve a category of dysfunction—still in the *DSM* today—that allowed unhappy gays to seek change. "Distress" over one's sexual orientation is still listed as a disorder. As a practical matter, he says, this category applies only to gays, not to heterosexuals. "I don't think there are heterosexuals," he says, "who wish they only were attracted to the same sex."

There was "tremendous opposition" to removing "homosexuality" from the *DSM.* How, then, does he account for that unanimous vote? "I think the leadership at that time decided, 'We gotta do this whether we like it or not. We gotta stop the gays from breaking up our meetings. We gotta help them out, and this makes sense.'" He adds: "It helped gays feel better and get treated better. Scientifically it may not have been correct, but socially it sure was."

In 1999 Spitzer entered the sexuality fray again—this time approaching a group of self-proclaimed *ex*-gays who were protesting at a convention. That event led to his controversial recent study, which suggests that some homosexuals can turn straight [*see main text*].

Formerly a hero to gays, Spitzer is now the reluctant darling of the Christian right, and his new research has been labeled "despicable" by a colleague at Columbia. Spitzer sees no contradictions in his actions: "I think of myself as a guy who loves controversy, loves to be where the action is—and I did some courageous things."

—R.E.

COURTESY OF ROBERT L. SPITZER

dergone some form of reorientation therapy. In addition to determining whether such therapy actually worked, Spitzer wanted to know just how dramatically people could alter their orientation. To his surprise, most of his subjects not only reported living long-term (more than 10 years) as heterosexuals, they also declared they had experienced "changes in sexual attraction, fantasy and desire" consistent with heterosexuality. The changes were clear for both sexes.

Not everyone who sets out to change his or her sexual orientation is successful in doing so, however. How can we understand these dynamics—why many people want to change, why some can, and why some appear unable to do so?

Continuity Rules

At the heart of the controversy about homosexuality are some microscopically small objects: the strands of proteins that make up our genes. Two genetic issues are relevant to our understanding of homosexuality. First, do genes play any role in sexual orientation? And second, if genes do help determine orientation, do they actually create two distinct types of orientation—gay and straight, as most people believe—or do they create a continuum of orientation?

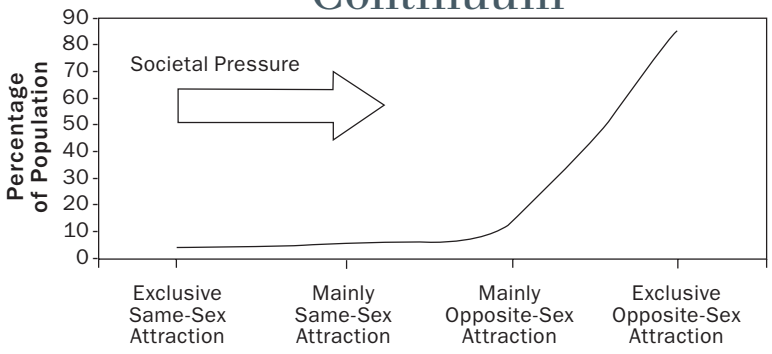
A variety of studies suggest that genes play at least some role in homosexuality. Although no one study is entirely conclusive, studies of twins

(The Author)

ROBERT EPSTEIN, who earned his Ph.D. in psychology at Harvard University in 1981, is the West Coast editor and former editor in chief of *Psychology Today,* a visiting scholar at the University of California, San Diego, and the founder and director emeritus of the Cambridge Center for Behavioral Studies in Concord, Mass. A longtime researcher and professor, he is currently working on a book called *The Case against Adolescence: Rediscovering the Adult in Every Teen.* He thanks Jill Nelson, a writer in California, who provided assistance in the preparation of an early draft of this article.

If people were raised in a truly orientation-neutral culture, what sexual orientation would they express?

The Sexual Orientation Continuum



The author's hypothetical curve, a theoretical extrapolation from statistical data, shows how sexual orientation is probably distributed across a large population. Sexual orientation lies on a continuum: it is not an all-or-nothing state.

raised together, twins raised apart and family trees suggest—at least for males—that the more genes one shares with a homosexual relative, the more likely it is that one will be homosexual—the hallmark of a genetic characteristic. But more interesting for our purposes is the question of a continuum. Sometimes, as with eye color, genes create discrete characteristics. But with many attributes, such as height and head width, genes create continuities. Whereas most people believe that "straight" and "gay" are discrete categories, there is strong evidence that they are not—and this fact has important implications for the way we understand the various controversies surrounding homosexuality.

Ever since the late 1940s, when biologist Alfred Kinsey published his extensive reports on sexual practices in the U.S., it has been clear, as Kinsey put it, that people "do not represent two discrete populations, heterosexual and homosexual.... The living world is a continuum in each and every one of its aspects." A recent position statement by the APA, the American Academy of Pediatrics and eight other national organizations agrees that "sexual orientation falls along a continuum." In other words, sexual attraction is simply not a black-and-white matter, and the labels "straight" and "gay" do not capture the complexities.

For obvious evolutionary reasons, most people are strongly inclined to prefer opposite-sex partners, because such relationships produce children who continue the human race. But a few—probably between 3 and 7 percent of the population—are exclusively attracted to members of the same sex, and many are in the middle. If a person's genes place him or her toward one end of what I call the Sexual Orientation Continuum, he or she almost certainly can never become homosexual [*see illustration at left*]. If the genes place the person at the other end of the curve, he or she almost certainly cannot become straight—or at least not a happy straight. But if an individual is somewhere in between, environment can be a major influence, especially when the person is young. Because society strongly favors the straight life, in the vast majority of cases the shift will be toward heterosexuality.

The way sexuality plays out is eerily similar to the process by which people become left- or right-handed. It may sound contrary to common sense, but scientific studies suggest that genes play a relatively small role in handedness; its heritability—an estimate of what proportion of a trait's variability can be accounted for by genes—is only about 0.32, compared with, say, 0.84 for height and 0.95 for head width. Then why is more than 90 percent of the population right-handed? It is because of that cultural "push" working again. Subtle and not so subtle influences make children favor their right hand, and the flexibility they probably had when they were young is simply lost as they grow up. Although they can still *use* the left hand, their handedness becomes so well established that they would find it difficult, if not impossible, to become left-handed.

Preliminary studies by psychologist J. Michael Bailey of Northwestern University, Michael King of University College London and others suggest that the heritability of homosexuality is not much higher than that of handedness—perhaps in the range 0.25 to 0.50 or so for males and somewhat lower for females. This finding raises an intriguing question: If people were raised in a truly orientation-neutral culture, what sexual orientation would they express? Although it is unlikely that half of us would end up gay, without societal pressure it is clear that a much larger proportion of the population would express homosexuality than we see now.

Matt's Choice

As for Matt, it is likely that he, like most or all people who change sexual orientation, was not near an extreme end of the continuum to begin with. It is unreasonable to say that he has

ROBERT EPSTEIN

How Gay Are You?

To see where you fall on the Sexual Orientation Continuum, take this simple quiz. It is designed to produce a statistically correct distribution along the lines of the continuum shown in the illustration on the opposite page.

How strongly are you attracted to members of the opposite sex?
__ 0 = VERY STRONGLY
__ 1 = MODERATELY
__ 2 = NOT AT ALL

Have you ever felt sexually attracted to a member of the same sex?
__ 0 = NO
__ 1 = YES

Have you ever had a dream about a sexual encounter with a member of the same sex?
__ 0 = NO
__ 1 = YES

Have you ever had a waking fantasy about a sexual encounter with a member of the same sex?
__ 0 = NO
__ 1 = YES

Have you ever voluntarily had sexual contact (such as kissing or petting) with a member of the same sex?
__ 0 = NO
__ 1 = YES

How frequent are your same-sex fantasies or dreams?
__ 0 = NEVER HAD THEM
__ 1 = RARE OR OCCASIONAL
__ 2 = FREQUENT

Have you ever felt sexually aroused when you've had any exposure to two people of your same sex having a sexual encounter (through gossip, a video or some other means)?
__ 0 = NO
__ 1 = YES

Would you be willing to have sexual relations with someone of the same sex?
__ 0 = NO
__ 1 = MAYBE
__ 2 = YES

How frequent are your same-sex encounters?
__ 0 = NEVER HAD THEM
__ 1 = RARE OR OCCASIONAL
__ 2 = FREQUENT

Now add up the numbers and see where you stand:

0–1: Exclusively heterosexual
2–3: Predominantly heterosexual
4–5: Predominantly heterosexual, with homosexual tendencies
6–7: Equally heterosexual and homosexual
8–9: Predominantly homosexual, with heterosexual tendencies
10–11: Predominantly homosexual
12–13: Exclusively homosexual

been returned to a "natural" state, however; with strong social support, he has simply chosen a new path for himself—one that his genes made possible but that is almost certainly not possible for every gay person. Someday I suspect that psychobiological research will allow us to find precise physical correlates of sexual orientation: genes, neural structures or perhaps more subtle physical characteristics. But no advances in science will ever completely resolve the moral and philosophical issues that Matt's conversion raises.

Do gays have a choice? Because of the enormous pressures pushing all of us toward the straight end of the Sexual Orientation Continuum from the time we are very young, it is reasonable to assume that most of the people who currently live as homosexuals were probably close to the gay end of the continuum to begin with; in other words, they probably have strong genetic tendencies toward homosexuality. Even though the evidence is clear that some gays can switch their sexual orientation, the vast majority probably cannot—or at least not comfortably. If you doubt that—and assuming that you are right-handed—try eating with your left hand for a day or two, and good luck with your soup. M

(Further Reading)

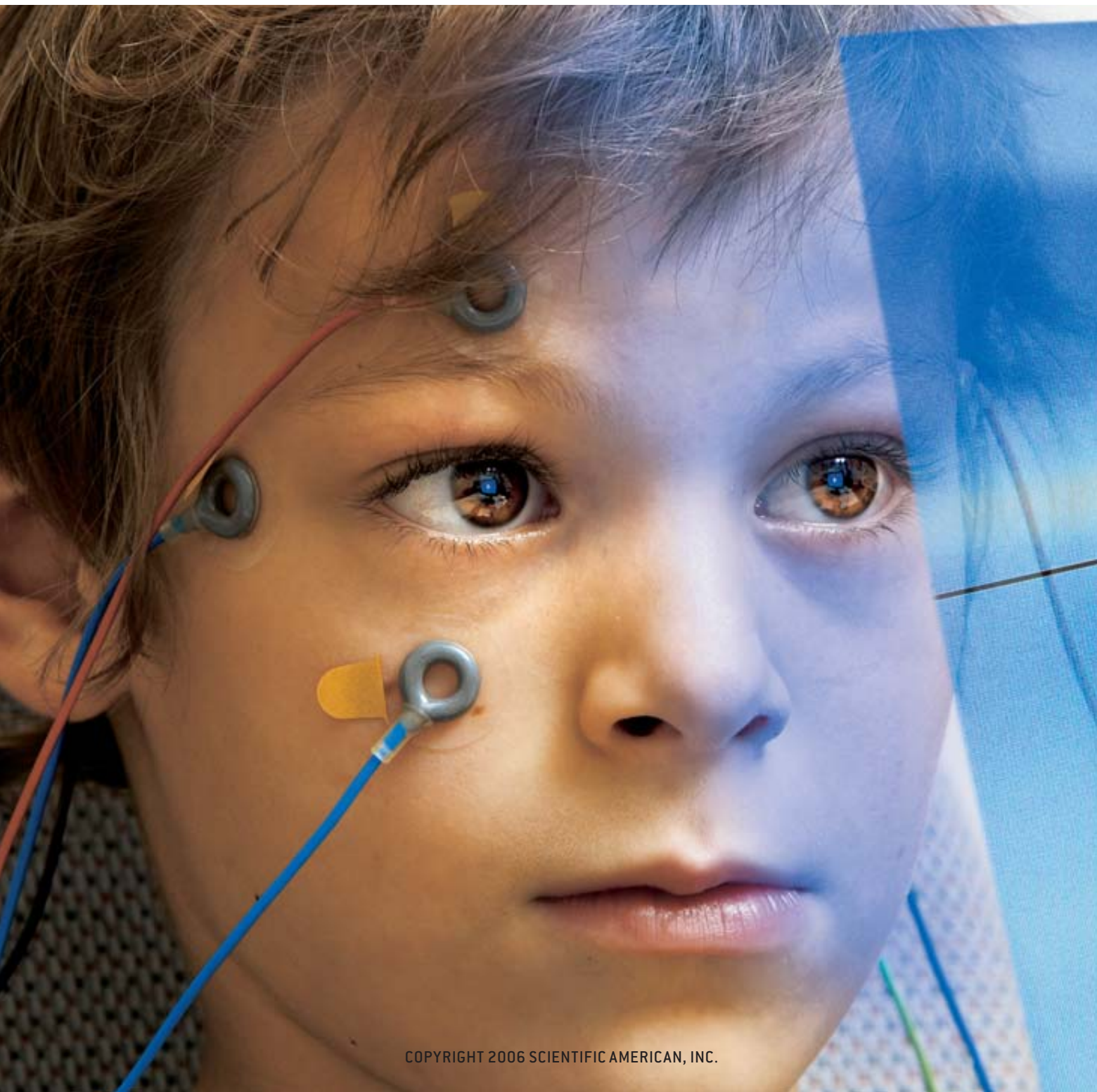
- **Homosexuality and American Psychiatry: The Politics of Diagnosis.** Ronald Bayer. Princeton University Press, 1987.
- **Neurobiology and Sexual Orientation: Current Relationships.** Richard C. Friedman and Jennifer Downey in *Journal of Neuropsychiatry and Clinical Neurosciences,* Vol. 5, No. 2, pages 131–153; 1993.
- **Sexual Behavior in the Human Male.** Alfred Charles Kinsey, Wardell Baxter Pomeroy and Clyde E. Martin. Indiana University Press, 1998.
- **Can Some Gay Men and Lesbians Change Their Sexual Orientation? 200 Participants Reporting a Change from Homosexual to Heterosexual Orientation.** Robert L. Spitzer in *Archives of Sexual Behavior,* Vol. 32, No. 5, pages 403–417; 2003.

