TEARS OF JOY AND SORROW: WHY ONLY PEOPLE CAN CRY

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Criminal Mind
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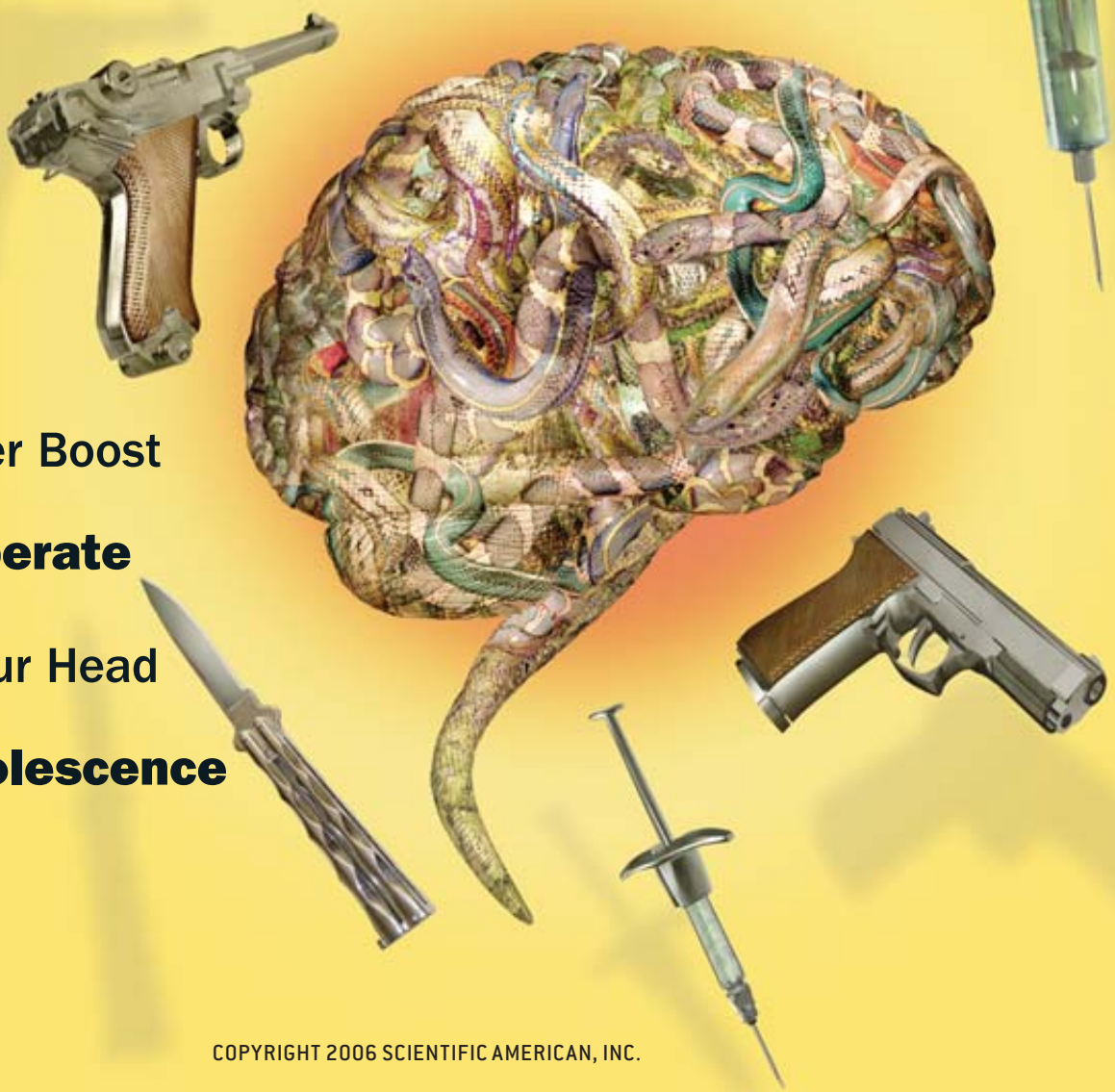

Brain Scans on Trial

Mental Power Boost

Born to **Cooperate**

Voices in Your Head

Surviving **Adolescence**

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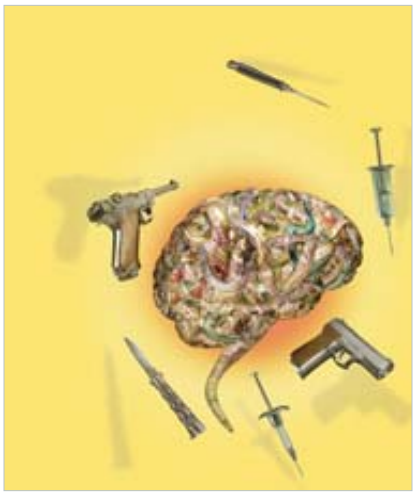

Together and Apart

As an editor, I've read thousands of pieces of writing. Yet some manage to stand out vividly, such as one column, "Ten Thousand Acts of Kindness," penned almost 20 years ago by the late Harvard University paleontologist and evolutionary biologist Stephen Jay Gould for *Natural History* magazine. We tend to remember the bad encounters we have had with other people, Gould noted, such as the time a driver rudely cut you off in traffic and then yelled at you on top of it. He believed that such incidents are memorable partly because they are rare. In fact, he pointed out, for each unpleasant moment we probably experience 10,000 acts of kindness—or at least neutral interactions—when we meet up with other people. Social togetherness, empathy and cooperation are hallmarks of humanity.

How puzzling, then, is the criminal mind, the subject of this issue's cover. What complex interplay of social and physical factors could lead to such aberrant behavior? The article "The Violent Brain," by Daniel Strueber, Monika Lueck and Gerhard Roth, explores the psychobiological roots of brutality in the brain. The story starts on page 20.

If brain chemistry is at least partly at fault for aggression, perhaps the latest imaging technologies can help in pointing out those flaws in accused perpetrators who are facing trial. After all, imaging has taught us a great deal about mental processing in general. Not so fast, argue neuroscientist Michael S. Gazzaniga and his colleagues in "Brain Scans Go Legal." Turn to page 30 to find out why imaging is not ready for the rigorous challenge of proving guilt in a court of law.

As Gould explained, most of us do more than merely cooperate with the law. An aspect of those 10,000 everyday acts of kindness is how people fluidly and automatically coordinate their actions with one another on even the most mundane tasks, such as when two partners carry a large box up a flight of stairs. Beginning on page 52, Natalie Sebanz discusses how people's seemingly effortless yet unrehearsed dances of togetherness arise in "It Takes Two to …" Maybe it will inspire you to share *Scientific American Mind* with a friend.

Mariette DiChristina
Executive Editor
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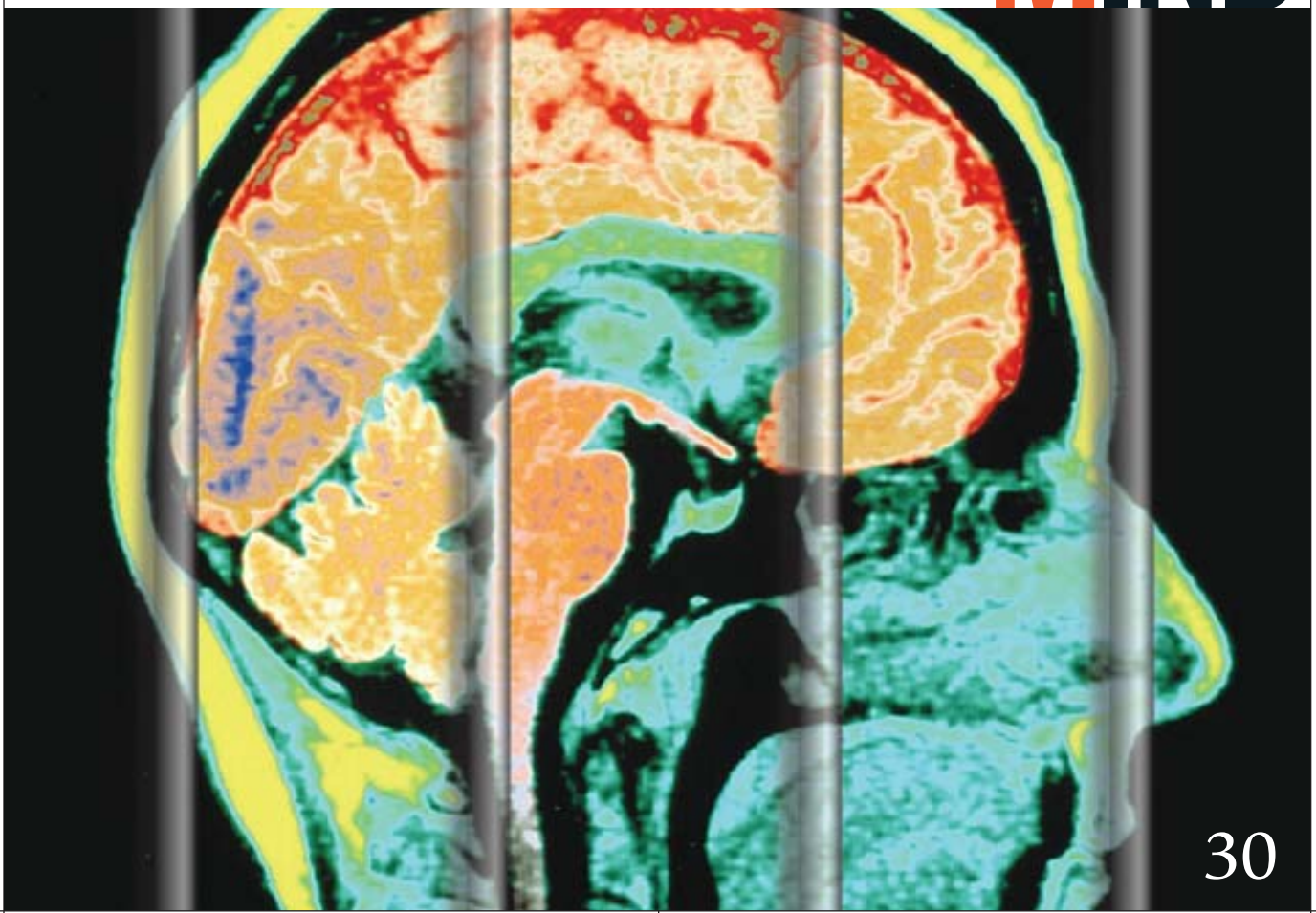

FEATURES

DEPARTMENTS

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TEEN BRAIN

In Leslie Sabbagh's revealing article on brain development in adolescents, "The Teen Brain, Hard at Work," psychologist Robert Epstein's passionate objection to data suggesting differences in teenage and adult brains seems puzzling and misplaced. I have worked for the past 15 years with children who come from immigrant homes with tightly knit family units, where social interaction is closely monitored and limited, as well as with children from more open-ended family structures, where preteens and teens are allowed greater autonomy in regard to peer relations.

The stress that both groups of students experience in highly pressurized academic environments appears to be the same. Research such as that featured in the article suggests that it is vital to "de-stress" learning environments for all school-age children while they are developing greater "endogenous control." Educators might also be more empathetic toward students if they knew that their students' brain capacities are still in significant transition.

Jason Ablin
Director of Studies
Milken Community High School
Los Angeles

The teen brain article stated that MRIs showed a distinct difference between teen brains and adult brains. Yet a critic mentioned that teens in certain other societies act differently from American teens and that environment can change the brain. It would be interesting to do a study that compares MRIs of teens in different societies with American teens.

Cynthia Creary
Lewiston, Mich.

SURGICAL INSPIRATION

Katrina Firlik's "Should We Operate?" was an eye-opener. As a fourth-year medical student aspiring to become a surgeon, I found Firlik to be a true inspiration. Thank you, Katrina Firlik, for showing us that neurosurgery is not just about dealing with the brain but also about dealing with the minds of terrified patients—and for showing us that a career in neurosurgery is possible, even for students like me who are women.

Kavita Gundur
London

As a surgeon who has counseled cancer patients for 30 years and who, like Firlik, has also trained and worked at Yale University, I appreciated her comments. We doctors are informed but not educated during our training because we are trained to treat disease and not the patient's experience. We are tourists, whereas patients are the natives, each living a unique experience even when their diagnosis is the same.

My life changed when a patient told me, "I feel better when I am in the office with you, but I can't take you home with me. So I need to know how to live between office visits." That's when I began support groups and the patients trained me. I learned a great deal from being a patient, too. Spending time in a hospital bed should be a part of medical training.

The easiest way to find a good doctor is to ask him or her if he or she has ever been criticized by patients, nurses or family members. If the answer is yes, you have a good doctor. A good M.D.

is one who is learning from the natives and his or her own mistakes and who is capable of apologizing and not acting like a Medical Deity who is never truly "wrong." No one wastes time criticizing or providing feedback to someone who always has an excuse and is never at fault. For me, "M.D." also stood for "My Disease," and thinking about it that way has taught me a great deal.

Last, but not least, I use drawings by my patients and doctors to see what the experience of the operating room or the practice of medicine means to them. Patients will draw the operating room as heaven or hell, depending on how they feel about the experience—and it alters their recovery.

Bernie Siegel
Woodbridge, Conn.

Cave drawings from Lascaux, France, marked the rise of "mythic consciousness," in which ancient stories were depicted through art.

MIRRORS FOR FAINTING?

In "Feeling Faint," Rolf R. Diehl suggests that fainting at the mere sight of blood may result from the caudal midline medulla's attempt to invoke the vasovagal mechanism, after stimulation from a signal originating in the limbic system. I'd like to suggest an alternative explanation based on neuronal mirroring. Perhaps on seeing blood on another individual, the subject's so-called mirror neurons fire to activate the relevant motor neurons, which in turn stimulate the medulla's action.

Stephane Joseph Savanah
via e-mail

MAKING THE MODERN MIND

Regarding "Rise of the Modern Mind," by Cameron McPherson Smith: I have an unanswered question underlying both Merlin W. Donald's theory of evolving levels of cognition and new states of consciousness and Steven Mithen's theory of increasing fluidity and cross-referencing between the linguistic, social, technical and natural-history modules of intelligence. Why was the need to connect with and help others by communicating and sharing personal observations so strong in our earliest ancestors? In chimps, this need does not extend to adults who are nonkin, and it ends when their offspring reach independent adulthood. Lacking an explanation for the development in our evolutionary past of this seminal need, cognitive anthropology fails to lay the foundation for the uniquely human emotional dimension of our complexly interwoven neurological mind/body processes, leaving a gaping hole in our self-understanding.

Marilyn Kramer
Wausau, Wis.

WRONG PICTURE

I write about an error in the article "Picture This," by Thomas Grueter [February/March 2006]. It described my work as follows: "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."

In my review of the research literature on vividness of visual imagery (*Vividness of Visual Imagery: Measurement, Nature, Function and Dynamics*, Brandon House, 1995), I did note (page 20) that imagery may be less vivid with eyes open than closed because visual perceptual input may interfere with visual imagery; however, my combination of the results of five comparisons from four studies showed that the overall mean difference in imagery vividness under these two conditions was not significantly different.

This conclusion was reinforced by the results of another study (page 210), in which 20 out of 26 groups showed no difference in the two conditions. So it is certainly not the case that I found that mental imagery is generally better with eyes open than shut.

Stuart J. McKelvie
Bishop's University
Sherbrooke, Quebec

ERRATA On page 1 the credit should have read "COVER IMAGE BY KENN BROWN."

On page 50 the credit for the illustration should have read "SIGANIM *Gehirn & Geist.*"

ROBERT HARDING *Getty Images*

Head Lines

STUART McCALL *Getty Images*

Malicious Mirror

One of the symptoms of schizophrenia is having sensory illusions such as hallucinations or hearing voices. Now clues about the role that one area of the brain may play in generating such powerful illusions come from a study by Olaf Blanke of the Brain Mind Institute of the Swiss Federal Institute of Technology in Lausanne and his colleagues.

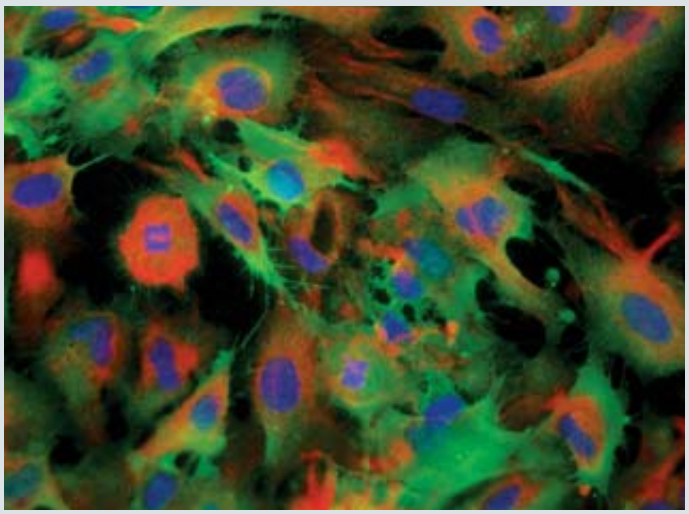
Blanke's team has described a 22-year-old woman with a normal psychiatric history who reported a "shadow man" right behind her when doctors stimulated a certain area of her brain, the left temporoparietal junction, in preparation for neurosurgery. When she sat up from a prone position, so did her phantom man, which convinced Blanke that what she was really experiencing was a distorted sense of her own body.

The patient felt the man was intent on grabbing her and interfering with her actions. "The shadow had bad intentions," Blanke says, describing how the patient felt. He points out that this compelling sense of an imagined entity bent on causing harm could also underlie conditions such as paranoia, persecution, and the feeling that someone else is in control of your body, a disorder known as alien control.

—Jonathan Beard

Safer Neuron Source

As your body develops, neural stem cells transform into the specialized neurons, glia and other cells that make up your brain. Researchers have long hoped to harness these stem cells to grow replacements for neurons damaged in degenerative disorders such as Parkinson's disease. But there is also some risk that neural stem cells will form tumors when implanted in a patient's brain. Now there may be an alternative.



Glial cells (*marked in green*), under the right conditions, can turn into neural progenitors (*in red*), which behave like stem cells. Blue indicates the cell nucleus.

Dennis Steindler of the McKnight Brain Institute at the University of Florida and other scientists were able to extract a population of neural progenitor cells from glia of adult human brains. Proteins in the progenitor cell membranes clearly distinguished them from stem cells. Nevertheless, the progenitors possessed stem cell–like abilities, although—unlike stem cells—they exhibited no tendency to form tumors.

"Glial cells have been viewed as the support cells of the brain," Steindler says, in contrast to neurons, the message-sending cells. For example, one type of glial cell provides the myelin sheath that wraps around neurons and insulates them. But when Steindler's group implanted the extracted human glial cells into the brains of mice, the cells grew into a wide variety of neurons.

The progenitors also have tremendous potential for growth. Normally glia can divide only 20 times in the test tube before the cells shut down. In this study, the scientists immersed the cells in a special broth known to sustain stem cells. The progenitors survived more than 60 divisions. The authors believe hormones in the broth triggered a mechanism to protect the cells' DNA, which accumulates damage as cells age.

"Of course, we're not jumping into clinical trials," Steindler says. But in the future, glia cultured on the lab bench may produce biological factors that can protect neurons at risk in patients with Parkinson's or Alzheimer's disease. And should you need to repair damage in your brain, you may be able to generate your own replacement cells. —*Kaspar Mossman*

SOURCE: "DERIVATION AND LARGE-SCALE EXPANSION OF MULTIPOTENT ASTROGLIAL NEURAL PROGENITORS FROM ADULT HUMAN BRAIN," BY N. M. WALTON, B. M. SUTTER, H. X. CHEN, L. J. CHANG, S. N. ROPER, B. SCHEFFLER AND D. A. STEINDLER IN *DEVELOPMENT*, VOL. 133, NO. 18; SEPTEMBER 2006 (EPUB AUGUST 16, 2006) (*top*); CORBIS (*bottom*)

Curiosity Trumps E-Popularity

What stops a few popular Web sites from dominating the global exchange of ideas on the Internet? Human curiosity powered by search engines, researchers say.

Visitors view and link to a few Web sites such as Yahoo, eBay and MySpace often, whereas most sites are hardly noticed. Some experts worry that search engines such as Google exaggerate this trend, because they rank search results partly by how popular a Web site already is. As a result, big sites could get ever more popular and small sites could grow relatively more obscure—an increasingly undemocratic result that critics deride as a "Googlearchy."

But Filippo Menczer, who teaches cognitive and computer science at Indiana University, found that this is not the way it works in the real world. His team studied databases of search terms and Web page traffic and then created a mathematical model to explain the observed patterns. It turns out that even though search engines reward pages for being popular, they also boost traffic to remote sites.

Menczer's model suggests that this effect occurs because people use search engines when they are looking for very specific information. So a small site that closely matches their individual interests will beat out a much more popular site that does not.

"That's a piece of behavioral data that the previous model did not consider. If you do not consider it, you assume everybody thinks the same way, everybody's interested in the same things. But that's not the case," Menczer says.