DAVID JOHNSON *Workbook*

TRAIN YOUR BRAIN

MENTAL EXERCISES WITH NEUROFEEDBACK MAY EASE SYMPTOMS OF ATTENTION-DEFICIT DISORDER, EPILEPSY AND DEPRESSION—AND EVEN BOOST COGNITION IN HEALTHY BRAINS

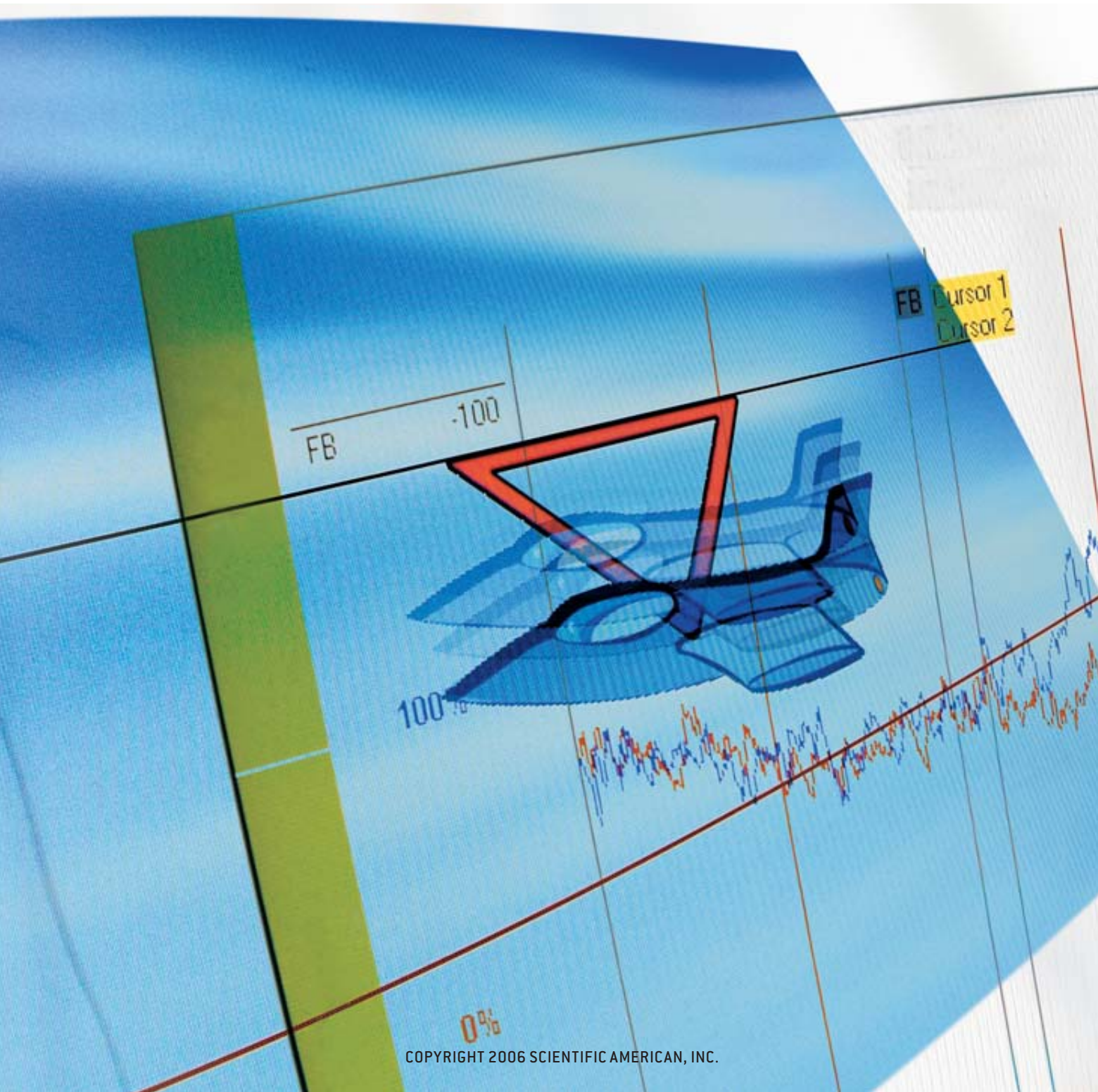
BY ULRICH KRAFT



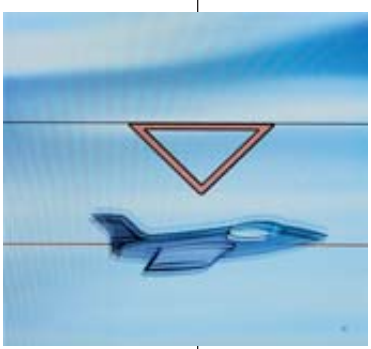
At first the computer game looks awfully easy for an eight-year-old—like something out of the Stone Age of arcades in the 1980s. A red triangle "arrow" appears on the monitor's blue screen, and then the nose of a cartoon airplane glides into view from the left. If the arrow points upward, Ben must make the plane climb. When he succeeds, a spiky yellow sun beams.

A second glance shows that all is not as it seems. For one thing, Ben has no joystick. Instead several electrodes glued to the boy's face and to the skin under his hair let him pilot the plane by thought alone.

Ben is participating in an experiment. The point is to take advantage of neurofeedback—a training tool based on electroencephalography (EEG), the measurement of changes in electrical potential that accompany any brain activity. Electrodes conduct the brain signals, which are then processed by a computer program and fed into the game. The



MANFRED ZENTSCH *Gehirn & Geist*



Neurofeedback training uses an arrow to tell Ben, a participant in an experiment, where to mentally steer an airplane. If he can do it, the "sun" will shine.

plane's motion thus reveals to Ben what just happened in his head. "Through the feedback the children are supposed to learn to deliberately control certain parameters of their brain activity," explains psychologist Ulrike Leins of the Institute of Medical Psychology and Behavioral Neurobiology at the University of Tuebingen in Germany.

Such "mind reading" offers many possible applications. It has, for instance, enabled "locked-in" patients—who cannot speak or gesture—to communicate with caregivers [see "Thinking Out Loud," by Nicola Neumann and Niels Birbaumer; Scientific American Mind, Premier Issue, Vol. 14, No. 5, 2004]. By controlling their brain waves, the patients manipulate letters and words on a computer screen. Practice with neurofeedback may also benefit those who suffer from epilepsy, attention deficits, depression and other debilitating mental disorders. The experimental therapy, also called EEG biofeedback, may even help rev up healthy brains, improving cognitive performance.

From Bio to Neuro

The technique is a high-tech twist on biofeedback—a method long used to treat stress-related disorders. In biofeedback, people see or hear physiological measurements that can indicate stress, such as increases in blood pressure, heart rate or muscle tension. Receiving such information from monitoring devices makes normally undetectable body functions accessible for conscious regulation. A person can realize from listening to his racing pulse, for example, that he is under strain and then learn to bring his heart rate down purposely.

MANFRED ZENTSCH *Gehirn & Geist*

There is no magic formula for learning how to harness one's brain waves.

The first clues that brain waves could be altered intentionally came nearly four decades ago. In the late 1960s sleep researcher M. Barry Sterman learned something interesting while tracking the EEGs of cats. He found a previously unknown pattern of brain waves with frequencies between 12 and 15 hertz (Hz), or cycles per second, in a part of the brain called the sensorimotor cortex. Sterman, now professor emeritus at the University of California, Los Angeles, dubbed this pattern the sensorimotor rhythm, or SMR. SMR was always present, he learned, in relaxed and awake felines. When he rewarded the animals at those moments with snacks, they began to produce stronger SMRs. Through this conditioning experiment, Sterman demonstrated that it is possible to change one's own brain waves deliberately.

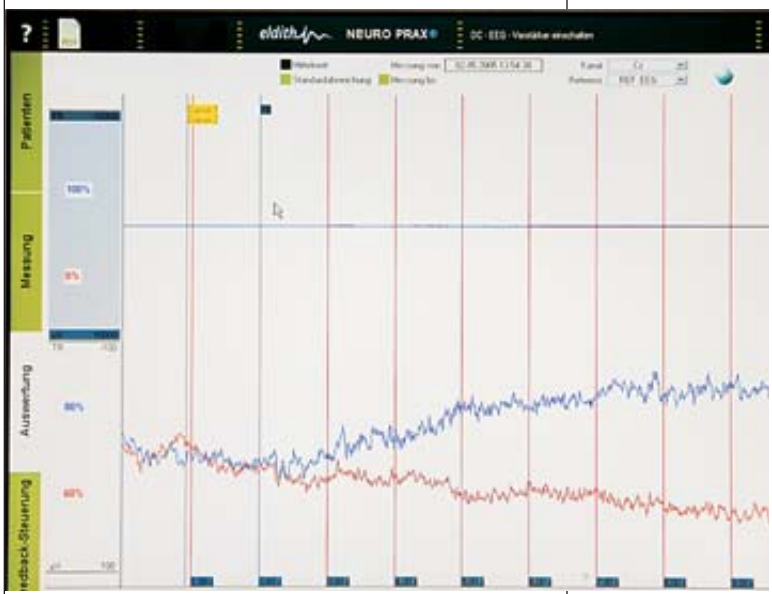
The researcher might well not have followed up on this discovery. But at roughly the same time, he received a request from the U.S. Air Force, which wanted him to test the potential cognitive effects of exposure to monomethylhydrazine, a substance used in some rocket fuels and known to cause seizures. Sterman injected the chemical into cats. About an hour afterward, most of them suffered a seizure. In a few of the subjects, however, the seizure's onset occurred considerably later than usual; three others escaped the convulsions entirely. Seeking an answer for the resistance, Sterman examined his experimental protocol. He observed that the resilient cats had one thing in common: they had previously been involved in his conditioning tests. Could their ability to control their SMR waves have been a factor?

Sterman pursued the question in further experiments. In the early 1970s he found indications that people with epilepsy also could reduce their risk of seizures if they learned to heighten their SMR levels. Yet the idea remained controversial for lack of thorough study.

Brain Control

More than 30 years after Sterman's initial work with SMRs, scientists are exploring how neurofeedback might be used to treat a variety of ailments. In addition to SMRs, other brain waves at different frequencies characterize certain mental states [*see illustration on page 63*]. In deep sleep, for example, delta waves, with frequencies of up to 4 Hz and high amplitudes, dominate. Frequencies around 10 Hz, known as alpha waves, are present in a relaxed but awake brain; they emerge, for example, when we lie back with our eyes closed. If we then begin to concentrate on something, beta waves, with frequencies greater than 13 Hz, travel across the cortex. Lower-frequency theta waves appear when the brain relaxes. Theta waves, with high amplitudes and frequencies falling between those of delta and alpha waves, normally appear in adults during light sleep and meditation.

Regardless of frequency, there is no magic formula for learning how to harness one's brain waves. "Each subject must discover his own individual strategy, by trial and error," Leins explains. To increase brain activity, which steers the video plane upward, many children in the Tuebingen experiment say they think about something exciting—like jumping off a diving board. Ben imagines that he is spending a night camping in the woods. If the directional arrow points down, the boy tries to calm his brain to make the plane dip; in his thoughts, he lies down in bed and naps.



To steer upward, Ben pushes the electrical potential of certain brain waves in an electrically negative (*blue*) direction. Flying down requires a positive direction (*red curve*).

(The Author)

ULRICH KRAFT, a physician and regular contributor to *Gehirn & Geist*, is a freelance science writer in Berlin.

MANFRED ZENTSCH *Gehirn & Geist*

At Tuebingen, researchers working on epilepsy therapy are looking at yet another component of the EEG, called slow cortical potential, or SCP. These brain waves can indicate activity in the cortex. Detecting them is useful, because epileptic seizures begin with overexcitement in cortical neurons, usually in a very limited area, from which brain activity spreads uncontrollably. The SCPs of patients shift in an electrically negative direction just before a seizure. Such negative slow potentials also arise normally in the brain. Therefore, the goal of neurofeedback is for patients to come to recognize this onset of electrical negativity and then to push their SCPs in the positive direction. Patients learn to limit brain activity consciously, thus suppressing an epileptic attack.

The method seems promising. In a 2001 study Niels Birbaumer and his colleagues at Tuebingen worked with epileptics who had not been helped by conventional medical therapies. On average, patients using SCP neurofeedback were able to reduce the number of seizures they suffered by a third. The positive effects lasted long after the training sessions had ended.

After the sessions, the subjects performed better on evaluations of their attention and intelligence.

Mental Aerobics

Beta waves are the target of therapies for children with attention-deficit hyperactivity disorder, or ADHD. "It is exactly these higher-frequency brain waves that are, in children with ADHD, weaker compared with those in healthy children," Leins states. In the U.S., more than 700 groups are using EEG biofeedback to treat ADHD, according to the Association of Applied Psychophysiology and Biofeedback.