For example, if you search Google for "windows," the first hit will be Microsoft Corporation, maker of the Windows operating system and one of the world's most popular Web sites. But if you search for "double-hung windows," you will come up with the little-known Web site for Iowa-based Pella Corporation, which makes actual windows.

Menczer's model suggests that search engines introduce people to 20 percent more Web sites than they would find if they were forced simply to surf from site to site—as Web users did in the old days, before search engines. —*Kurt Kleiner*

Switching off the Inner Scrooge

Self-serving impulses and moral considerations often act as two opposing forces that govern our everyday behavior. But how does the brain decide which one wins?

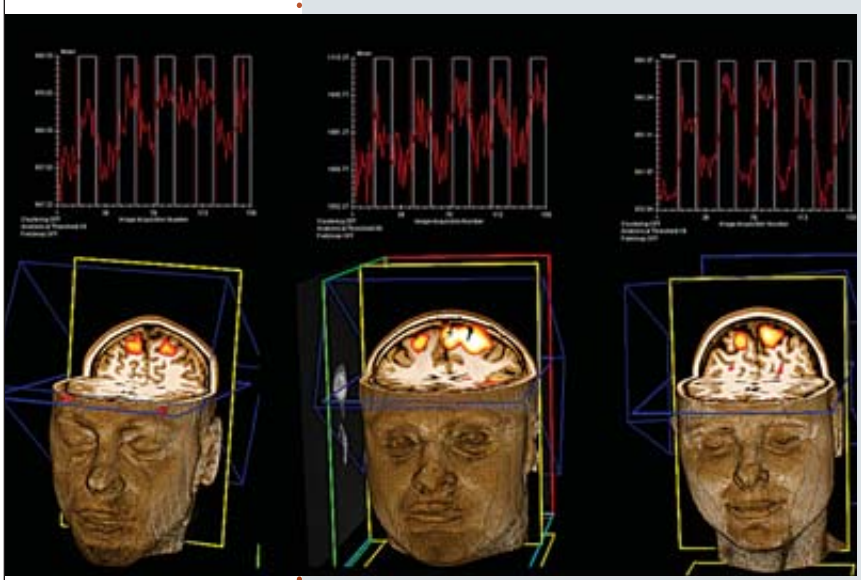
As a step toward answering that question, Ernst Fehr of the University of Zurich and his colleagues watched as 52 volunteers played the ultimatum game, an anonymous exchange in which an individual decides whether to punish a partner's behavior at his or her own cost. In this version of the game, one player proposes how to divide 20 Swiss francs with the second player. If the responder accepts, the first player gets the money demanded and the responder gets the rest. But if the responder rejects a lopsided offer, neither gets anything. "In this game, players must overcome selfish impulses if they want to punish their partners for an unfair offer," Fehr explains.

To test how the brain regulates the control of these impulses, the researchers disrupted the activity of the right or left dorsolateral prefrontal cortex (DLPFC), a brain region known to be involved in self-control. Using repetitive transcranial magnetic stimulation, a technique that delivers short magnetic pulses that penetrate the skull and temporarily disrupt neural firing, the team inhibited the DLPFC in 36 responders while they were making their decision. The remaining 16 players served as a control group.

The researchers found that turning off the right side of the DLPFC made the volunteers much more likely to accept highly uneven splits, even though they still judged these offers as unfair. "That suggests that right DLPFC activity is crucial when it comes to the ability to override selfish impulses," says Fehr, adding that dysfunctions of this brain region may cause certain mental disorders characterized by excessive selfishness. *—Nicole Branan*

Is Anybody in There?

At first glance, a patient in a persistent vegetative state may appear only to be resting, eyes open. But such patients show no sign of recognizing or interacting with their surroundings, and the likelihood that they ever will decreases as the months pass. Relatives and doctors face the difficult choice between continuing or ending life support, guided only by statistics and each patient's unique clinical profile. That may soon change. Scientists at the University of Cambridge and the University of Liège in Belgium reported that they had used MRI brain-imaging technology to detect signs of awareness in a 23-year-old woman who had been in a vegetative state for five months. "The brain scan showed us that not only was she able to understand speech, she was able to follow simple instructions," says Adrian M. Owen, lead author of the study.



The researchers first observed that ordinary speech produced responses identical to those of healthy volunteers. Because such activity could be automatic, they then asked the woman to imagine herself at Wimbledon, playing tennis. During this exercise, neurons fired in her supplementary motor area. A request for her to imagine walking through her home activated brain areas responsible for spatial navigation. Owen claims this response proves she was willfully following instructions.

Not everyone agrees. His results provoked a storm of media interest, along with skepticism from some experts. Even Owen is cautious about extending the conclusions of this study to other patients. "They're all different, including their chances of recovery," he says. But he speculates that by using brain imaging, doctors may be able to carry on two-way "conversations" with some vegetative patients, perhaps getting them to answer simple yes-or-no questions by imagining themselves playing tennis versus navigating their home. *—Kaspar Mossman*

GETTY IMAGES (*top*); COURTESY OF ADRIAN M. OWEN *University of Cambridge* (*bottom*)

Monkey See, Great-Great-Great-Grand Monkey Do

Wild chimpanzees from different places often display distinct regional behaviors, leading researchers to suspect that chimps can maintain local traditions across many generations.

In support of this theory, Victoria Horner of Emory University and the University of St. Andrews in Scotland and her colleagues recently showed that captive chimpanzees can transfer newly acquired knowledge through a chain of simulated generations. The study suggests that cultural learning may be rooted deep within the evolutionary process and may be traced back to a common ancestor.

The team trained a pair of chimpanzees to open the door of a box that contained fruit. But each animal was taught a different technique—one by sliding the door, the other by lifting it. Then each animal demonstrated the technique to another chimpanzee, which in turn simulated a member of a next generation. Once successful at using the method, the newly taught chimps became the teachers of a third generation, and so on. The experiment generated a chain of six chimpanzees that exclusively lifted the door and a chain of five chimps that slid the door open.

"Cultural learning determined which of the two techniques the chimpanzees used in much the same way it determines whether humans use knife and fork or chopsticks," Horner says. *—Nicole Branan*

Think Again

The brain is built to multitask, as long as the tasks require different types of perception. Some scientists have proposed that when the brain processes information from any sense, those data are then converted to an abstract code. This "code central" theory helps to explain how we transfer rules learned through one sense to another.

But it also suggests that we should be prone to mixing up information coming in from two senses at once because they would both be reduced to the same code. To test that prediction, Christopher Conway of Indiana University and Morten Christiansen of Cornell University evaluated how well people could discern complex patterns in sequences of objects on a computer screen or sounds played through headphones. The sounds or objects appeared based on two complex sets of invented rules, also known as "grammars."

Subjects were able to learn either grammar when it was presented by itself, through visual or auditory training. Code central theory would predict that when the two grammars were presented in the same learning session through different senses, subjects should be unable to distinguish between them. But that wasn't the case.

Instead they identified a grammar as correct only if it was presented through the same sensory stimuli in which it was learned. Surprisingly, people learned the grammars just as well whether they were presented one at a time or two at a time through different senses—excellent news for multitaskers. But performance plummeted if both grammars were presented with very similar stimuli, for example, two sets of abstract shapes or two sets of invented words. *—Temma Ehrenfeld*

BRIEFS

- **Twins** pay a price for being born with a partner, including lowered birth weight and an increased risk of congenital problems. But a recent study of Danish twins born from 1986 through 1988 finds that, contrary to what was previously believed, twins are not less intelligent. The twins did just as well as their singleton contemporaries on national achievement tests given in the ninth grade. Improved prenatal and pediatric care may have erased the cognitive handicap seen in older twins.

- **One competition** in the battle of the sexes has now been declared a photo-finish tie: the race to arousal. Men have long been thought the runaway favorites in this event. But this conclusion was drawn from experiments in which genital temperature was measured by direct, and distracting, contact via probes attached to the genitals. Scientists at McGill University used thermal-imaging cameras to more discreetly clock the speed at which men and women heat up and found that both sexes reached their peak in 11 to 13 minutes.

- **A misfolded protein** has been identified that plays a key role in two distinct neurological disorders. TDP-43 forms clumps inside brain cells in patients suffering from either frontotemporal dementia, the second most common cause of dementia in people younger than 65, and amyotrophic lateral sclerosis, a motor neuron disease famous for having crippled baseball player Lou Gehrig and physicist Stephen Hawking.

CORBIS (*top*); JULIA FULLERTON-BATTEN Getty Images (*bottom*)

God (Neurons) May Be Everywhere

In many faiths, a specific place is reserved for the ritual of reaching out to God, be it a church, synagogue, mosque or some other venue. Researchers recently examined whether certain brain locations are specially activated when a religious believer communes with his or her deity.

About a decade ago scientists advanced the hypothesis that neural activity during religious rapture occurs in a "God module" in the temporal lobes. The theory was inspired by the study of epilepsy patients in whom temporal lobe seizures induced mystical feelings. Results from a study by Mario Beauregard and Vincent Paquette of the University of Montreal, however, suggest that the neural activity that accompanies spiritual enlightenment is usually more complex.

Fifteen Carmelite nuns volunteered to recall the most intense mystical experience of their lives while being scanned in an MRI machine. It was not possible to observe spontaneous revelation, which the nuns believe is a product of God's grace. The researchers watched as neurons fired in the right temporal lobe and several other brain domains, including the caudate nucleus—associated with emotions such as love and happiness—and the superior parietal lobule, responsible for the spatial perception of self. Beauregard's conclusion: "There is no single God spot."

—Kaspar Mossman

Nuns volunteered to recall intense mystical experiences while being scanned in an MRI machine.

Treating Trauma on a Grand Scale

The fifth anniversary of the World Trade Center's collapse on 9/11, the second of the Indian Ocean tsunami, and the first anniversary of Hurricane Katrina's devastation of New Orleans recently put the issue of disaster preparedness back in the headlines. But despite a growing body of research and experience, the best way to be ready for the mental health effects of disasters is still unclear. "This is a field that is just coming of age," says Barbara Lopes Cardozo, a psychiatrist at the Centers for Disease Control and Prevention. A surge of new publications on disaster psychiatry in prestige journals is providing new data and insights.

Craig Katz of the Mount Sinai School of Medicine was part of a team providing services to rescue workers from 9/11. They found that half the patients answered mental health questionnaires in a way that triggered a follow-up exam, and half of those needed and accepted treatment. "We were surprised to see in the years that followed that those numbers never dropped off and the need never dropped off."

Researchers studying American soldiers have documented cognitive changes in healthy troops before and after deployment to Iraq, including the development of deficits in attention, learning and memory. But the same soldiers demonstrate an improvement in reaction time, suggesting they cannot shake off the state of hypervigilance their duty in hostile territory required. Although these mental changes fall short of clinical diagnosis of mental disorder, they may set the stage for later problems.