Children with ADHD struggle with schoolwork and social skills because they are restless, impulsive and have difficulty concentrating. Reduced levels of the higher-frequency brain waves are especially noticeable in the prefrontal cortex, an area involved in attention control. The kids also have an increase in lower-frequency waves, especially theta waves from 4 to 7.5 Hz. With neurofeedback, Leins says, "our ADHD subjects train their brains to produce fewer theta waves and thereby more beta waves."

Today Ben makes 45 "hits"—times when he has successfully lifted or lowered his brain activity at will. He gets five points on a gift card, and then he is free to leave. His mental exercises are not over for the day, however. Ben has been told to practice brain control in his everyday life, too. Before beginning homework, for example, he is to first imagine sinking a couple of baskets. Revving up the brain in this manner seems to help kids like Ben focus. "Many children say they can concentrate better after it and complete their homework more quickly," Leins says.

Children in the Tuebingen experiment train for 30 hours. The researchers measure their cognitive performance immediately before and after treatment, using standardized tests especially geared to monitor attention. Six months after the therapy, they are checked again. After the neurofeedback sessions, the subjects performed better on evaluations of their attention and intelligence. Teachers reported that they were quieter and less impulsive in class. Many parents also said that their children had fewer problems doing homework. Leins sees these results as positive, though not definitive. "What we still lack are controlled studies of many children, which would compare this technique with other therapeutic methods," the researcher says.

Balancing Act

Many mental illnesses are accompanied by unusual brain-wave patterns, a fact that offers another possible therapeutic application for neurofeedback. Whether these variations are the cause or effect of such disorders is not always clear. At the least, the presence of such uncommon patterns may hinder recovery. In the early 1990s, for example, Richard J. Davidson, professor of psychology and psychiatry at the University of Wisconsin–Madison, noticed unusual asymmetries in the brain-wave patterns of people with depression. Apparently the distribution of alpha activity between the anterior parts of the right and left hemispheres can be associated with mood. Among depressive subjects, the pendulum swung to the right; their left hemispheres were comparatively less active.

With that in mind, psychologist J. Peter Rosenfeld of Northwestern University is trying to

ease depression with neurofeedback. If patients could correct their own brain-wave patterns, Rosenfeld posits, they might be able to lift the gloom from their minds. So he and psychologists Elsa Baehr and Rufus Baehr of the NeuroQuest Neurofeedback Center in Evanston, Ill., developed a neurofeedback training program in the mid-1990s. Whenever the amplitude of alpha waves in the left frontal cortex rose above that in the right, the participants would hear a pleasant note played on a clarinet. During sessions lasting 15 to 30 minutes, the subjects worked to learn how to keep the tone in their ears for increasingly longer periods.

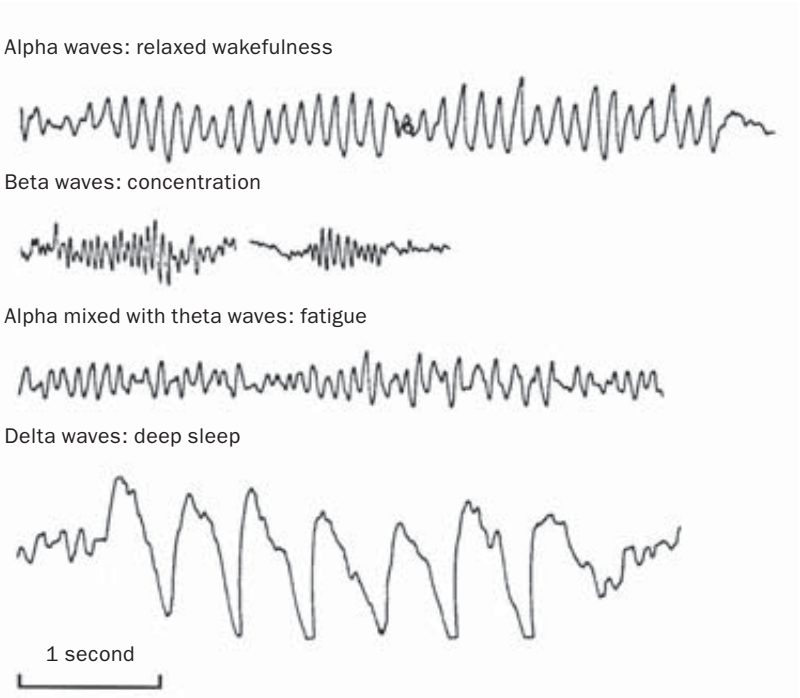
One spectacular case involved a woman who had previously been treated for recurrent bouts of depression for 12 years, without success. After just 35 hours of training, in combination with psychotherapy, her symptoms decreased drastically. In the subsequent six-year tracking period, she remained free of depression. Although the scientists can also point to successes with EEG feedback among other patients with depression, Elsa Baehr urges caution. "This is an experimental protocol," she notes. "Until there are controlled studies, we won't know how effective the therapy is."

Brain Boost?

In addition to therapies, could neurofeedback improve cognition in healthy brains? NASA, for one, has been using EEG biofeedback for years to increase concentration in its pilots.

To find out more, psychologist David Vernon, now at Canterbury Christ Church University in England, asked 40 volunteers to come to his lab. He and others wanted to find out whether deliberately influencing certain brain-wave patterns could boost working memory—which temporarily stores and manages information required to carry out complex cognitive tasks such as learning or reasoning. He first presented his subjects with a list of words. Then he gave them a category, such as "animals," and asked them to recall as many words from the list as possible that fit into that grouping.

Before training, the participants were able to remember just 71 percent of the words. In eight sessions, they learned to strengthen their SMRs—the same patterns that Sterman had worked with. After training, Vernon tested his subjects again, and this time they could remember almost 82 percent of the words. Vernon's group announced the results in January 2003. "Here we have the first evidence of a connection between neurofeedback and improvement in memory," Vernon claims.



Brain waves at certain frequencies characterize specific mental states.

A study published in 2003, carried out at Imperial College London, supports the notion that brain-wave training can improve cognition. Neuroscientists Tobias Egner, now at Columbia University, and John H. Gruzelier recruited test subjects at the Royal College of Music, London's elite school for promising young musicians. Some of the subjects learned, via feedback on a computer screen, how to control the slow waves in the alpha and theta ranges. After neurofeedback, the musicians' abilities had grown enormously, according to expert evaluators. The improvements came in such various areas as musical understanding, stylistic precision and imaginative interpretation. What is more, the students made significantly fewer mistakes.

If further experiments confirm such results, neurofeedback may offer a suite of applications. Gruzelier, for example, is considering how SMR reinforcement could be used to train people whose professions require exceptionally steady hands, such as eye surgeons. M

(Further Reading)

- **The Effect of Training Distinct Neurofeedback Protocols on Aspects of Cognitive Performance.** D. Vernon, T. Egner et al. in *International Journal of Psychophysiology,* Vol. 47, No. 1, pages 75–85; January 2003.
- **EEG Biofeedback of Low Beta Band Components: Frequency-Specific Effects on Variables of Attention and Event-Related Brain Potentials.** T. Egner and J. Gruzelier in *Clinical Neurophysiology,* Vol. 115, No. 1, pages 131–139; 2004.

GEHIRN & GEIST

Fighting Parkinson's

KENNETH LAMBERT *AP Photo*

The disease remains incurable, but research advances point to better treatments for this increasingly common disorder

By Konrad Schmidt and Wolfgang Oertel

The list of celebrities who have largely disappeared from public view because of Parkinson's disease has become familiar to many: boxer Muhammad Ali, former attorney general Janet Reno, actor Michael J. Fox. Pope John Paul II and others have died from the brain disorder. But they are only the most visible of its many victims: today four million people worldwide have the disease, with 500,000 to one million in North America. About 1 percent of the population older than 60 acquires Parkinson's, and as life expectancies climb, the number of victims is predicted to double by 2040. And yet

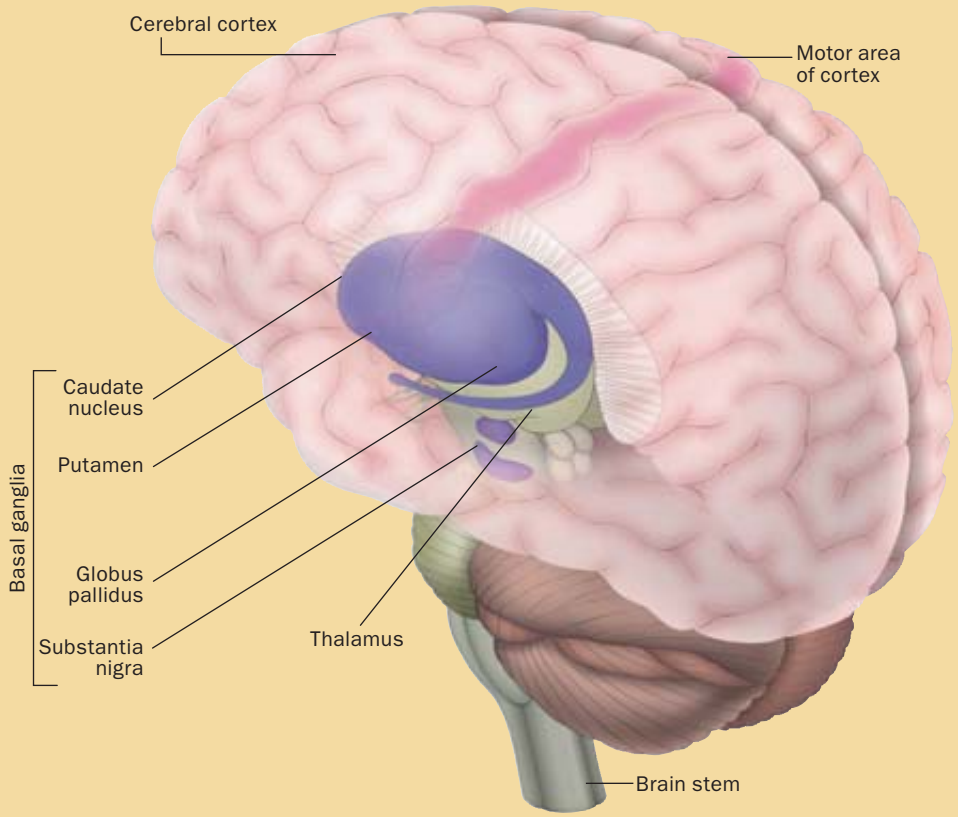
fully half of all patients show symptoms before age 60, in some cases as early as 35 or 40. Medical science is increasingly challenged to find the cause and to develop effective therapies.

Although investigators have bettered their understanding, the cause of Parkinson's remains unclear—and until it is pinned down, the disease cannot be prevented or stopped. Nevertheless, recent insights into how the ailment prompts brain proteins to malfunction and into the root genetic causes of those malfunctions and other harmful molecular processes are providing some optimism for new treatments.

Former boxer Muhammad Ali and actor Michael J. Fox mock a fight to symbolize their battle against Parkinson's, before testifying at Senate hearings in 2002.

Losing Motor Control

Most cell death underlying Parkinson's disease occurs in the substantia nigra, which controls voluntary movement and helps to regulate mood. Although the rest of the brain can initially compensate, it can no longer do so when 50 to 80 percent of the cells in the substantia nigra have been lost. At that point, other parts of the brain engaged in motor control, including the rest of the basal ganglia, the thalamus and the cerebral cortex, can no longer work together, and movement becomes disjointed and uncontrollable.



Cause Not Clear

When diagnosed early, Parkinson's symptoms can be managed fairly successfully with drugs for as long as eight to 15 years. But often the malady is not recognized soon enough, because it begins with very nonspecific symptoms. Tense muscles in an arm or shoulder, for example, tend to send people to orthopedists, not neurologists. Fatigue, depression or sudden outbreaks of sweating are typically pegged to other common problems.

These conditions often remain mild for a long time; nine to 12 years can pass before the disease fully asserts itself. But by then a large percentage of cells in certain brain regions have already died. Individuals begin to lose their fine-motor coordination: they cannot thread a needle, and their handwriting becomes tiny and hard to read. Soon everyday tasks such as combing hair, buttoning a shirt or tying shoes become impossible. Telltale tremors—uncoordination among larger muscle groups—can set in. Patients become dependent on others, and their quality of life declines dramatically. As movement slows, so do mental processes. Thinking drags, and speech drawls. Half of all patients suffer from depression or anxiety disorders, and a third slip into full-blown dementia.

British physician and pharmacist James Parkinson first described the condition that now bears his name in 1817. Because of his patients' striking tremors, he dubbed it "shaking palsy." This was a double misnomer, we now know, because Parkinson's is not a palsy and does not necessarily lead to trembling. The cardinal symptom is a general and progressive difficulty with

SARA CHEN

movement, followed by deterioration in mental function.

Scientists have known since the late 1920s that as the disease advances, neurons in the midbrain die off. Most affected is the basal ganglia, which controls the automatic execution of learned movements [*see box on opposite page*], such as walking or reacting to a sudden slip on ice. The part of the basal ganglia most critically affected is the substantia nigra, a nugget of neurons that produce dopamine. This neurotransmitter is vital to the fluid execution of all body movements and also regulates mood. When dopamine production sags, the midbrain cannot function properly, exacerbating the problem.

The thalamus, which serves as a central switchboard for the midbrain, also depends on dopamine. As dopamine levels fall, the thalamus can no longer work well with the cerebral cortex, and certain mental functions become difficult to carry out. Neurons in other regions may try to compensate, with some success early on. And yet the cooperation can also lead to highly synchronized impulses that can cause a person's fingers, hands or legs to tremble, as if signals are falling into a reverberation that tells muscles to twitch repeatedly.

Neuroscientists still cannot say definitively what triggers the trouble. In some cases, physical brain damage from accidents or blows to the head from boxing, for example, may start the process. Heavy metals and pesticides such as paraquat as well as rotenone, used in organic farming, have also been implicated by some epidemiological and animal studies.

Though lacking a culprit, experts concur that some mechanism causes brain proteins to misfold, which in turn kills neurons. A genetic defect is involved in 5 to 10 percent of cases, and the aberrations provide interesting clues. To date, researchers have identified defects in nine gene loci, and at least four of them affect protein processing. In some cases, neurons become fatally clogged with their own proteins. In other instances, the genetic control of energy usage in neuron mitochondria—the cells' power plants—falters, and the cells shut down. As cells die, dopamine production wanes.

Drugs Treat Symptoms

Propping up dopamine production has been the central strategy in alleviating Parkinson's symptoms. The crucial breakthrough was development of the drug levodopa, or L-dopa, a precursor compound that the brain converts into dopamine. Unlike dopamine, L-dopa can pass through the blood-brain barrier—a membrane that surrounds the brain and prevents harmful substances from entering.

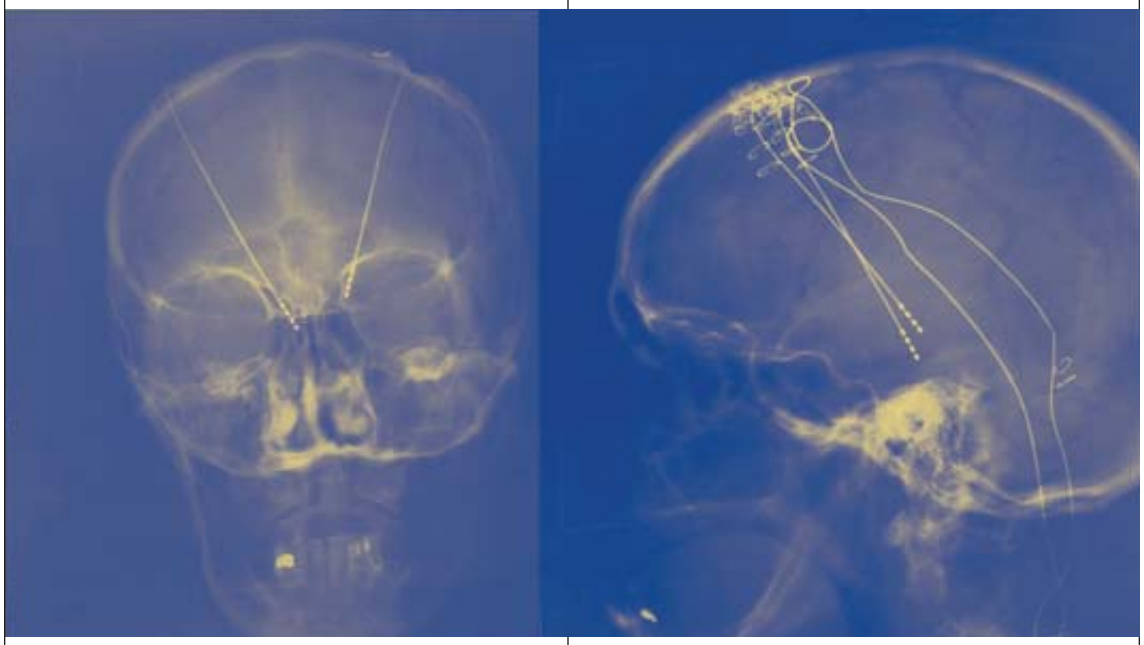
The initial effects of L-dopa are impressive: muscle mobility returns, and patients can once again take part in life. But after a few years doctors find it increasingly difficult to determine the right dosage, because the dopamine receptors in the striatum become extremely sensitive as the disease progresses. Also, only a few neurons may remain that can control and moderate levels of dopamine in the brain. Overdoses lead to uncontrollable, exaggerated movements, whereas underdoses offer no help at all. Many patients swing between the extremes and report that this experience is worse than the symptoms would be without medication.

Another class of substances, called dopamine agonists, can help by imitating the function of dopamine. These include bromocriptine, cabergoline, pramipexole and ropinirole, among others. Even though they are not initially as effective as L-dopa, over time they are easier to dose correctly. Yet patients—especially older ones—may suffer from nausea, vomiting or even hallucinations. For some people, combining an agonist with L-dopa seems to offer the best relief.

Difficulty finding the right combination and level of drugs has focused a large portion of Parkinson's research on better medication protocols. The many years of experiments, testing and safety proofs have driven the costs of drugs that do make it to market sky high. A typical regimen costs $200 or more a month.

An alternative therapy target, which may be more effective, is a growth factor called GDNF, for glial cell line–derived neurotrophic factor, a protein important to the survival of nerve cells. In apes the substance has been found to aid in cell regeneration and to slow the death of additional neurons. In 2002 Steven Gill and his colleagues

Physicians are placing their hopes on stem cells, which have reversed some symptoms in monkeys.



Electrodes implanted deep in the brain deliver impulses from a battery-powered "pacemaker" implanted near the collarbone, to quiet misfiring neurons.

at the University of Bristol in England administered the protein to five patients with advanced Parkinson's disease via a catheter that led directly to the striatum, the main recipient of dopamine normally produced by the basal ganglia. Symptoms were lessened, and dopamine uptake was improved. But in a larger trial in 2004 by Amgen Corporation, patients who received GDNF fared no better than those who received placebos. Amgen later announced concerns about GDNF's safety, too.

A naturally occurring protein called KDI tripeptide might provide another answer. In November 2005 researchers from the University of Helsinki in Finland announced promising test results at the Society for Neuroscience annual meeting. They first gave rats a drug known as 6-hydroxy-dopamine, which is widely used to mimic Parkinson's disease. Rats who later received an injection of KDI did not show the subsequent, massive neuron destruction that took place in rats that did not receive the tripeptide. More rat tests with KDI are under way.

Deep-Brain Stimulation

The sad reality is that for many patients, drugs eventually lose their effectiveness. Neurosurgery is then the only option. In the 1960s and 1970s surgeons simply cut out compromised parts of the brain or destroyed them by injecting alcohol. Since the mid-1990s doctors have increasingly improved the more elegant approach of deep-brain stimulation. A surgeon implants several thin platinum wires—electrodes—into one of two regions of the basal ganglia, near the thalamus. A battery and controller implanted under the skin near the collarbone or abdomen send tiny, timed currents into the region to improve neuron firing.

The surgery is extremely difficult and expensive, demanding incredibly delicate procedures in the core of the brain. For one thing, the electrodes must not damage any blood vessels, which could cause stroke or paralysis. On the plus side, because no pain receptors exist in the brain, the patient can be conscious during the operation. Being awake and aware is a decisive advantage—surgeons ask patients questions, and the responses can indicate whether any important brain function is being damaged.

If the operation succeeds, a substantial reduction in muscle tremors and rigidity often occurs. Using a remote control to adjust the stimulation, patients who once could hardly move can now walk smoothly across a room. This state of improvement can last for years and allows people to decrease their drug dosages significantly. But deep-brain stimulation does not sharpen mental functions or stop the disease from progressing and can affect adjacent parts of the brain, which can lead to deafness, speech disorders and balance problems.

(The Authors)

KONRAD SCHMIDT is a physician and science writer in Potsdam, Germany. WOLFGANG OERTEL heads the Clinic for Neurology at Philipps University of Marburg and is spokesperson for the Competence Network on Parkinson's Disease, which coordinates research among multiple institutes in Germany.

MICHAEL F. LEVESQUE *Neurogeneration.com*

The ultimate goal for researchers, of course, is a cure. One idea is to simply replace the neurons that have died. But almost all attempts at transplanting cells from the patient's own body or from animal donors have failed. One prospect lies in the implantation of human retinal epithelial pigment cells. These cells, taken from infants who have unfortunately died, are capable of producing L-dopa and grow well in the lab. In a 2002 pilot study Ray L. Watts, now at the University of Alabama at Birmingham, implanted such cells into the striatum of six Parkinson's patients. Using a standard rating scale to measure their progress, Watts found that six months later all the patients had improved, on average, by 42 percent. Larger studies are now under way.

Physicians are also placing great hopes on stem cells, which can mature into any type of cell. They are found not just in embryos but in adults as well. A reservoir lies in the subventricular zone of the midbrain, a source of new neurons that are needed to preserve the brain's plasticity. The hippocampus, necessary for memory, is particularly reliant on a constant flow of these cells.

Jun Takahashi of Kyoto University in Japan is trying to transform embryonic stem cells into dopamine-producing neurons by means of natural growth factors. These cells would then be transplanted into patients. In January 2005 Takahashi was able to reverse some Parkinson's symptoms in monkeys using this approach. Stem cell methods are fraught with ethical and political complications, however, because in many lines of research they are much more effective when obtained from fetuses than from adults.

That is one reason why researchers are looking deeper, into genetic programming itself. Ultimately, if faulty genes cause Parkinson's, testing those genes and fixing them could offer a cure. Several groups are now experimenting with gene-based therapies. The idea is to use specially modified viruses to carry genes into the midbrain. The genes would then activate certain enzymes that release or transport dopamine. Initial animal tests show promise, but many scientists remain skeptical about gene therapy because there is too little experience so far to gauge its benefits and risks adequately.

As research continues, and even if potential cures are found, a patient's quality of life is a critical factor in weighing treatment plans. A caring social environment can often reduce psychological symptoms to a heartening degree, and regular therapeutic exercises can promote mobility.

Many victims are very inventive in how they deal with daily life. Some wear headphones and blast themselves with music, which forces them to speak louder and more clearly. They place patterns on the carpet to guide their footsteps. They wear special glasses, crafted with what is called the Parkaid system, that lessen the risk of perceptual faults that lead to falls. And they use a special computer mouse, such as those designed by IBM, that enables them to deftly move a cursor across a screen despite their tremors.

Other individuals try to engage in practices that naturally boost dopamine levels—practices that could help forestall the disease if it is detected early enough. Regular athletic activity, which may raise dopamine levels, can lessen symptoms. A 2005 study by Alberto Ascherio of the Harvard School of Public Health indicated that for men, athletics halves the risk of Parkinson's onset.

The same effect has also recently been ascribed to nicotine and caffeine. A 2004 study by Nancy L. Pedersen of the Karolinska Institute in Stockholm confirmed results of earlier work: smokers apparently fall victim to Parkinson's disease less frequently than nonsmokers. In tests on lab animals, nicotine (not the tobacco itself, which has long-known deleterious effects) seems to stimulate the release of dopamine in the striatum, and caffeine seems to enhance the uptake of dopamine. More research is needed in clinical trials to determine if these substances actually help people. M

> Regular exercise, which may raise dopamine levels, can **lessen risk**, especially for men.

(Further Reading)

- **Dopamine Depletion Impairs Precursor Cell Proliferation in Parkinson Disease.** G. U. Hoeglinger in *Nature Neuroscience,* Vol. 7, No. 7, pages 726–735; 2004.
- **Physical Activity and the Risk of Parkinson Disease.** H. Chen et al. in *Neurology,* Vol. 64, No. 4, pages 664–669; 2005.
- National Parkinson Foundation: **www.parkinson.org**

Photographs prove tricky to many toddlers because they have not mastered dual representation: awareness that a symbolic object is itself (in this case, a photograph) as well as a representation of something else (a sneaker). Many try to interact with objects in photographs, such as attempting to put a foot in a shoe.

Mindful of SYMBOLS

On the way to learning that one thing can represent another, young children often conflate the real item and its symbol. These errors show how difficult it is to start thinking symbolically

BY JUDY S. DeLOACHE

Photographs by Randy Harris

About 20 years ago I had one of those wonderful moments when research takes an unexpected but fruitful turn. I had been studying toddler memory and was beginning a new experiment with two-and-a-half- and three-year-olds. For the project, I had built a small-scale model of a room that was part of my lab. The real space was furnished like a standard living room, with an upholstered couch, an armchair, a cabinet and so on. The miniature items were as similar as possible: they were the same shape and material, covered with the same fabric and arranged in the same positions. For the study, a child watched as we hid a miniature toy—a plastic dog we dubbed "Little Snoopy"—in the model, which we referred to as "Little Snoopy's room." We then encouraged the child to find "Big Snoopy," a large version of the toy "hiding in the same place in his big room." We wondered whether children could use their memory to figure out where to find the toy in the large room.

The three-year-olds were very successful. After they observed the small toy being placed behind the miniature couch, they ran into the real room and found the large toy behind the real couch. But the two-and-a-half-year-olds, much to my and their parents' surprise, failed abysmally. They cheerfully ran into the big room, but most of them had no idea where to look, even though they remembered where the tiny toy was hidden in the miniature room and could readily find it there.

Their failure to use what they knew about the model to draw an inference about the room indicated that they did not appreciate the relation between the model and room. I soon realized that my memory study was instead a study of symbolic understanding and that the younger children's failure might be telling us something interesting about how and when youngsters acquire the ability to understand that one object can stand for another.

What most distinguishes humans from other creatures is our ability to create and manipulate a wide variety of symbolic representations. This capacity enables us to transmit information from one generation to another, making culture possible, and to learn vast amounts without having direct experience—we all know about dinosaurs despite never having met one. Because of the fundamental role of symbolization in almost everything we do, perhaps no aspect of human development is more important than becoming symbol-minded. What could be more fascinating, I concluded, than finding out how young children begin to use and understand symbolic objects and how they come to master some of the symbolic items ubiquitous in modern life?