Traumatized people found little shelter from Hurricane Katrina.

Katrina provided lessons about how the entire mental health support system can collapse, even in rich, developed countries. Victims who saw and suffered enormous losses from the storm had new acute mental health needs. At the same time, many mental health workers had fled the area.

Cardozo and her colleagues looked at rates of post-traumatic stress disorder (PTSD) in adults and children after the tsunami. In adults, rates of PTSD declined significantly between two and nine months after the waves hit, but rates in children did not decline, suggesting they are at heightened risk for later psychiatric problems.

Most experts agree that the field next needs to move from epidemiology to interventional trials, trying different techniques to treat victims and monitoring the effect on mental health in the long term. But they are less confident that the current interest will translate into sustained support for large-scale trials. "In public health, mental issues are given less priority than physical ones. And in policy work, interest in disaster planning is episodic," Katz says.

—Phil Cohen

CORBIS (*top*); SEAN GARDNER *epa/Corbis* (*bottom*)

Hormone Harms Hearing

A popular form of hormone replacement therapy (HRT), which is often used to stave off the changes associated with female aging, can accelerate hearing loss. University of Rochester researchers led by Robert D. Frisina found that women who were taking a combination of estrogen and progestin had hearing deficits typically expected in women five to 10 years older. The study of 124 women between the ages of 60 and 86 points to progestin as the culprit, because the hearing of participants who took estrogen alone was unaffected by the treatment.

Previous studies have also documented slight hearing loss in women taking birth-control pills containing progestin and in younger women during the stage of their menstrual cycles when progesterone, the hormone's natural form, is at its highest level. Yet women still have better overall hearing than men up until menopause, a benefit attributed to natural estrogen.

Frisina thinks that the progestin-induced damage detected in the study may arise when nerve cell membranes are exposed to a progestin metabolite, allopregnanolone: the cells become less excitable, or responsive, to stimulation. If that is the mechanism at work, then the nerve cells in the HRT group with hearing loss may be dampened but not dead, suggesting that the effect is reversible. Frisina's group plans to study next what happens to women's hearing when they stop HRT.

Frisina would like to see drug companies perform similar sensory testing during development of HRT products and release any results they may already have. "It might be valuable information," he says. In the meantime, the hearing risk "should be part of the conversation when a woman and her doctor discuss HRT," he adds, particularly for women who already have hearing loss.—*Christine Soares*

Venus in Repose

If we see someone attractive, we say he or she is "easy on the eyes." Now new research suggests that beautiful faces, paintings, objects or patterns are attractive because they are easy on the mind.

Previous research showed that people tend to find typical things more attractive, from watches to birds to faces. In fact, researchers found that the secret to creating an attractive face was to "average" many faces into a digital composite (*right*). One idea is that evolution adapted us to like typical-looking faces because they suggest good health in a prospective mate. But this notion does not explain why we would like typicality in cars, fish or other things we are not trying to mate with.

It turns out that our brains might simply "like" stimuli that do not take too much effort to process, says Piotr Winkielman, a psychologist at the University of California, San Diego. And that holds whether we are looking at a human face or a pattern of dots.

Winkielman and his colleagues created two different random patterns out of eight dots. They called one of the patterns an "Ack" and the other one a "Blub." Then they showed people variations of these two patterns and asked them to rate each pattern as either an Ack or a Blub.

The closer each pattern was to its prototype, the faster people were able to make the classification and the more attractive they found the pattern—even though it was just a series of random dots with no obvious aesthetic value. The easier the pattern was to perceive, the prettier people found it.

The brain judges an "average" face—such as this digital composite of 16 people—to be more attractive than a single, unique portrait, which takes more effort to process.

"I think ultimately there's a reward for successful perception," Winkielman says. "There's an internal brain reward for processing efficiency. By making the pattern easier to perceive, we're letting the brain give itself a pat on the proverbial back." —*Kurt Kleiner*

ELIZABETH KNOX *Getty Images (top)*; JUDITH H. LANGLOIS *University of Texas at Austin (bottom)*

Ancient Sleep in Modern Times

Breaking a night's sleep into two pieces may not be a sign of insomnia but of a natural sleep pattern bubbling to the surface BY WALTER A. BROWN

IMAGES.COM *Corbis*

WE SEEM TO REGARD seven to eight hours of unbroken sleep as our birthright. Anything less means that something is awry. And people are willing to try anything to achieve that solid slug of slumber. Like a new-millennium version of Goldilocks, they try firm beds, pillow-topped mattresses and all manner of sleep systems to find one that is "just right." They shun caffeine and change their diet—porridge and warm milk, anyone? They visit sleep clinics and swallow some $3 billion worth of sleeping pills every year.

Yet a recent discovery and a reexamination of some classic sleep literature suggest that for some people the perfect eight hours of sleep remains elusive for a very simple reason: our need for such uninterrupted slumber may be nothing but a fairy tale.

The source of this new assault on conventional thinking comes not from a drug company lab or a university research program but from a historian. In his 2005 book *At Day's Close: Night in Times Past,* A. Roger Ekirch, professor of history at Virginia Polytechnic Institute and State University, reveals that in preindustrial times, before gaslights and electricity were widely used, people typically slept in two bouts they called first sleep and second sleep. Back then, sleep was closely tied to natural light. Within an hour or so after sunset, people retired to bed, slept for about four hours and then woke up. They remained awake for a couple of hours and then at about 2 A.M. returned to sleep for roughly another four hours.

From before the first century on, the period between first and second sleep afforded a chance for quiet contemplation or—if you had company—sexual intimacy. But people also got out of bed and did household chores or visited with family and friends. "They did anything and everything," Ekirch says. Of course, this pattern of sleep is no longer the norm in developed countries, where artificial light extends the workday. But anthropologists still observe a similar pattern of segmented sleep in some contemporary African tribes.

Snoozing Science Surprise

This history of broken sleep had been long forgotten until unearthed by Ekirch's recent detective work. Quite independently, however, sleep research has suggested that breaking a night's rest in two may result in a pattern more in tune with our inherent circadian rhythms and the natural environment. In the early 1990s Thomas A. Wehr, then a sleep researcher at the National Institute of Mental Health (NIMH), and his colleagues reported that when eight healthy men had their schedules shifted from their customary 16 hours of light and eight hours of dark to one in which they were exposed to natural and artificial light for 10 hours a day and confined to a dark room for 14

hours each night (similar to the natural durations of day and night in winter), they developed a sleep pattern characterized by two four-hour bouts, separated by one to three hours of quiet wakefulness. Thus, when freed from the time constraints on night imposed by modern life, subjects reverted to the segmented sleep of earlier times.

This sleep pattern is deeply embedded in mammalian evolution. Many animals that are active during the day—chimpanzees, chipmunks and giraffes among them—sleep at night in two distinct periods. In fact, Wehr points out that modern humans may be unique among animals in the extent to which their sleep is consolidated.

> Modern humans may be **unique among animals** in the extent to which they consolidate sleep.

Wehr, now a scientist emeritus at the NIMH, thinks that the current common pattern of an uninterrupted seven or eight hours of sleep may be an artifact driven by chronic sleep deprivation. For example, when the subjects of his experiments were adapted to their customary eight-hour night, they fell asleep in just 15 minutes, suggesting they were exhausted. And no wonder. They slept for an average of only 7.2 hours. But when their schedules were switched to 14 hours of darkness, at first they slept for about 11 hours, as if they were catching up on many lost naps. Finally, their average amount of sleep settled to 8.9 hours (although it was divided into two). They also fell asleep much more gradually, taking about two hours.

The insights from Ekirch and Wehr have significant implications for both the understanding of sleep and sleeping problems. "Waking up after a couple of hours may not be insomnia," Wehr says. "It may be normal sleep." But sleep specialists are mostly unaware of these findings and have not yet incorporated them into clinical practice. One reason is that these discoveries have not been widely disseminated. Although Ekirch's book received positive reviews, it is about history and not at the top of most reading lists. And whereas Wehr's research is well known to sleep specialists, it is usually viewed in the context of mechanisms governing sleep.

It also does not help that these findings fly in the face of current thinking. Todd Arnedt, a sleep researcher and clinician at the University of Michigan at Ann Arbor, says that for patients who cannot maintain sleep he follows the conventional approach of attempting to consolidate their sleep. He did not know about the two bouts of sleep discovered by Ekirch and Wehr but in light of that phenomenon thinks that the conventional approach might not always be the best one. He points out that how patients perceive their sleep determines to some extent how well they sleep. He already tries to get his patients with insomnia to "stop seeing their sleep as problematic." Ekirch notes that since he wrote his book many people have contacted him to tell him "how relieved they are to hear that their sleeping problem is natural."

Arnedt speculates that if patients were told that interrupted sleep was normal, they might be less distressed and fall back to sleep more easily. Mary Carskadon, a sleep researcher at Brown University, agrees. She also did not know of Ekirch's historical findings but did know of the segmented sleep pattern discovered by Wehr and that some animals take two sleeps. Considering these observations, she wonders if the archaic sleep pattern had some functional purpose. The change in sleep pattern "highlights something humanity might have lost in the hurly-burly times we live in today," she observes.

Perchance to Dream

So did the interval between bouts of sleep, common in earlier times, actually provide something of value, or did our ancestors merely tolerate it? Ekirch believes that the period of quiet wakefulness did offer a unique opportunity to contemplate dreams—and thus gain access to an otherwise less accessible part of mental life. He points out that people in that era took their dreams more seriously than we do today. Dreams were thought to "predict the future, offer a mirror to one's soul and reveal relations with God." And dreams influenced people's waking lives. "A dream prompted Virginian colonist John Rolfe to marry Pocahontas," Ekirch offers as one example. Dreams were more likely to be recalled after the first bout of sleep than in the morning when they tend to "evaporate more quickly." Wehr's research backs up this idea. His subjects usually woke from their first sleep during a rapid eye movement (or REM) period, when dreaming is most likely.

But Carskadon points out that civilization as we know it is unlikely to return to those simpler times. "It's hard to adapt to two bouts of sleep when you have to be at work at 8 A.M.," she says.

Still, if you find yourself awake in the middle of the night, it is comforting to know that you are not abnormal or alone. You're in the company of giraffes and chipmunks, of your ancestors and some of your contemporaries. If the usual measures don't suffice to bring on solid sleep, you can choose instead to savor your hours of sleeplessness. It's a time to meditate, have sex, think about dreams. Or, as Wehr says, you can "just lie there and go back to sleep." M

WALTER A. BROWN is clinical professor of psychiatry at Brown Medical School and the Tufts University School of Medicine.

When the Two Eyes Clash

A tale of binocular rivalry

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

WE LOOK AT THE WORLD from two slightly different vantage points, which correspond to the positions of our two eyes. These dual vantage points create tiny differences between the two eyes' images that are proportional to the relative depths of objects in the field of view. The brain can measure those differences, and when it does so the result is stereovision, or stereopsis.

To get an idea of this effect, extend one arm to point at a distant object. While keeping your arm extended, alternately open and close each eye. Notice how your finger shifts in relation to the object, illustrating the horizontal disparity between the eyes.

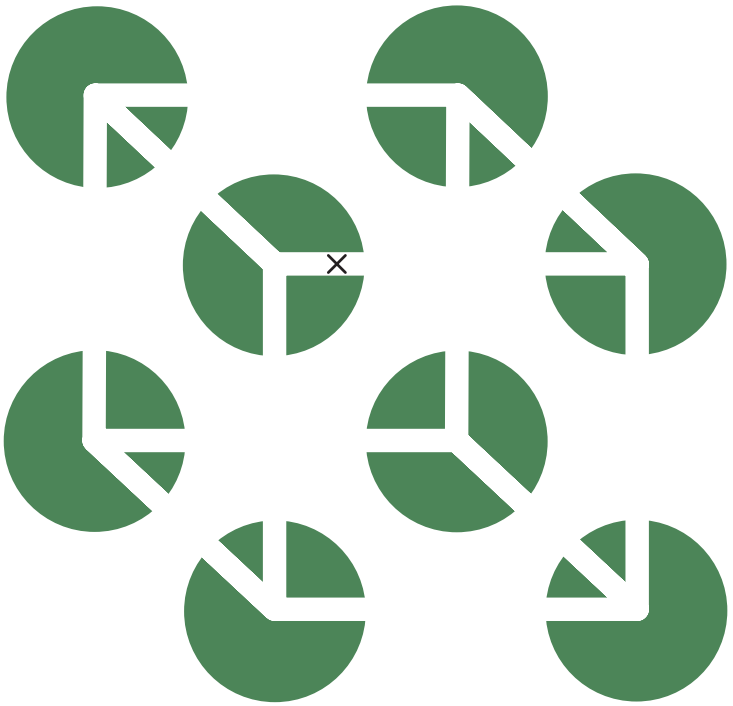
Viewing devices that took advantage of stereopsis to create illusions of depth in images of natural scenes, architectural monuments and even pornography became immensely popular in Victorian drawing rooms. View-Master and Magic Eye are their familiar descendants available today.

Brain Fusion

A less commonly appreciated fact about stereovision is that even though we see two images of an object—one through each eye—we perceive only one object. (In similar fashion, if you touch a single banana with your two hands, you feel one banana, not two.) Thus, the images of the two eyes must be "fused" somewhere in the brain to give rise to a unitary item of perception, or percept. But we can ask the questions, What if the eyes look at completely dissimilar things? Would we perceive a blend?

Try the following experiment. Get low-power reading glasses, such as you can find in any drugstore. Affix two colored filters, one bright red and one bright green, to the front of each lens. Put the glasses on. If you now look at, say, a white object or surface, what do you see? If you close one eye or the other, you see red or green as expected. But what if you open both? Do the two colors harmonize and blend in your brain to produce yellow as they would if blended optically? (As any preschooler knows, red and green make brown if you mix pigments like tempera paints. But if you mix lights by projecting them onto a screen, red and green produce yellow.)

a



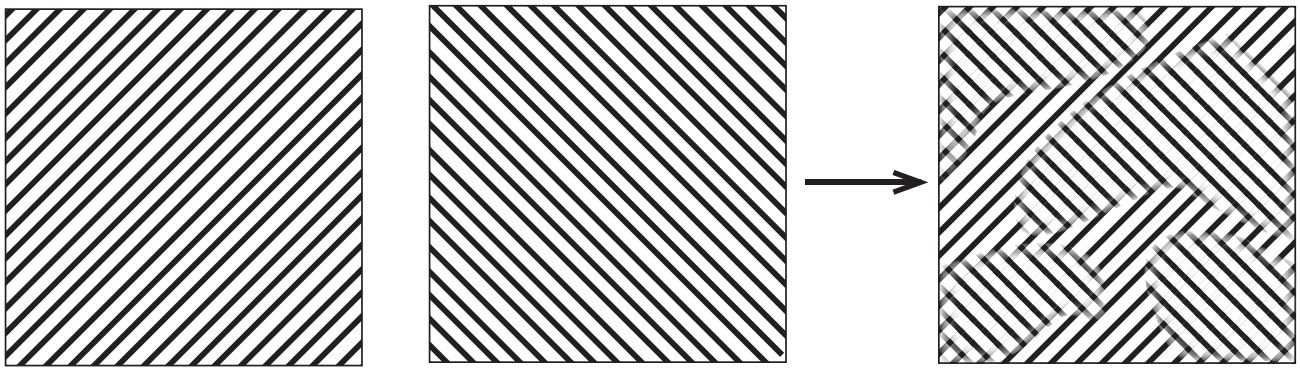
The surprising answer is that you see only one thing at a time. The object appears alternately red and then green. The eyes seem to take turns politely, as if to avoid conflict. This phenomenon is called binocular rivalry, and the effect is similar to what you see in the Necker Cube (*a*). To the viewer, it may seem as though these dynamic perceptual experiences arise because the object is itself changing. Yet the stimulus is perfectly stable, and it is instead the pattern of brain activity that is changing during viewing and producing the perceptual alterations or the illusion of an unstable object.

We can use rivalry as a powerful tool to explore the more general question of how the brain resolves percep-

The changing pattern of brain activity produces the illusion of an **unstable object**.

JOHNNY JOHNSON

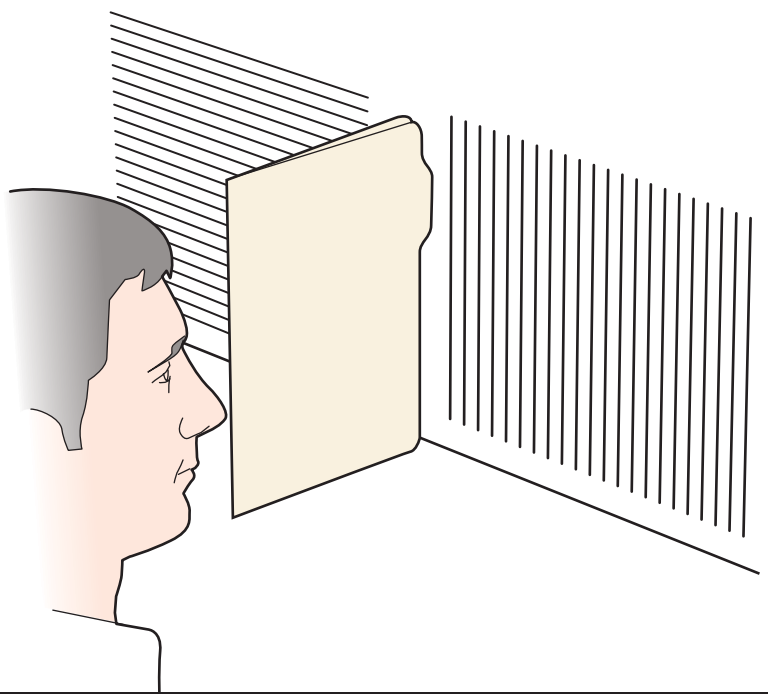
You will see either the two sets of stripes alternating or a fluctuating mosaic but **never a grid**.



b

tual conflicts. Let's try another experiment. Instead of two different colors, what if you give the eyes two sets of stripes that are perpendicular to each other? Would they produce a grid? Or do they clash? The answer is that sometimes you see them alternate—but equally as often you see a mosaic of patches, with sections of both eyes' images interleaved (*b*). No grid.

Theoretically, you could do this experiment by putting vertical stripes for the right eye and horizontal for the left in a stereo viewer. But if you do not have one, you can create what we call the poor man's version (*c*). Just prop up a vertical partition, like a manila folder, right at the boundary between two images corresponding to left and right eyes. Put your nose on the partition so the left eye looks exclusively at one image and the right eye at the other. You will see either the stripes alternating or a fluctuating mosaic but never a grid. With practice you can dispense with the partition and just learn to "free fuse" the two images by converging or diverging your eyes. It helps if you initially look at a pencil tip halfway between the images and your face.



c

Once you have learned this trick, you can try a number of new things. We know, for example, that different areas of the brain are involved in processing color and form of visual images. So we can ask, Does the rivalry occur separately for these two, or do they always happen together? What if you looked at the left eye's stripes through a red filter and the right eye's through a green one? There will now be both rivalry of color and rivalry of form. Can these two rivalries come about independently, so that the left eye's color goes with the right eye's stripes, or do they always "rival" synchronously? The short answer is that they do so together. Putting it crudely, the rivalry is between the eyes themselves rather than in processing the colors or shapes.

Complete the Picture

But that is not always true. Consider the curious display in *d*. Each eye's picture is a composite of a monkey's face and foliage. Intriguingly, if the brain fuses the images it has a strong tendency to complete either the monkey or the foliage—even though doing so requires assembling fragments from two different eyes to complete the patterns. In this case, the brain is picking bits from each eye that make "sense" as a holistic pattern when combined correctly.

Let's return to stereopsis, the com-

SCIENTIFIC AMERICAN (*top*); JASON LEE (*bottom*)

You can use relatively simple experiments to gain **deep insights** into visual processing.

d

putation of relative depth from images in the two eyes that are slightly different because the eyes are separated horizontally in the skull. Here both image fusion and stereo depth occur instead of rivalry. It is quite remarkable that people wandered our planet for millennia without recognizing stereopsis (probably assuming that the benefit of two eyes is that if you lose one you have a spare). Leonardo da Vinci pointed out that this information existed 500 years ago; the fact that the brain actually uses it was discovered by Victorian physicist Charles Wheatstone. You can create an example of Wheatstone's discovery by viewing a drawing of a bucket shape as seen from the top. When you fuse the two eyes' pictures (using free fusion or the partition card), a gray disk jumps out at you—as if suspended mysteriously in thin air—from the plane of the outer circle.

But do you *need* fusion for stereopsis to occur? This may seem like a trick question, because one would think so intuitively, but that intuition is wrong. Three decades ago Anne Treisman of Princeton University, Lloyd Kaufman of New York University and one of us (Ramachandran) independently showed that, paradoxically, rivalry can coexist with stereopsis.