Pictures Come to Life

The first type of symbolic object infants and young children master is pictures. No symbols seem simpler to adults, but my colleagues and I have discovered that infants initially find pictures perplexing. The problem stems from the duality inherent in all symbolic objects: they are real in and of themselves and, at the same time, are representations of something else. To understand them, the viewer must achieve dual representation: he or she must mentally represent the object as well as the relation between it and what it stands for.

A few years ago I became intrigued by anecdotes suggesting that infants do not appreciate the dual nature of pictures. I would hear of a baby who tried to pick up a depicted apple

or to fit a foot into a photograph of a shoe. My colleagues—David H. Uttal of Northwestern University, Sophia L. Pierroutsakos of St. Louis Community College and Karl S. Rosengren of the University of Illinois—and I decided to investigate even though we assumed such behaviors would be rare and therefore difficult to study. Fortunately, we were wrong.

We began testing infants' understanding of pictures in a very simple way. We put a book containing highly realistic color photographs of individual objects in front of nine-month-olds. To our surprise, every child in the initial study, and most in our subsequent studies, reached out to feel, rub, pat or scratch the pictures. Sometimes the infants even grasped at the depicted objects as if trying to pick them up off the page.

> Symbolic representation **enables us to learn** vast amounts about dinosaurs despite never having met one.

We had a unique opportunity to see how universal this response was when anthropologist Alma Gottlieb of the University of Illinois took some of our books and a video camera to a remote Beng village in Ivory Coast. Beng babies sat on the ground or in their mother's lap as chickens and goats wandered around and other children and villagers played, worked, talked and laughed nearby. Yet the Beng babies, who had almost certainly never seen a picture before, manually explored the depicted objects just as the American babies had.

The confusion seems to be conceptual, not perceptual. Infants can perfectly well perceive the difference between objects and pictures. Given a choice between the two, infants choose the real thing. But they do not yet fully understand what pictures are and how they differ from the things depicted (the "referents"), and so they explore: some actually lean over and put their lips on the nipple in a photograph of a bottle, for instance. They only do so, however, when the depicted object is highly similar to the object it represents, as in color photographs. The same confusion occurs for video images. Pierroutsakos and her colleague Georgene L. Troseth of Vanderbilt University found that nine-month-olds seated near a television monitor will reach out and grab at objects moving across the screen. But when objects bear less resemblance to the real thing—as in a line drawing—infants rarely explore them.

By 18 months, babies have come to appreciate that a picture merely represents a real thing. Instead of manipulating the depicted object, they point to it and name it or ask someone else for the name. In 2004 Melissa A. Preissler of Yale University and Susan Carey of Harvard University provided a good example of this development. The two researchers used a simple line drawing of a whisk to teach 18- and 24-month-olds the word for this object that they had not seen before. Most of the children assumed the word referred to the object itself, not just to the picture of it. They interpreted the picture symbolically—as standing for, not just being similar to, its referent.

One factor we think contributes to the decline of manual exploration of pictures is the development of inhibitory control. Throughout the first years of life, children become increasingly capable of curbing impulses. This general developmental change is supported by changes in the frontal cortex. Increased inhibitory control presumably helps infants restrain their impulse to interact directly with pictures, setting the stage for them to simply look, as adults do.

Experience with pictures must play a role in this development as well. In an image-rich society, most children encounter family photographs and picture books on a daily basis. From such interactions, children learn how pictures differ from objects, and they come to appreciate images as targets of contemplation and conversation, not action.

Nevertheless, it takes several years for the nature of pictures to be completely understood. John H. Flavell of Stanford University and his colleagues have found, for example, that until the age of four, many children think that turning a picture of a bowl of popcorn upside down will result in the depicted popcorn falling out of the bowl.

Pictures are not the only source of symbol confusion for very young children. For many years, my colleagues and students and I watched toddlers come into the lab and try to sit down on the tiny chair from the scale model—much to the astonishment of all present. At home, Uttal and Rosengren had also observed their own daughters trying to lie down in a doll's bed or get into a miniature toy car. Intrigued by these remarkable behaviors that were not mentioned in the scientific literature, we decided to study them.

Scale errors, another example of failed dual representation, are common among 18- to 30-month-olds. They interact with small objects as they would with larger versions. This boy kept falling off the chair. (In experiments, objects can be even smaller.)

Gulliver's Errors

We brought 18- to 30-month-old children into a room that contained, among other things, three large play objects: an indoor slide, a child-size chair and a car toddlers could get inside of and propel around the room with their feet. After a child had played with each of the objects at least twice, he or she was escorted from the room. We then replaced the large items with identical miniature versions, only about five inches tall. When the child returned, we did not comment on the switch and let him or her play spontaneously.

We then examined films of the children's behavior for what we came to call scale errors: earnest attempts to perform actions that are clearly impossible because of extreme differences in the relative size of the child's body and the target object. We were very conservative in what we counted as a scale error.

Almost half the children committed one or more of these mistakes. They attempted with apparent seriousness to perform the same actions. Some sat down on the little chair: they walked up to it, turned around, bent their knees and lowered themselves onto it. Some simply perched on top, others sat down so hard that the chair skittered out from under them. Some children sat on the miniature slide and tried to ride down it, usually falling off in the process; others attempted to climb the steps, causing the slide to tip over. (With the chair and slide made of sturdy plastic and being so small, the toddlers faced no danger of hurting themselves.) A few kids tried to get into the tiny car; they opened the door and attempted—often with remarkable persistence—to force a foot inside.

Interestingly, most of the children showed little or no reaction to their failed attempts. A couple seemed a bit angry, a few looked sheepish, but most simply went on to do something else. We think the lack of reaction probably reflects the fact that toddlers' daily lives are full of unsuccessful attempts to do one thing or another.

Our interpretation of scale errors is that they originate in a dissociation between the use of visual information for planning an action and for controlling its execution. When a child sees a miniature, visual information—the object's shape, color, texture and so on—activates the child's mental representation of its referent. Associated with that memory is the motor program for interacting with the large object and other similar objects. In half the children we studied, this motor program was presumably activated but then inhibited, and the children did not attempt to interact with the miniature in the same way.

But in the other half the motor routine was not inhibited. Once the child began to carry out the typical motor sequence, visual information about the actual size of the object was used to accurately perform the actions. Some children, for instance, bent over the tiny chair and looked between their legs to precisely locate it; those trying to get into the miniature car first opened its door and then tried to shove their foot right in. The

(The Author)

JUDY S. DeLOACHE specializes in early cognitive development—specifically of symbolic thinking—at the University of Virginia, where she is professor of psychology. DeLoache also holds an appointment in psychology at the University of Illinois, where she earned her doctorate and has taught since the late 1970s.

Two-year-olds have difficulty appreciating the symbolic relation between a model of a room and a room itself. This boy can see the toy hidden behind the plant in the model but does not know to look for it behind the real plant.

children relied on visual information linking the replica to the normal-size object, but in executing their plan, they used visual information about the miniature's actual size to guide their actions. This dissociation in the use of visual information is consistent with influential theories of visual processing—ones positing that different regions of the brain handle object recognition and planning versus the execution and control of actions.

The Magical Machine

Scale errors involve a failure of dual representation: children cannot maintain the distinction between a symbol and its referent. We know this because the confusion between referent and symbolic object does not happen when the demand for dual representation is eliminated—a discovery I made in 1997 when Rosengren and Kevin F. Miller of the University of Illinois and I convinced two-and-a-half-year-olds—with the full consent of their parents, of course—that we had a device that could miniaturize everyday objects.

Using our amazing shrinking machine, we hoped to see if the need to think of an object in two ways at once was at the heart of children's symbol difficulties. If a child believes that a machine has shrunk an object or a room, then in the child's mind the miniature is the thing itself. There is no symbolic relation between room and model, so children should be able to apply what they know about the big version to the little one.

We used the powers of our device to shrink toys and a large tent. In front of the child, we placed a toy—a troll doll with vivid purple hair—in a tent and aimed the shrinking machine at the tent. The child and experimenter then decamped to another room to wait while the machine did its work. When they returned to the lab, a small tent sat where the big one had been.

When we asked the children to search for the toy, they immediately looked in the small tent. Believing the miniature to actually be the original tent after shrinking, they successfully retrieved the hidden toy. Unlike in our scale model experiment, they had no dual representation to master: the small tent was the same as the large tent, and thus the toy was where it should be, according to the toddlers' view of the world.

Understanding the role of dual representation in how young children use symbols has important practical applications. One has to do with the practice of using dolls to interview young children in cases of suspected sexual abuse. The victims of abuse are often very young children, who are quite difficult to interview. Consequently, many professionals—including police officers, social workers and mental health professionals—employ anatomically detailed dolls, assuming that a young child will have an easier time describing what happened using a doll. Notice that this assumption entails the further assumption that a young child will be able to think of this object as both a doll and a representation of himself or herself.

These assumptions have been called into question by Maggie Bruck of Johns Hopkins University, Stephen J. Ceci of Cornell University, Peter

A. Ornstein of the University of North Carolina at Chapel Hill and their many colleagues. In several independent studies, these investigators have asked preschool children to report what they remember about a checkup with their pediatrician, which either had or had not included a genital check. Anatomically detailed dolls were sometimes used to question the children, sometimes not. In general, the children's reports were more accurate when they were questioned without a doll, and they were more likely to falsely report genital touching when a doll was used.

Common failures show that using dolls to interview young children about sexual abuse may be faulty.

Based on my research, I suspected that very young children might not be able to relate their own body to a doll. In a series of studies in my lab using an extremely simple mapping task, Catherine Smith placed a sticker somewhere on a child—on a shoulder or foot, for example—and asked the child to place a smaller version of the sticker in the same place on a doll. Children between three and three-and-a-half usually placed the sticker correctly, but children younger than three were correct less than half the time. The fact that these very young children cannot relate their own body to the doll's in this extremely simple situation with no memory demands and no emotional involvement supports the general case against the use of anatomically detailed dolls in forensic situations with young children. (Because of many demonstrations akin to this one, the use of dolls with children younger than five is viewed less favorably than in the past and has been outlawed in some states.)

Educational Ramifications

The concept of dual representation has implications for educational practices as well. Teachers in preschool and elementary school classrooms around the world use "manipulatives"—blocks, rods and other objects designed to represent numerical quantity. The idea is that these concrete objects help children appreciate abstract mathematical principles. But if children do not understand the relation between the objects and what they represent, the use of manipulatives could be counterproductive, as some research suggests.

Meredith Amaya of Northwestern University, Uttal and I are now testing the effect of experience with symbolic objects on young children's learning about letters and numbers. Using blocks designed to help teach math to young children, we taught six- and seven-year-olds to do subtraction problems that require borrowing. We taught a comparison group to do the same but using pencil and paper. Both groups learned to solve the problems equally well—but the group using the blocks took three times as long to do so. A girl who used the blocks offered us some advice after the study: "Have you ever thought of teaching kids to do these with paper and pencil? It's a lot easier."

Dual representation also comes into play in popular books for children that include flaps that can be lifted to reveal pictures, levers that can be pulled to animate images, and so forth.

Graduate student Cynthia Chiong and I reasoned that these manipulative features might distract children from information presented in the book. Accordingly, we recently used different types of books to teach letters to 30-month-old children. One was a simple, old-fashioned alphabet book, with each letter clearly printed in simple black type accompanied by an appropriate picture—the traditional "A is for apple, B is for boy." Another book had a variety of manipulative features. The children who had been taught with the plain book subsequently recognized more letters than did those taught with the more complicated book. Presumably, the children could more readily focus their attention with the plain 2-D book.

As these various studies show, infants and young children are confused by many aspects of symbols that seem intuitively obvious to adults. They have to overcome hurdles on the way to achieving a mature conception of what symbols represent, and today many must master an ever expanding variety of symbols. Perhaps a deeper understanding of the various stages of becoming symbol-minded will enable researchers to address learning problems that might stem from difficulty grasping the meanings of symbols. M

(Further Reading)

- **Becoming Symbol-Minded.** J. S. DeLoache in *Trends in Cognitive Sciences,* Vol. 8, No. 2, pages 66–70; February 2004.
- Images of children making symbol-related errors can be seen at **www.faculty.virginia.edu/childstudycenter/home.html**

IMAGES.COM *Corbis*

One Person, One Neuron?

Nerve cells devoted to recognizing Halle Berry or Bill Clinton? **Absurd.** That's what most neuroscientists thought—until recently

By Katja Gaschler

Think of the hundreds of people you can remember ever having met. Add those individuals—such as celebrities, politicians and other famous figures—whose faces you know well only from movies, TV and photographs. Is it possible that each of those individuals, along with thousands of other objects you can easily recognize from earlier encounters, could be captured in your memory by its own personal brain cell?

The neuron responded to three different pictures of Clinton but not of other American presidents.

Perhaps. A recent study published in the journal *Nature* by scientists at the California Institute of Technology and the University of California, Los Angeles, suggests that our brains use far fewer cells to interpret any given image than previously believed. For instance, researchers discovered a "Bill Clinton cell" that responds almost exclusively to the former president. Another neuron fires only when the actor Halle Berry comes into view.

Exactly how the brain recognizes images has been a matter of debate. Two wildly divergent theories exist. In one, millions of neurons work together to create a cohesive picture. In the extreme version of the other, the brain contains a separate neuron for each individual object and person. In 1967 Polish neurophysiologist Jerzy Konorski described his theory of "gnostic neurons"—derived from *gnosis,* Greek for "recognition." According to this theory, the activity of one or several nerve cells determines whether someone thinks of his boss, wife or grandmother. Jerome Lettvin, then a neuroscientist at the Massachusetts Institute of Technology, thus dubbed the neurons "grandmother cells," and the name stuck.

Many researchers immediately criticized the theory: Wouldn't such one-to-one congruence take up too much space? Opinions were still much the same two decades later. "It's very hard to take the grandmother cell theory seriously," commented neurobiologist and Nobel Prize laureate David H. Hubel in the 1980s.

Back then, it was not even clear how to go about exploring the entire problem of the neuronal foundations of consciousness. Using electrodes, neurophysiologists at the time had managed to trace the activity of individual neurons in the brains of monkeys and cats. But animal subjects cannot discuss their thoughts with us, making experiments on consciousness and perception more than a little difficult. Analogous tests on human beings had not yet been undertaken because of the obvious risks of inserting electrodes into the brain.

Surprise Volunteers

In recent years, however, a set of human volunteers unexpectedly emerged: patients suffering from forms of epilepsy that cannot be treated with medication. In the early 1990s a number of patients were slated to undergo brain surgery to remove the zone in their brain responsible for the onsets of their seizures. Sometimes techniques such as electroencephalography and magnetic resonance imaging cannot locate the zone precisely enough. In such cases, neurosurgeons may implant as many as 10 thin electrodes in the brain. These fine sensors monitor neuronal activity day and night on a continuous basis until the seizure-onset zone can be localized with sufficient precision and can then be removed by the neurosurgeon.

Researchers realized that this procedure offered a unique opportunity to study the activities of individual cells. This fact led neurosurgeon Itzhak Fried of U.C.L.A., one of the principal investigators in the current research, to design a study as early as 1992 and then invite otherwise untreatable epileptics to participate in this basic neural research. The grandmother cell study, carried out with bioengineer Rodrigo Quian Quiroga of the University of Leicester in England as chief experimentalist, was rather simple. Test subjects lay in bed watching while photographs flashed on a computer screen at one-second intervals. At the same time, Quian Quiroga monitored the electrical signals coming from the "attached" neurons.

One of the first gnostic neurons discovered using this method was the Bill Clinton cell, lo-

FAST FACTS

Grandmother Cells

1» The controversial grandmother cell theory holds that the firing of individual nerve cells can represent the abstract concept of a specific thing or person.

2» Recent research has confirmed the existence of such neurons in the medial temporal lobe. Neuroscientists have found nerve cells in the brains of epilepsy patients that respond to images of specific persons—independent of the type of image.

3» The brain presumably generates this kind of sparse representation within a small group of neurons, particularly for persons and things we encounter frequently.

cated deep inside one female patient's amygdala—the almond-shaped region of the brain involved in emotions. The neuron responded to three different pictures of Clinton: a drawing, a painting and a group portrait with other politicians. When the patient looked at photographs of other American presidents, from George Washington to George H. W. Bush, the cell remained silent.

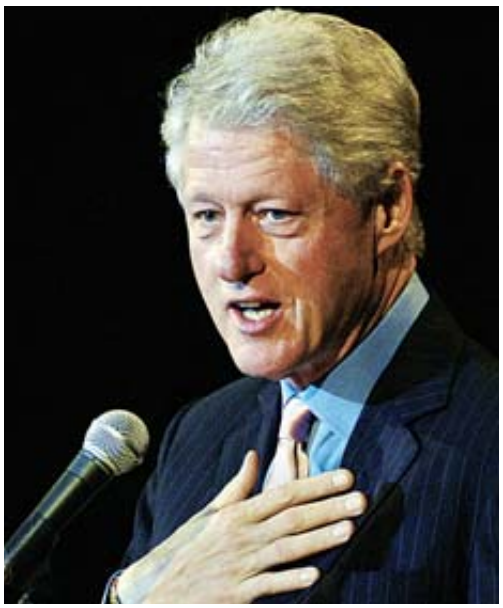
Shortly thereafter, Fried's team found similar selective nerve cells in other patients in the medial temporal lobe that responded to the Beatles, the TV cartoon Simpsons family and one neuron that was galvanized into action only at the sight of Jennifer Aniston. In another test subject, one nerve cell in the right hippocampus fired as soon as Halle Berry appeared on the screen—even when she was in a Catwoman costume and her face was masked. Apparently, the cell responded to the idea of her as a person, not just to a view of her face: the caption "Halle Berry" was enough to get the neuron going.

Quian Quiroga and his co-workers were fascinated. They theorized that the specialized nerve cells were crucial to the process of recognition. Their locations were in the hippocampus, entorhinal cortex, parahippocampal gyrus and amygdala—all structures in the medial temporal lobe known to be involved in long-term memory. But how are we to conceive of a single neuron capable of representing something as complex as the identity of Bill Clinton?

From the point of view of information theory, this question is not hard to answer, according to computational neuroscientist Christof Koch of Caltech, who was also involved in the study and has been working with Fried's team since 1998. In his book *The Quest for Consciousness* (Roberts & Company Publishers, 2004), Koch illustrates this premise with an analogy. When we turn on the TV, the screen presents us with an explicit—that is, immediate—pattern of multicolored pixels distributed over the monitor. Yet implicitly concealed within this pattern is specific information, such as data about Bill Clinton's face.

Let us assume that a robot is tasked with determining whether the ex-president's image is currently on the screen. Its electronic brain has to expend enormous computational resources to extract the concealed information from the array of pixels. The computation involves many iterations, with some level of screening for Clinton-like information going on at each one, and each iteration involves a more and more sophisticated Clinton search through a smaller and smaller set of screened data. Whereas the initial mass of data shrinks with each computational step, the "logical depth of processing" increases steadily. In the end, a minute quantity of information—one bit—remains, indicating explicitly whether Clinton is present or not: 1 (Bill) or 0 (no Bill).

According to a theory of consciousness de-



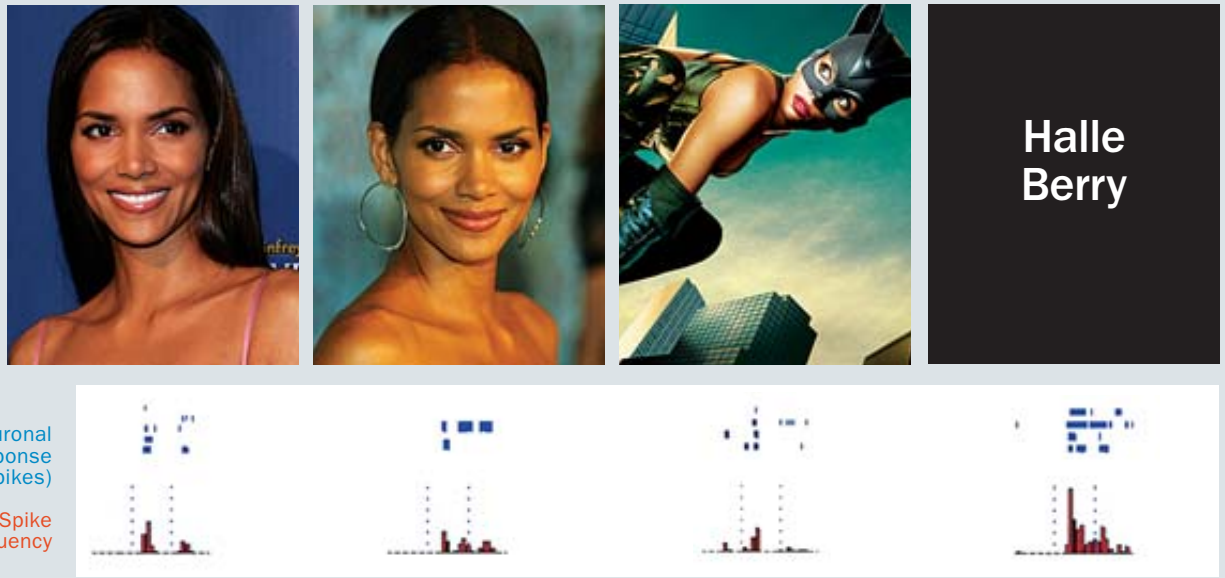
Former president Bill Clinton's image (*left*) excited a single neuron in a female patient's brain; a cell in another person responded to the Beatles (*right*).

STAN HONDA *AFP Getty Images (left)*; UNDERWOOD & UNDERWOOD *Corbis (right)*

(The Author)

KATJA GASCHLER has a Ph.D. in biology and is an editor at *Gehirn & Geist*.

Firing for Halle Berry



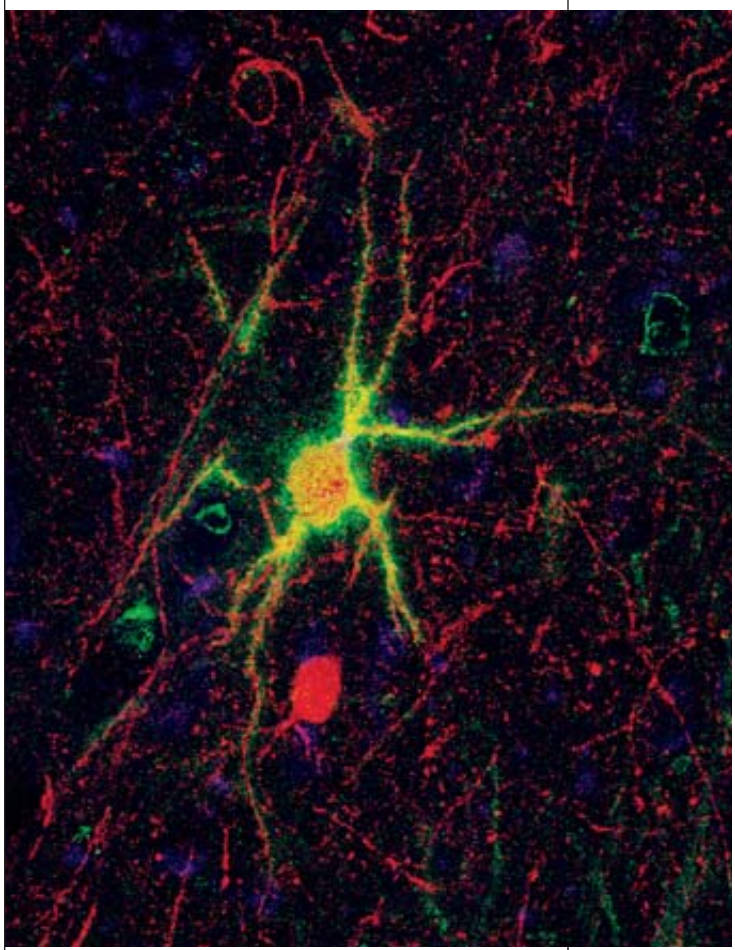
A neuron in the right hippocampus of one test subject reacted strongly to various photographs of Halle Berry, even as Catwoman (*top row*). Her typewritten name by itself also caused the nerve cell to fire. In contrast, photographs and names of other celebrities such as actor Julia Roberts (*left*) elicited hardly any response.

veloped by Koch and his late colleague and friend, the Nobel Prize–winning Francis Crick, our brain proceeds in similar fashion. From its initial impression on the retina to actual consciousness, Clinton's face generates a firestorm of neuronal activity. But whereas many groups of neurons are involved at the lower processing levels, such activity is limited to fewer and fewer nerve cells in subsequent steps.

"I'm not claiming that a single cell represents the total neuronal correlate of Bill Clinton," Koch emphasizes. "The firing of a single neuron would be much too weak a signal." Nevertheless, he considers it probable that the concerted activity of a small group of neurons would be strong enough to catapult Clinton into consciousness. Because these cells encode only the abstract idea of Clinton, the tilt of the head in relation to the picture or whether Clinton is wearing a ski cap has no effect whatsoever on the behavior of the cells. And if we were to destroy all these cells? Then the perception of "Look, there's Bill Clinton" would turn to "Look, there's a guy who looks familiar, but I can't quite place him."

MARK MAINZ *Getty Images (top left)*; MICHAEL BUCKNER *Getty Images (top center)*; DOANE GREGORY *Warner Bros./Bureau L.A. Collections/Corbis (top right)*; RODRIGO QUIAN QUIROGA ET AL., *NATURE* 2005 *(graphs)*; ARNALDO MAGNANI *Getty Images (bottom)*

From its initial impression on the retina to consciousness, Clinton's face generates a neuronal firestorm.



Two neurons (*yellow-green* and *red blobs*) in the amygdala, a brain region involved in emotions.

SABINA BERRETTA *Translational Neuroscience Laboratory, McLean Hospital, Harvard Medical School*

Quian Quiroga has been able to monitor simultaneously as many as 40 neurons—a number that researchers in the 1980s would not even have dared to dream of—with the help of implanted electrodes. Still, the question arises about whether the probability of finding a specific "Jennifer Aniston cell" from among the millions of neurons that make up the temporal lobe might be infinitesimally small. Koch agrees: "However, we theorize that there are numerous cells dedicated to familiar persons or objects: our grandmother, the dog, my laptop, etcetera"—and knowledge about what is familiar can help guide scientists who are looking for single cells. For this reason, the researchers questioned each test subject about his or her interests prior to testing. Only then did they select the approximately 100 images to show to that patient.

The sparse coding advanced by Koch and his colleagues differs fundamentally from the conventional notion of how persons and things are represented in consciousness. According to the theory of distributed representation, large and widely scattered groups of neurons fire off in the brain for any given person or object. Each individual cell contributes only a minute portion of the total data—which is why it is not too consequential if some of this information gets lost.