To understand this phenomenon, look at the stereogram shown in *e*. It has two patches of stripes shifted horizontally in opposite directions relative to the outer circles. When the brain fuses these circles, something extraordinary happens. You will see the entire patch floating out in front—yet only one patch at a time, because the stripes themselves are orthogonal. In other words, the brain extracts the stereo signal from the patches as a whole—interpreting the individual chunks as blobs—yet those patches themselves are seen to rival.

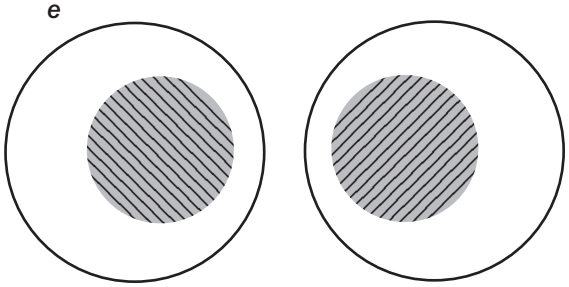
The information about the location of the patches on the retina is extracted by the brain and produces stereopsis even though only one eye's image is visible at a time. It is as if information from an *invisible* image can nonetheless drive stereopsis.

Such "form rivalry" occurs in a different brain area from stereopsis, so that the two can coexist in harmony. The correlation between them in normal binocular vision is coincidental, not obligatory. This discovery that certain visual information can be processed unconsciously in a parallel brain pathway reminds us of the enigmatic neurological syndrome of blindsight. A patient with damage to the visual cortex is completely blind. He cannot consciously perceive a light spot. But he can reach out and touch it using a parallel pathway that bypasses the visual cortex (which you need for conscious awareness) and projects straight to brain centers that are on a kind of autopilot to guide your hand.

A similar experiment could, in theory, be done for binocular rivalry. When one eye's image is suppressed entirely during rivalry, can you nonetheless reach out and touch a spot presented to that eye, even though that spot, for the suppressed eye, is invisible?

The phenomenon of rivalry is a striking example of how you can use relatively simple experiments to gain deep insights into visual processing. M

e



VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego.

(Further Reading)

- **Stereopsis Generated with Julesz Patterns in Spite of Rivalry Imposed by Colour Filters.** V. S. Ramachandran and S. Sriram in *Nature,* Vol. 237, pages 347–348; June 9, 1972.
- **Binocular Vision and Stereopsis.** Ian P. Howard and Brian J. Rogers. Oxford University Press, 1995.
- **Binocular Rivalry.** Edited by David Alais and Randolph Blake. MIT Press, 2004.

(calendar)

LA BELLA MANO, BY DANTE GABRIEL ROSSETTI, SAMUEL AND MARY R. BANCROFT MEMORIAL (1); *NEW YORK HARBOR COMPOSITE*, 2003, BY YVONNE JACQUETTE, YALE UNIVERSITY ART GALLERY, GIFT OF MARY RYAN IN FOND MEMORY OF ALLAN KAPLAN, B.A. 1957 (2); PHOTOGRAPH BY FRANK MASI/WARNER BROS. PICTURES AND LEGENDARY PICTURES, *WE ARE MARSHALL*, DISTRIBUTED BY WARNER BROS. (3); WWW.DEVELINTEL.BLOGSPOT.COM/ (4)

MUSEUMS/EXHIBITIONS

1 Waking Dreams: The Art of the Pre-Raphaelites from the Delaware Art Museum

In 1848, the year of revolutions in Europe, three British art students rebelled against the formalities of the British Academy and sought to follow a Romantic ideal of responsible freedom. Their goal was to express novel ideas, their muse was to be Nature, and they derived their artistic technique from principles they felt had lost integrity following the rise in influence of Renaissance painter Raphael.

These artists' longing for an earlier time is a spectacular chapter in cultural and art history. If you miss the exhibition in Cincinnati, it travels in 2007 to St. Louis and then San Diego.

Cincinnati Art Museum
October 31, 2006–January 7, 2007
513-639-2984
www.cincinnatiartmuseum.org/

2 To Know the Dark: American Artists' Visions of Night

In the absence of daylight the imagination takes over. This exhibition "explores that evocative period from dusk to dawn" in works from American artists of the 19th and 20th centuries whose interpretation of night includes "intimations of suspense, mystery, romance, fantasy, fear, despair, and hope."

Yale University Art Gallery
On exhibit through January 14, 2007
203-432-0600
artgallery.yale.edu/

Logic Puzzle Museum

Did the Slocum Puzzle Room at the Lilly Library (in Bloomington, Ind.) whet your appetite? Want some tactile stimulation to go with your brainteasers?

This small Wisconsin museum not only has 50-plus hands-on "brain twisters" for anyone who calls ahead and reserves a time slot but also shares space with museums that exhibit spinning tops and teach yo-yo skills. Tangrams, take-aparts, giant Rush Hour, but "no jigsaw puzzles."

Burlington, Wis.
262-763-3946
www.logicpuzzlemuseum.org/

CONFERENCE

1st North American Regional Epilepsy Congress

The American Epilepsy Society, the Canadian League against Epilepsy and the Jamaican Chapter of the International League against Epilepsy join forces this year to bring together epilepsy care professionals in the struggle against a neurological condition that affects up to 50 million people worldwide.

San Diego
December 1–5
info@aesnet.org
860-586-7505
www.aesnet.org/Visitors/AnnualMeeting/index.cfm

MOVIES

3 We Are Marshall

On November 14, 1970, a plane crashed into a misty hillside in West Virginia. Among the 75 who died were most of the players and coaches from the Marshall University football team. The title comes from the team cheer, and the film is based closely on the events that followed the crash, as the school's president (the talented David Strathairn) and the new coach (Matthew McConaughey) struggle to rebuild the football program and in so doing help the community of Huntington, W.Va., and the university recover from a devastating tragedy.

Warner Bros. Pictures
Opens December 22
www.wearemarshall-themovie.com/

Apocalypto

As a Mayan kingdom slides into extinction, its rulers attempt to offer up as a sacrifice one Jaguar Paw (Rudy Youngblood). Rather than helping out his nation and appeasing the Gods, the young man selfishly chooses to flee. Directed (and co-written and financed) by Mel Gibson, the film is a broad allegory of his perceived decline of modern Western civilization. The director seems to be settling well into his new role as cultural lightning rod, so the wider discussions swirling around this film promise to be as fascinating as the work itself (though less gory, one hopes).

Distributed by Touchstone Pictures (Disney)
Opens December 8
http://apocalypto.movies.go.com/

WEB SITES

www.apsa.org

The American Psychoanalytic Association expanded its Web site recently. The site's most refreshing pages contain answers to the fundamental questions that a corporate culture might be tempted to brush off, such as "Does Psychoanalysis Cure?" There is a wealth of information on conditions, diagnoses and theories (all from the psychological school of thought that stems from the theories of Sigmund Freud—so you know there's going to be an awful lot on the interpretation of dreams) as well as position statements (for instance, their "Marriage Resolution" on same-gender couples) and more practical information for students training in the psychoanalytic method.

4 develintel.blogspot.com

The author of the Developing Intelligence blog, Chris Chatham, has obviously spent more time putting together this fine blog on cognitive neuroscience than pursuing his own Ph.D. studies. As lucky recipients of his efforts, we can catch up on such interesting topics as working memory and read about how commercial applications of basic research in cognitive science have propelled the burgeoning "brain fitness" movement for older adults as well as the related "enriched play" toys aimed at toddlers.

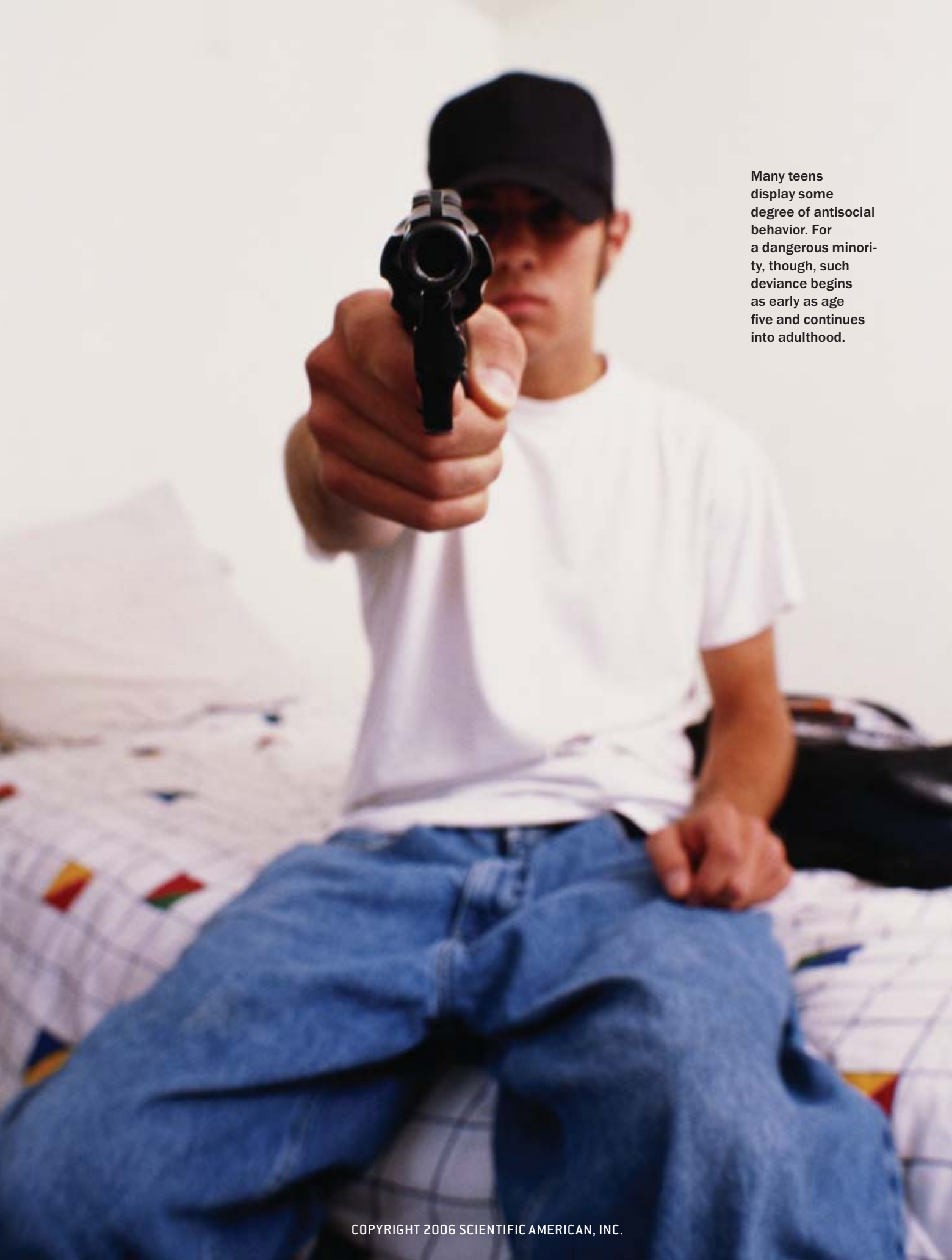
Compiled by Dan Schlenoff.
Send items to editors@sciammind.com

THE VIOLENT BRAIN

VIOLENT BEHAVIOR NEVER ERUPTS FROM A SINGLE CAUSE. RATHER IT APPEARS TO RESULT FROM A COMPLEX WEB OF RELATED FACTORS, SOME GENETIC AND OTHERS ENVIRONMENTAL BY DANIEL STRUEBER, MONIKA LUECK AND GERHARD ROTH

On September 13, 2006, Kimveer Gill walked into the cafeteria at Dawson College in Montreal and, without apparent motive, shot 21 people, injuring 19 and killing two, including himself. The same day a judge in West Virginia sent a woman to jail for, among other atrocities, forcing her six children and stepchildren to gorge themselves on food and then eat their own vomit. Also on the 13th, a court in New York sentenced a man for killing his girlfriend by setting her on fire—in front of her 10-year-old son. There was nothing special about that Wednesday. From around the world we hear reports of murder, manslaughter, cruelty and abuse every day. Violence is ubiquitous.