Further, the groups of cells are not dedicated exclusively to one particular face but are involved in the identification of a large number of people. The specific pattern of powerful neuronal firing is what signals who is being recognized. Researchers have no doubt that divided representation in the brain is a reality for certain tasks. This type of processing is how the brain makes out new faces, Koch explains.

Together with Crick, Koch developed a theory of the neuronal correlates of consciously perceived phenomena. When processing visual information, for example, neuronal groups that may be widely separated from one another unite in the sense that they fire in unison. Various coalitions of neurons stand for alternative interpretations of the particular thing or happening. Which of these interpretations comes to predominate depends on which characteristics of the image our brain pays the most attention to.

Grandmother cells function differently, Koch theorizes. "Thanks to highly specialized cells, we recognize our own grandmother immediately in the crowd of other elderly ladies at the senior citizen home, without having to think twice about it." M

(Further Reading)

- **Invariant Visual Representation by Single Neurons in the Human Brain.** R. Quian Quiroga, L. Reddy, G. Kreiman, C. Koch and I. Fried in *Nature,* Vol. 435, pages 1102–1107; June 23, 2005.

askthe**Brains**

What causes insomnia?

—H. York, England

Henry Olders, assistant professor of psychiatry at McGill University, explains:

PEOPLE CAN EXPERIENCE sleep difficulties for a variety of reasons, including medications, alcohol, caffeine, stress and pain. When the underlying cause is removed, these bouts usually get better on their own. For many people, however, sleep problems turn into insomnia, the chronic inability to either fall asleep or keep sleeping.

Whereas many insomniacs believe that they lack sufficient sleep, evidence is mounting that they are in fact getting at least as much as they require and possibly more. Insomniacs tend to go to bed early, stay there late and sleep during the day—all of which contribute to the problem.

Why would someone spend more time asleep than he or she needs? Opinions about sleep seem to be important. Individuals who experience insomnia are more likely to be concerned about not sleeping and to think about problems, events of the day and noises in the environment while preparing to sleep. They also underestimate the amount of time they actually sleep. Simply put, if you believe you need eight hours of sleep a night, you will arrange your retiring and rising times so that you spend eight hours in bed. If you require only six hours of sleep, however, you will spend two hours tossing and turning.

How much sleep do you need? And how can you tell if you are getting the right amount? Although eight hours a night is a figure repeated so often that it has almost become an article of faith, the reality is that sleep need is highly individual. Large-scale epidemiological studies have shown that sleeping seven hours a night is associated with the lowest mortality risk (for factors including heart disease, cancer and accidental death) compared with longer or shorter periods of shut-eye. In addition, as we age, we probably need less sleep. Many people believe that if they have a good night's sleep they will wake up without an alarm, feeling rested and refreshed. Yet circadian rhythm studies show that people are usually drowsy early in the morning, even after a full night's sleep. If you are truly sleep-deprived, you will have trouble remaining awake during the day. (Brief, 10-minute naps can be rejuvenating.)

To help treat insomnia, practice good "sleep hygiene." Measures include adjusting the levels of noise, light and temperature so that you are comfortable; not reading or watching TV in bed; avoiding excess food, alcohol, nicotine, caffeine and other stimulants; completing exercise at least three hours before lights out; and determining your optimum bedtime. The longer you are awake, the more slow-wave (delta) sleep you will have; slow-wave sleep is what leads to feeling rested and refreshed. Limiting the time you spend in bed may also help. Together these nonpharmacological approaches are more effective and longer-lasting than medications for insomnia are.

Are humans the only primates that cry? *—C. Henderson, Winter Park, Colo.*

Kim A. Bard, a reader in comparative developmental psychology at the University of Portsmouth in England, responds:

THE ANSWER to this question depends on how you define "crying." If crying is defined as tears coming from the eyes, then the answer is yes: tears appear to be unique to humans among the primates. If you define crying as a vocalization that occurs under conditions of distress or what humans might describe as sadness, then you can find crying in almost all primates.

In contrast, others argue that all mammals have feelings, because emotions are the product of deep-brain functioning with a long evolutionary history. Some reserve such emotional terms for humans alone and will not use such words for other primates. Others take a conservative stance and say that it is too difficult to tell whether or not nonhuman primates have feelings. Rather than broadly describing some primate vocalizations as crying, scientists prefer specific names for certain conditions. For example, a young primate that is not in contact with its mother produces a separation call. Investigators will also describe what the vocalization sounds like, as with the "smooth early high" coos of squirrel monkeys. Or researchers will describe what the animal is trying to communicate, such as when infants try to satisfy their basic needs for food, social contact or relief from pain. M

"Whereas many insomniacs believe that they lack sufficient sleep, evidence is mounting that they are in fact getting at least as much as they require and possibly more."

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

PAUL WABY Department of Psychology, University of Portsmouth (Bard)

Upstaging Stage Fright

Anxiety can ruin your performance in a play, business meeting or exam, but exercises can help BY MARION SONNENMOSER

FEAR IS GOOD; in emergencies, it enables us to fight or flee. But often we get scared at the wrong time—when we step onto the field for a big soccer game or up to the microphone at a contentious town meeting. Professional athletes and actors say some nervousness helps them concentrate better. But when performance anxiety is too powerful, it undermines our efforts: a player's legs become wobbly, a violinist cannot find the correct notes, a manager in a meeting forgets all the talking points. Survival may not hang in the balance, but social, professional or financial success can seem to be in grave danger.

The human anxiety reaction begins almost automatically and includes clear physiological symptoms: a racing heart, sweating, stomach pains, even diarrhea. Some people have trouble breathing or feel faint. Thus alarmed, victims may withdraw into themselves or shock others around them with aggressive outbursts. If the need to perform is a regular requirement, they may suffer from nightmares or fall into depression. All these symptoms eat away at the very resources needed to rise to the occasion: steady hands, clear memory and a cool head. Studies reveal that anxiety-plagued executives are less able to apply logical intelligence on standard tests than calmer colleagues.

Because performance anxiety arises when other people are present, many

Embarrassment in a school play or a **botched test** in childhood can cause adults to avoid any similar undertaking.

CORBIS

psychologists believe that the condition is a subcategory of social anxiety. Yet psychologist Douglas H. Powell of Harvard Medical School is convinced that severe stage fright is a phenomenon unto itself, given that it appears in only certain well-defined situations. Sociophobes, in contrast, suffer merely when others are present. Whereas people with social phobias fear the negative feelings of others, those with performance anxiety are their own harshest critics. They are perfectionists and would rather cancel an appearance—or avoid it—than not meet their own standards and, by extension, not be able to demonstrate how good they are.

This catastrophic style of thinking often arises from a lack of self-esteem. The individual begins by imagining failure, works himself or herself into a state and then deprecates his or her own abilities. Previous bad experiences can be a trigger—an embarrassing experience in a school play or a single botched test can sometimes evoke such strong feelings of shame in youngsters that as adults they will avoid any remotely similar undertaking.

Getting a Grip

If you are prone to stage fright, you can choose from several tactics that can allay fears. So-called cognitive methods are based on the observation that you can control your feelings through directed thinking. To ward off negative thoughts, begin by writing them down. Then, find a quiet time and place to review them and consciously block them by replacing them with favorable notions. Afraid to give a short speech? Recall a great talk you gave to your son or daughter. Worried you'll forget a line? Remember how well you tell stories to your friends.

It also helps to examine the real risk involved. Decide what value the upcoming performance in question has for you. If you fail, will the world really come to an end? Does your inner peace really depend on stunning success in this situation? Over the long term, your sense of self-worth depends mostly on things unconnected to any given performance, such as having a happy family or enjoying good friends.

Another proven technique for overcoming fear of failure is called desensitization. After some initial guidance from an expert, you can do it for yourself. The technique exploits the fact that anyone who regularly finds himself or herself in the same fear-inducing situation gradually gets used to it. The first step to lessen a fear of public speaking, for example, would be to talk through your presentation while imagining that you are explaining the topic to your always supportive parents or siblings. Then read the talk aloud while sitting with a good friend. The next step in difficulty would be to choose a somewhat larger group of acquaintances and work from only a couple of note cards. Then invite some outsiders into the audience. Graduation from this desensitization training would be speaking extemporaneously to a hall full of strangers.

Some therapists utilize techniques that act against the physical symptoms of fear. Examples include restful breathing cadences and calm-inducing regimens such as the Jacobson exercise, which uses a controlled, progressive plan to systematically relax the body's muscles.

If the root of the performance anxiety is inadequate psychic stability, a controversial technique called eye movement desensitization and reprocessing may help. The approach, discounted by some psychologists, should be carried out only with a therapist trained in this method. Individuals face frightening situations or feelings while the left and right hemispheres of the brain are stimulated in alternation, by concentrating on different points of light or hand movements. The activity appears to reduce emotional pressure and promote a positive attitude toward the difficult performance situation.

Facing anxiety can be a hard task. But many times the fear arises from completely controllable preconditions. At Harvard, Powell realized this fact while treating 67 medical students and five young doctors who were suffering from high performance anxiety and had failed tests. He asked them to write down and categorize their thoughts, feelings and modes of behavior before and during important exams. What he found was that more than anything else, the individuals had poorly estimated the range of material that would be tested as well as the time needed to prepare well. They did not know how best to study or how to monitor their progress. Many of them began to cram only shortly before the test date. They also did not show much expertise at test taking: they addressed questions in order and spent too much time on vexing ones, instead of more efficiently handling the confidence-building easy questions and looping back to the tough ones later.

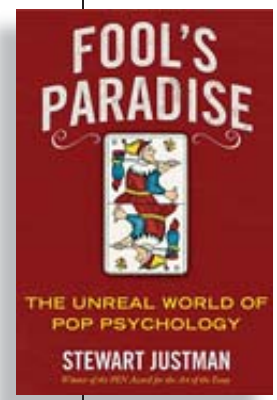
Avoiding stage fright for an impending speech may well come down to better preparation. Study the content until you know it cold, write out the entire presentation, rehearse it alone and in front of a few volunteers until you could give it in your sleep. Then perhaps the actual event won't seem so foreboding. M

Afraid to give a short speech? Recalling a great talk you gave your son or daughter will **boost confidence**.

MARION SONNENMOSER is a psychologist at the University of Landau in Germany and a freelance science writer.

Bad Advice

Fool's Paradise: The Unreal World of Pop Psychology



by Stewart Justman. Ivan R. Dee, 2005 ($27.50)

The genre of psychological self-help books has grown tremendously, and authors such as Dr. Phil (McGraw), Wayne Dyer and John Gray are repeat visitors to the best-seller lists. Such popularity poses a paradox, though: If the books really worked, why would readers need to keep buying them? In the erudite yet lively *Fool's Paradise,* literary scholar Stewart Justman argues that pop psychology texts are ineffective because, among other things, they encourage people to hyperfocus on their own emotional states. He approvingly cites philosopher John Stuart Mill's maxim: "Ask yourself whether you are happy, and you cease to be so."

Justman, professor of liberal studies at the University of Montana, offers a severe and mostly persuasive critique of pop psychology print media rather than of radio and television. Quoting liberally from books that purport to give life-changing advice, he castigates the field for offering unrealistic expectations of self-transformation, for dogmatic tone, and for dubious doctrines such as honoring one's "authentic self" by discarding feelings of obligation and morality. Along the way Justman points out some monumental ironies, such as authors' demands that readers reject other people's demands. He likewise notes that although the literature is unoriginal and repetitious, it instructs readers to make a sharp break with the past.

Pop psychology, according to Justman, is a "utopian enterprise" inspired by the protest movements of the 1960s and early 1970s. Although this interpretation has some merit, one could argue that pop psychology marked a turn away from political activism into self-absorption. Similarly, Justman's assertion that pop psychology derides most guilt but welcomes "liberal guilt" over historical injustices seems to overstate the politics of a genre that is largely apolitical.

Less disputable, however, is that most of the manuals are badly written. The literature is rife with supposed success stories about people overcoming negative emotions and behaviors—many of which are suspiciously sketchy and formulaic. Loose or out-of-context quotations from serious literary and philosophical works are another ill staple of the genre, as when self-help authors celebrate the Shakespearean line "To thine own self be true," mouthed by the questionable character of Polonius in *Hamlet.*

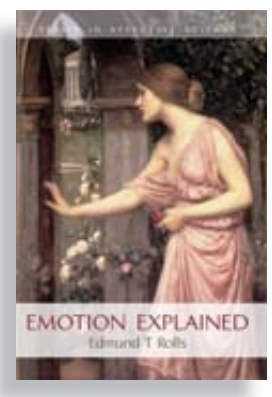
As Justman writes, pop psychology's many practitioners may include "a few who do not subscribe to the dubious doctrines probed here." Still, citing more than 40 guidebooks, he shows that the field's problems are serious indeed. —*Kenneth Silber*

Mind Reads

Following His Nose

Emotion Explained

by Edmund T. Rolls. Oxford University Press, 2005 ($75)



Physicians began to study in earnest the brain's generation of emotions in 1848 after a long iron bar shot through railroad worker Phineas Gage's prefrontal cortex. He lived, but his personality changed drastically.

The prefrontal cortex is the central switchboard in emotional processing. Edmund T. Rolls, professor of psychology at the University of Oxford, details this brain region at length in *Emotion Explained,* a state-of-the-field text intended for the upper-level university classroom. Rolls's thesis is that emotions are "states elicited by rewards and punishers" and that we behave so as to maximally reward hardwired circuits in our brains (which, he notes, we could do directly by electrical stimulation). He also posits that emotions have played an important role in human evolution by allowing our genes to set goals without specifying the actions we must take. But despite the book's bold title, it is clear that scientists are far from a complete explanation of emotion.

Emotion Explained can be a slow go. Rolls takes 360 pages to get to love and grief. Even then, he explains love in the context of sexual behavior and diagnoses grief as the absence of a reward, compounded by our knowledge that the reward will never return. His style is technical and textbooklike in the large chunk devoted to neuroanatomy, but Rolls leavens the tone with anecdotes and wry asides.

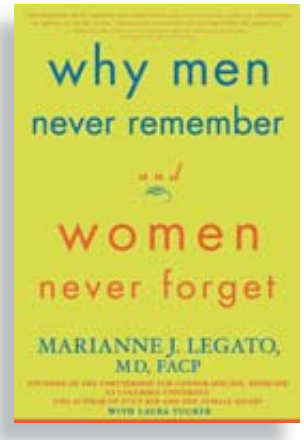
Although odor isn't the first thing one may think of in connection with emotion, much of the book focuses on how sensory inputs such as odor and taste are associated with reward values in the orbitofrontal cortex, located directly behind the eyeballs. Rolls's research specialty is olfaction, and he draws on it to illustrate the key linkages between primary and secondary stimuli and reward values. Rolls broadens his concept to other stimuli, but olfaction always lurks in the background.

Emotion Explained is a long, comprehensive survey, but the reader finishes with a wish for more explanation. There is no discussion of how genes might determine behavior, and Rolls dodges the question of whether social expectations influence our emotions. Evidently there is more to love, loss and satisfaction than meets the eye—or nose. —*Kaspar Mossman*

Brains of the Sexes

Why Men Never Remember and Women Never Forget

by Marianne J. Legato, with Laura Tucker. Rodale, 2005 ($24.95)



A four-year-old could tell you that men and women are not the same, but even adults struggle to explain why. That is where *Why Men Never Remember and Women Never Forget* steps in. Citing a plethora of recent research, Marianne J. Legato sets out to describe why men and women vary so widely in their reactions and thoughts. In so doing, she hopes that readers will grasp the science of our biochemically controlled brains and, in light of it, seek to limit discord between men and women in the home and workplace.

A tool kit to fix the male-female communication conundrum is an admirable goal, but one that Legato does not quite achieve. Although the science behind our divergent brains provides mini-epiphanies, the focus of the book gets lost in its mix of memoir, guidance and concrete science. The information to help the sexes get along better shows up occasionally, as in a brief reference to a mother who employs what she now knows about the male brain to fight less with her teenage son. Still, there are a lot of diversions along the way.

One distraction is the decidedly female vantage point taken. Legato, a champion of rectifying medicine's lapse in female-focused research, is a doctor who founded Columbia University's Partnership for Gender-Specific Medicine, where the word "gender" might as well be "female." For a book trying to bridge knowledge gaps, Legato represents the male world in strikingly few instances.

The skewed view may arise from trying to force the theme of "the sexes are from different planets." Legato might have better served the reader by explaining how sex-based brain revelations can affect our lives—how doctors could provide better health care when it is geared toward each sex, how teachers could optimize student learning by tailoring their approaches, and, yes, why women in the bedroom need not be offended if their male partners do not necessarily want to cuddle.

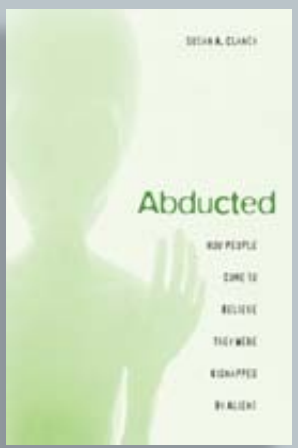
Despite missing the opportunity to explore the future relevance of gender brain science, the book does offer a fair amount of enlightening information. Although Legato does not provide that much guidance for how to use our new awareness, a thinking person can start to figure it out. And whether you are male or female, isn't that what our brains are for? *—Sarah Todd Davidson*

Really from Mars

Abducted: How People Come to Believe They Were Kidnapped by Aliens

by Susan A. Clancy. Harvard University Press, 2005 ($22.95)

One dark night in 1961 an event occurred that opened a new chapter in paranormal psychology: two Americans were, they later claimed, abducted by aliens. Similar claims have been coming ever since. Susan A. Clancy, a Harvard psychologist who describes herself as "a reluctant scholar of alienology," has investigated many of them and written this short, insightful and often funny description of abductees and the psychology behind their experiences. Clancy is never condescending toward the 50 subjects she interviewed; she simply asks questions, listens and then presents her own carefully reasoned explanation for why they might believe they were abducted.



Fortunately, Clancy is well equipped to understand strange events. She has not only studied hypnosis but experienced it and the false memories it can "recover." She has also awoken to the terror of "sleep paralysis," an unusual state in which an individual perceives senses as if she is awake but is unable to move because parts of the brain are still asleep; hallucinations are common. Clancy believes this phenomenon, which typically lasts about a minute, is behind most of her subjects' narratives. Many share the same basic storyline: the person awakens in the dark with aliens moving around her and is transported to a spaceship, where she is subject to medical or sexual experiments. Abductees may be able to recall every detail or instead only "know" that it happened. In quests to make sense of the traumatic experience, they usually read up on abductions and seek therapists who will help them recover and understand their memories of the event—often through hypnosis. Frequently they associate with fellow abductees, either in person or online.

Clancy gained access to this faith-based community in the simplest possible way: she put an ad in the newspaper asking, "Have you been abducted by aliens?" She interviewed her subjects at length and gave those who volunteered various tests to reveal any mental health problems (only one person qualified) and how susceptible they were to false memories. The book explains how individuals can have memories of events that never occurred and describes the types of people who are more likely to become believers. In a nutshell, they are fantasy-prone and are often unhappy and trying to make sense of their lives. The abduction provides a touchstone.

At the very end, and with obvious reluctance, Clancy concludes that abduction beliefs provide "the same things that millions of people the world over derive from their religions: meaning, reassurance, mystical revelation, spirituality, transformation." *—Jonathan Beard*

Head Games

Match wits with the Mensa puzzler

BY ABBIE F. SALNY

1 The same nine letters can be rearranged to fill in the blanks below. The first blank is a nine-letter word; the second blank is two words.

The following statement does not match the proverb, but for maximum safety a person with _ _ _ _ _ _ _ _ _ will indeed look closely at a _ _ _ _ _ _ _ _ _ _.

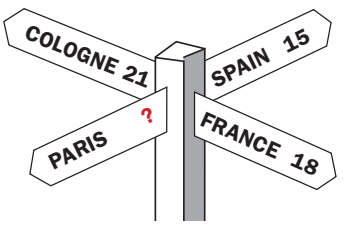
2 To the best of our knowledge, only one other word can be made from all the letters in the word below using each letter only once. What is that word?

CONSOLIDATES

3 Find a four-letter word that can be used before each of the words below to make a new word.

_ _ _ _ SLIP _ _ _ _ WAYS _ _ _ _ CAR _ _ _ _ REAL

4 Following the logic used in the three directions, fill in the fourth.



5 Add the values of the letters from left to right to get the sums at the right and from top to bottom to get the sums at the bottom. What is the missing number?

A	A	B	B	14
C	D	C	D	6
A	D	C	B	10
A	D	B	B	11
14	7	10	?	

6 Select the correct letter from the words in uppercase in each line. Put these letters in the same order and find the secret word.

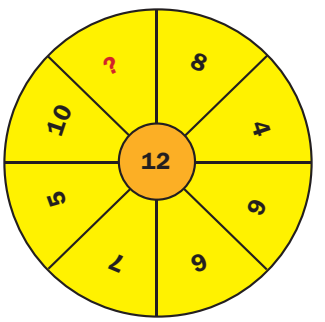
My first is in ROSE but not in NOTE.
My second is in HAIL but not in ROLE.
My third in YELLOW you will find.
My fourth is in KIT but not in KIND.
My fifth is in HOPE and also HEAD.
My last is in MEET but not in TREAD.
My whole in song is often heard,
A rather oddly spelled word.

7 Jane is abstemious. She likes to visit sequoias and is facetious, too. Would she prefer to have pneumonia or bronchitis?

8 Start at the correct letter and move in any direction to form a rather cynical statement. Hint: Begin with an "A" and use each letter only once.

M	H	T	V	A	S
U	R	W	E	Y	N
C	O	T	D	N	E
H	N	S	I	P	A

9 What number belongs in place of the question mark?



10 Jim's age is now two thirds of John's. In four years he will be as old as John is now. Four years ago Jim was half the age John was then. How old are they now?

Abbie F. Salny, Ed.D., was the supervisory psychologist for American Mensa (www.us.mensa.org/sciamm) and Mensa International (www.mensa.org) for more than 25 years. She is the author and co-author of many challenging puzzle books, including the Mensa Think-Smart Book *and the* Mensa 365 Brain Puzzlers Page-A-Day Calendar *(Workman Publishing).*

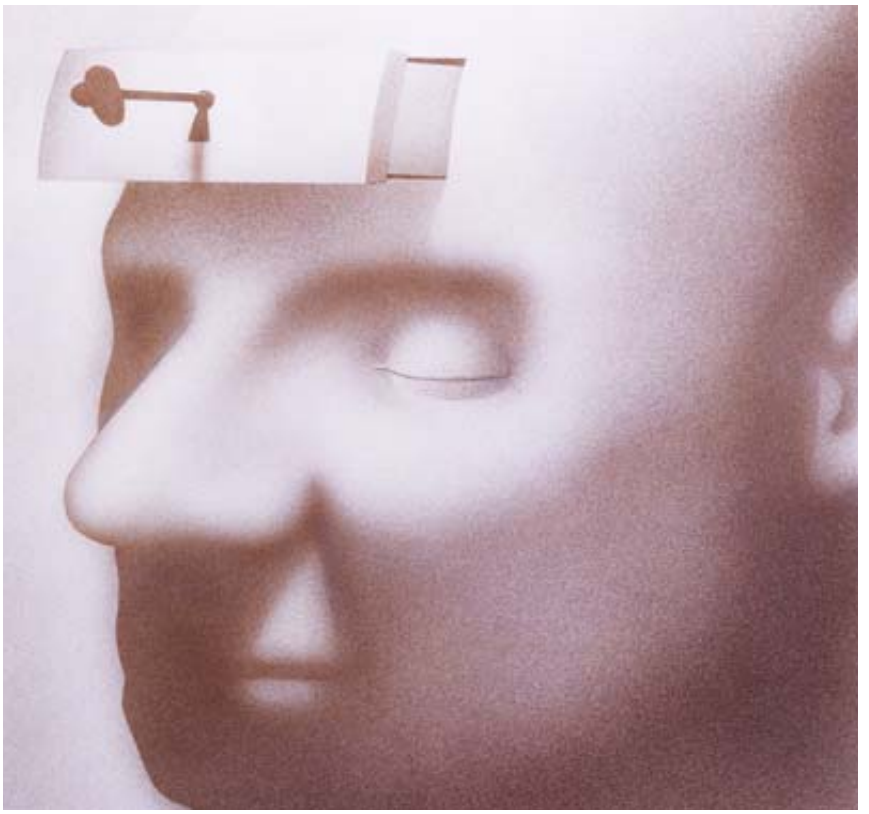
Answers

1. Foresight, gift horse.
2. Disconsolate.
3. Slide. (Sideslip, sideways, sidecar, sidereal.)
4. 15. (Three points for each letter.)
5. 10. (A = 4, B = 3, C = 2, D = 1.)
6. Rhythm.
7. Pneumonia. (She likes to describe herself with words containing all five vowels.)
8. "A penny saved isn't worth much."
9. 2. (Move clockwise and add the four pairs of consecutive numbers. Each pair adds up to 12.)
10. Jim is 8, and John is 12.

Coming Next Issue

SCIENTIFIC AMERICAN
MIND
THOUGHT • IDEAS • BRAIN SCIENCE

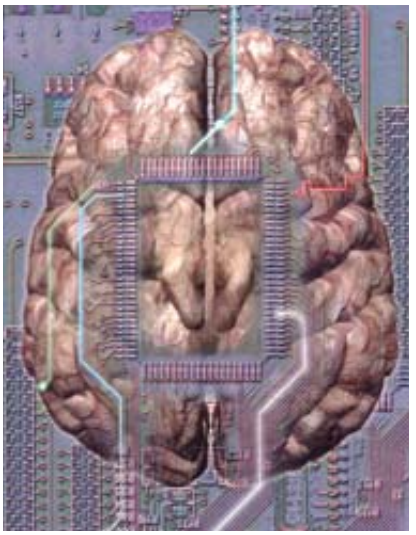
On sale in April



A Future of Memories
Nobel Prize winner Eric Kandel, who uncovered the molecular basis of memory strengthening, forecasts the future of his field.

Working to Death
Years of work stress can make you sick. It's called burnout syndrome, and more employees are coming down with it.

Bottled Up
Neurobiologists are gaining a better understanding of how people can develop alcoholism—and how to help them overcome their dependence.



Computing and Thought
Electronics modeled on brain cells promise to let machines take information-processing cues from Mother Nature. But will computers ever really *think?*

ONLY ON WWW.SCIAMMIND.COM

Two features highlighted from each issue

Neuroscience news

E-mail alerts for new issues

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.

IMAGES.COM *Corbis (top)*; SANFORD/AGLIOLO *Corbis (bottom)*