JIM CORWIN *Getty Images*



Many teens display some degree of antisocial behavior. For a dangerous minority, though, such deviance begins as early as age five and continues into adulthood.

Perpetrators who carefully plan their crimes typically express no empathy or regret.

But what drives one person to kill, maim or abuse another, sometimes for little or no obvious reason—and why do so many violent offenders return to crime after serving time in prison? Are these individuals incapable of any other behavior? We have evaluated the results of studies conducted around the world, focusing on acts ranging from fistfights to murder, in search of the psychobiological roots of violence. Our key conclusion is simple: violent behavior never erupts from a single cause. Rather it results from a combination of risk factors—among them inherited tendencies, a traumatic childhood and other negative experiences—that interact and aggravate one another. This realization has a silver lining: positive influences may be able to offset some of those factors that promote violence, possibly offering hope for prevention.

Impulse Control

In 1972 an international team of psychologists launched one of the largest longitudinal studies ever conducted. The Dunedin Multidisciplinary Health and Development Study has now followed approximately 1,000 people born in the New Zealand city of Dunedin for nearly 34 years. Terrie E. Moffitt and Avshalom Caspi, both at King's College London and the University of Wisconsin–Madison, have participated in the study, examining, among other things, antisocial behavior associated with physical violence. They have observed that those who exhibit antisocial behavior fall into two distinct groups. Most are between the ages of 13 and 15, and their delinquency stops just as quickly as it starts. A small minority, however, display antisocial behavior in childhood—in some cases as early as age five—and this conduct continues into adulthood. Among this latter group, almost all are boys.

Indeed, male gender is the most important risk factor for violent behavior. As criminal statistics show, boys and young men commit the majority of physical assaults. According to the Federal Bureau of Investigation's statistics on crime in the U.S., 90.1 percent of murderers apprehended in 2004 were male and men accounted for 82.1 percent of the total number arrested for violent crimes. Girls and women are not necessarily less aggressive, as was assumed until the 1990s. But women engage in more indirect, covert aggression, whereas men tend toward immediate, outward physical aggression [*see box on page 24*].

The causes of these gender differences are manifold. Learned sex roles certainly enter into it: "girls don't hit," for example, but "boys need to be able to defend themselves." Also, indirect aggressive strategies require a relatively high level of social intelligence, which girls develop earlier and faster. Moreover, neurophysiological discrepancies almost certainly play a role. The small group of males who exhibit chronic violent behavior from an early age typically share other telltale traits, among them a low tolerance for frustration, deficiencies in learning social rules, attention problems, a decreased capacity for empathy, low intelligence and, most characteristic, extreme impulsiveness.

Similarly, repeat offenders—particularly those who have long prison records—seem unable to keep their aggressive urges in check. The late neuroscientist Ernest S. Barratt and his colleagues at the University of Texas Medical Branch interviewed imprisoned criminals in Texas in 1999 and found that many inmates consistently picked fights, even though they knew that their lives

FAST FACTS

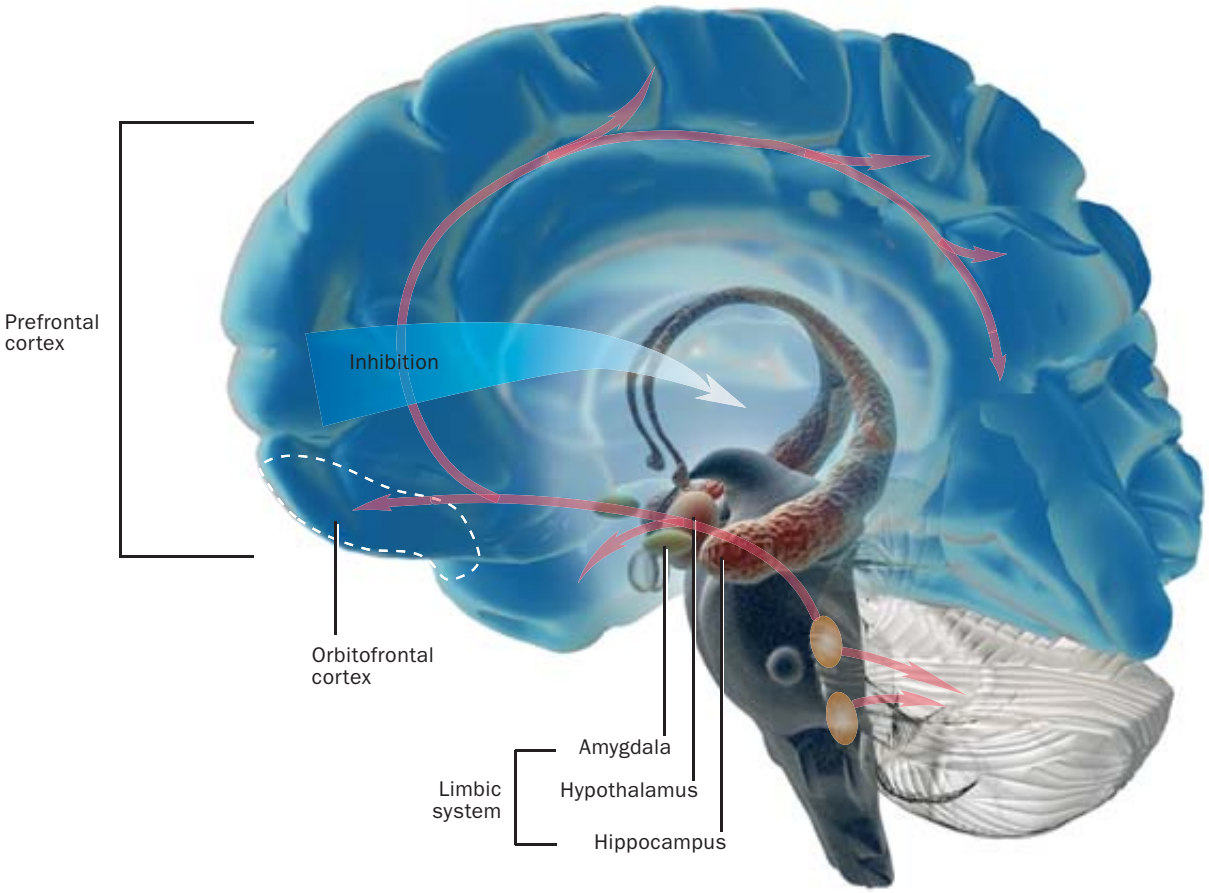
Roots of Violence

1» Violent behavior never erupts from a single cause. Rather it results from a complex web of interrelated factors—among them an individual's inherited tendencies, brain anatomy and childhood experiences. Male gender is the most prominent risk.

2» Abnormalities in the frontal cortex may cause deficiencies in emotional control that fail to stop impulsive criminals from acting. Anomalies in the limbic system may hinder communication between the hippocampus and amygdala so that emotional information is not processed correctly. Irregular neurochemistry, too, may cause increased aggression in some violent offenders.

3» If biology and circumstance conspire to prime certain individuals toward violence, how much responsibility do people really bear for their actions? Some legal experts now question whether a violent offender can truly exercise free will despite his or her psychobiological and social predispositions.

Anatomy of Aggression



Anomalies in the prefrontal cortex may handicap some individuals, making it difficult for them to show restraint. Some scientists hypothesize that the orbitofrontal cortex, an area involved in decision making, normally inhibits regions in the limbic system—specifically the hypothalamus and the amygdala, where fear and aggression arise. If a defect blocks this communication, a person might not be able to moderate his or her emotional reactions. Damage to the hippocampus may also impair the brain's processing of emotional information. In some instances, a malfunction of the amygdala may underlie violent behavior. This theory could explain the lack of fear, empathy and regret that is characteristic of criminals who plan their acts and commit them in cold blood. *—D.S., M.L. and G.R.*

would be made more difficult as a result. When asked why they continued to behave in ways that hurt them, many responded that they had no idea. Even though they understood the consequences and resolved to act with greater self-control the next time, they did not trust their own ability to keep their impulses at bay.

Preliminary research indicates that biology may handicap some of these individuals, making it more difficult for them to show restraint. Among violent offenders, neuroscientists have found anatomical and physiological differences in both the limbic system and the prefrontal cortex, brain regions that are involved in the development and control of emotions. Some scientists propose that the orbitofrontal cortex, a region of the prefrontal cortex where decision making takes place, inhibits areas of the limbic system—specifically the hypothalamus and the amygdala, primitive brain regions that are a source of fear and aggressive impulses. Thus, if some defect or injury impairs communication between the limbic system and the frontal cortex, a person might not be entirely able to moderate his or her emotional reactions.

Frontal Brain Hypothesis

This assumption underlies the so-called frontal brain hypothesis, which several studies support. Cognitive neuroscientist Jordan Grafman and his colleagues at the National Institutes of Health have discovered that Vietnam War veterans who suffered damage to the prefrontal cortex

The Testosterone Connection

Why are men more likely to resort to physical aggression? The sex hormone testosterone, which readily passes through the blood-brain barrier, offers some clues. In many animal species, male aggressiveness is closely linked to testosterone levels. In humans, the association seems slight—but researchers have found significantly higher levels of testosterone in violent offenders as compared with nonviolent criminals.

The concentration of testosterone is subject to considerable fluctuation: it increases in men, for example, just before competitive sports. The level remains high for some time in the winners but decreases rapidly in the losers. Constant competition and conflict may thus permanently alter an individual's testosterone level. In general, male testosterone levels peak in the late teens and remain high until the mid-20s—exactly the age group in which male aggression and violence are most common.

The data on testosterone in women are contradictory, which is not surprising given that women synthesize only a small fraction of the quantity that men do. Of interest, though, James Dabbs and his colleagues at Georgia State University measured testosterone in 87 women at a maximum-security prison and found that the hormone levels varied with the violence of the women's crimes and their behavior behind bars. The most violent women who also showed the greatest aggression toward other inmates had the most testosterone. When asked to describe the women who had the lowest hormone levels, prison staff used words like "sneaky" and "treacherous"—which may show that, in place of outward aggression, these women used less direct strategies to get their way. *—D.S., M.L. and G.R.*

tend to be more aggressive. Similarly, adult patients who have frontal brain lesions are generally more uninhibited, inappropriate and impulsive—much like people with antisocial behavior disorders. In these adult groups, however, there is no direct indication that their brain damage predisposes them to actual violence.

For children who suffer frontal brain injury, the behavioral consequences are often more dramatic, as documented by neuroscientist Antonio R. Damasio and fellow researchers at the University of Iowa College of Medicine. In one case, surgeons removed a tumor from the right frontal cortex of a three-month-old infant. By age nine the boy had become almost impossible to motivate in school, remained socially isolated and spent almost all of his free time in front of the television or listening to music. Occasionally he would "go wild" and threaten others, sometimes physically. Of significance, the boy grew up in a caring environment with loving parents and his siblings developed normally.

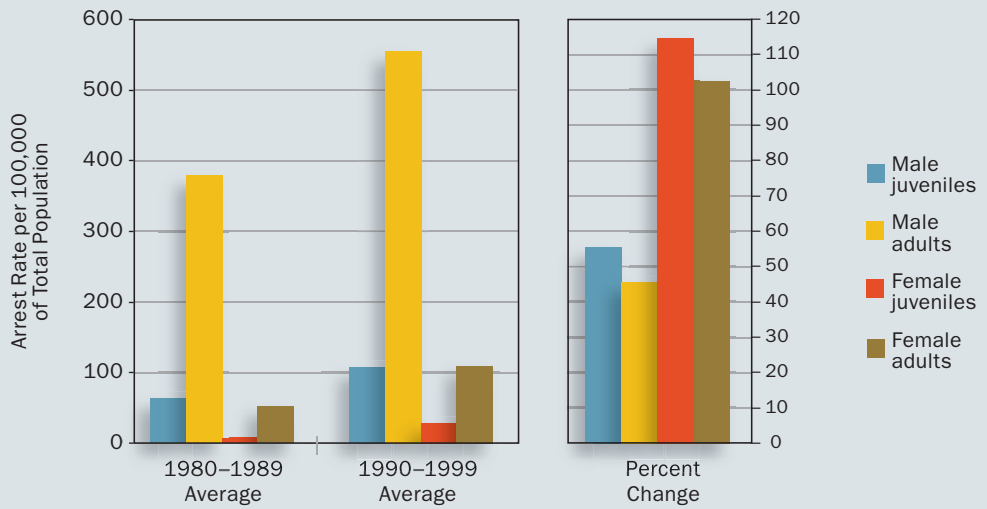
In another case described by Damasio, a 15-month-old girl suffered head injuries in a serious automobile accident. She progressed typically at first but, at age three, started to exhibit behavioral disorders. At the time, her parents noted that she failed to react at all to punishment. Later she refused to comply with rules, frequently fought with teachers and classmates, lied shamelessly, stole and broke into homes. Most notably, she constantly attacked other people both verbally and physically. She, too, had normal brothers and sisters.

Additional evidence bolstering the frontal brain hypothesis comes from Adrian Raine and his colleagues at the University of Southern California, who have studied convicted murderers.

SIGGI BUCHER *Reuters Corbis*

Women engage in more indirect, covert aggression, whereas men tend toward physical force.

Violent Crime Rates



Although men account for the majority of arrests for violent crime, the number of women taken into custody for similar offenses is rising—and rising fast. The total arrests among juvenile and adult females shot up by more than 100 percent from the 1980s to the subsequent decade, whereas the figure rose by approximately half that amount among male teenagers and even less than that among adult men.

—*D.S., M.L. and G.R.*

Using positron-emission tomography (PET), they found lower levels of metabolic activity in the murderers' frontal brain regions as compared with members of the general public. Further analysis, however, revealed that this difference existed only among criminals who had killed on impulse. The frontal brain appeared normal in those murderers who had planned their crimes meticulously and committed them in cold blood, seemingly without conscience.

"Successful Psychopaths"

This finding backs the notion that deficiencies in emotional control may fail to prevent impulsive violent offenders from acting. They do not stop to think through to the consequences. In contrast, the cold, calculating criminal requires a largely intact frontal brain because long-term planning involves complex decision processes. Even though perpetrators who plan carefully are relatively few in number, they elicit the most horror, in large part because they often express little to no empathy or regret.

Raine and his colleagues further investigated criminals who premeditate—both before and after capture. This new area of research is thorny, not least because of the methodological difficulties in identifying at-large psychopaths. To get reliable information, researchers must guarantee their subjects absolute confidentiality and promise not to alert the authorities, which is exactly what Raine and his co-workers recently did. They compared two groups of violent criminals who had antisocial personality disorders, only some of whom had faced conviction, with 23 control subjects. Raine characterized the 16 apprehended offenders as "unsuccessful psychopaths" and the 13 who evaded the law as "successful psychopaths."

(The Authors)

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SOURCE: NATIONAL CONSORTIUM ON VIOLENCE RESEARCH

Some repeat offenders report that they distrust their ability to control aggressive urges, despite having a desire to do so.

CHRIS LESCHINSKY *Getty Images*

An anatomical comparison using structural magnetic resonance imaging (MRI) revealed significant differences: the volume of gray matter in the prefrontal cortex was 22.3 percent lower among the unsuccessful offenders as compared with the control subjects. Moreover, the volume was within normal limits among those violent criminals who avoided capture. Supplemental testing showed that the frontal brains of successful psychopaths performed even better than average on a variety of neuropsychological tasks.

Additional investigations of the same violent criminals identified irregularities in the hippocampus, a limbic structure that straddles both hemispheres of the brain: in the unsuccessful group, the hippocampi in either hemisphere differed in size, an imbalance the researchers presume arose early in brain development. This asymmetry may impair the ability of the hippocampus and amygdala to work together, so that emotional information is not processed correctly. If the prefrontal cortex then fails as the control of last resort, inappropriate verbal and physical reactions might result.

Raine's findings, if substantiated, suggest that successful psychopaths exhibit an entirely different causal pattern of violent behavior. Although these calculating criminals have intact impulse control, they may suffer from other brain abnormalities. To find out, scientists must study the role of the amygdala, as well as the reward centers in the limbic system. Researchers such as James Blair of the National Institute of Mental Health now believe that these structures are responsible for psychopathic behavior. Blair has suggested that dysfunction of the amygdala detrimentally affects an individual's socialization, leading to a reduced capacity to feel empathy or guilt, among other emotional impairments.

Clearly, antisocial behavior is a complicated phenomenon—one that the frontal brain hypothesis may explain only in small part. In light of Raine's results, frontal brain defects seem more closely associated with the risk of apprehension than with serious, chronic violence. So, too, it is unclear whether the frontal brain hypothesis applies to women.

Female violent offenders are rare and therefore less well studied. Even so, no connection appears to exist in females between a decreased frontal brain volume and psychopathological tendencies, as has been shown in the male population. By nature, women appear to have more

Does it really make sense to assume that a criminal can consciously choose to not act violently?

effective impulse control, which tends to fail only when the functioning of the prefrontal cortex is massively impaired in childhood.

A Combustible Mix

Other lines of evidence suggest that neurochemistry may help prime the violent brain. Numerous studies have linked low levels of serotonin—an often inhibitory and fear-reducing substance in the brain—to antisocial, impulsive acts. Of interest, researchers have found this association not only among criminals but among men in general. Studies have not confirmed the same connection in women, suggesting that the male sex hormone, testosterone, also plays a role. Psychologist James Dabbs of Georgia State University has conducted several studies demonstrating that violent criminals have higher testosterone levels than nonaggressive criminals do. Such biochemical differences may be genetic or linked to environmental factors. For example, neglect and abuse in childhood may permanently reduce serotonin levels.

Biochemical differences, as well as genetic and structural brain variations, do seem to increase the risk of violent behavior in some men. Except in the most severe and early cases of damage, though, these factors are not enough to precipitate actual violence. It is in combination with psychosocial risk factors that a predisposing biological mix can become explosive, as numerous studies have confirmed. Such psychosocial risk factors include serious deficiencies in the early mother-child relationship, abuse in childhood, parental neglect and inconsistent parenting, as well as persistent parental conflicts, a breakup or loss in the family, parental criminality, poverty and long-term unemployment.

Researching these factors is problematic because several cannot be viewed independently from the anatomical and physiological changes mentioned previously. If, for example, behavioral and emotional disorders are present very early on, the parents' child-rearing abilities will be severely tested. As Mechthild Papoušek, a pediatric psychiatrist at the Max Planck Institute of Psychiatry in Munich, has shown, intimate communication between the infant and the primary caregiver begins shortly after birth. The two reinforce each other's behavior, both in the positive and in the negative sense. The infant's qualities determine the interaction just as much as the caregiver's personality and psychological state do. And a problematic early relationship can in time lead to severe developmental disorders, among them lowered impulse control, a lack of empathy and a reduced capacity for resolving conflicts. The result is a vicious cycle.

A robust cognitive and emotional makeup can help some children to overcome the negative influences in their environment. At present, it is still unclear why many people are able to compensate for terrible childhood experiences or early brain damage and violent offenders are often not. This knowledge gap is worrisome. Can we hold people responsible for their genetic makeup, brain development or traumatic experiences? How much responsibility do people bear for their actions? Does it make sense to believe that a criminal could decide to not act violently—if only he or she wanted to?

Some legal experts now question the assumption that a violent offender can exercise free will despite psychobiological and social predispositions [see "Brain Scans Go Legal," by Scott T. Grafton, Walter P. Sinnott-Armstrong, Suzanne I. Gazzaniga and Michael S. Gazzaniga, on page 30]. It is an assumption that, when reconsidered, may force us to revise our notions of culpability. But we need not be helpless in the face of violent crime. Though a subject of contentious debate, it may be enough to pursue a policy of prevention, consisting of deterrence, treatment and incarceration. Future research, too, may provide the tools to help authorities identify potential offenders sooner and intervene before it is too late. M

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Essay

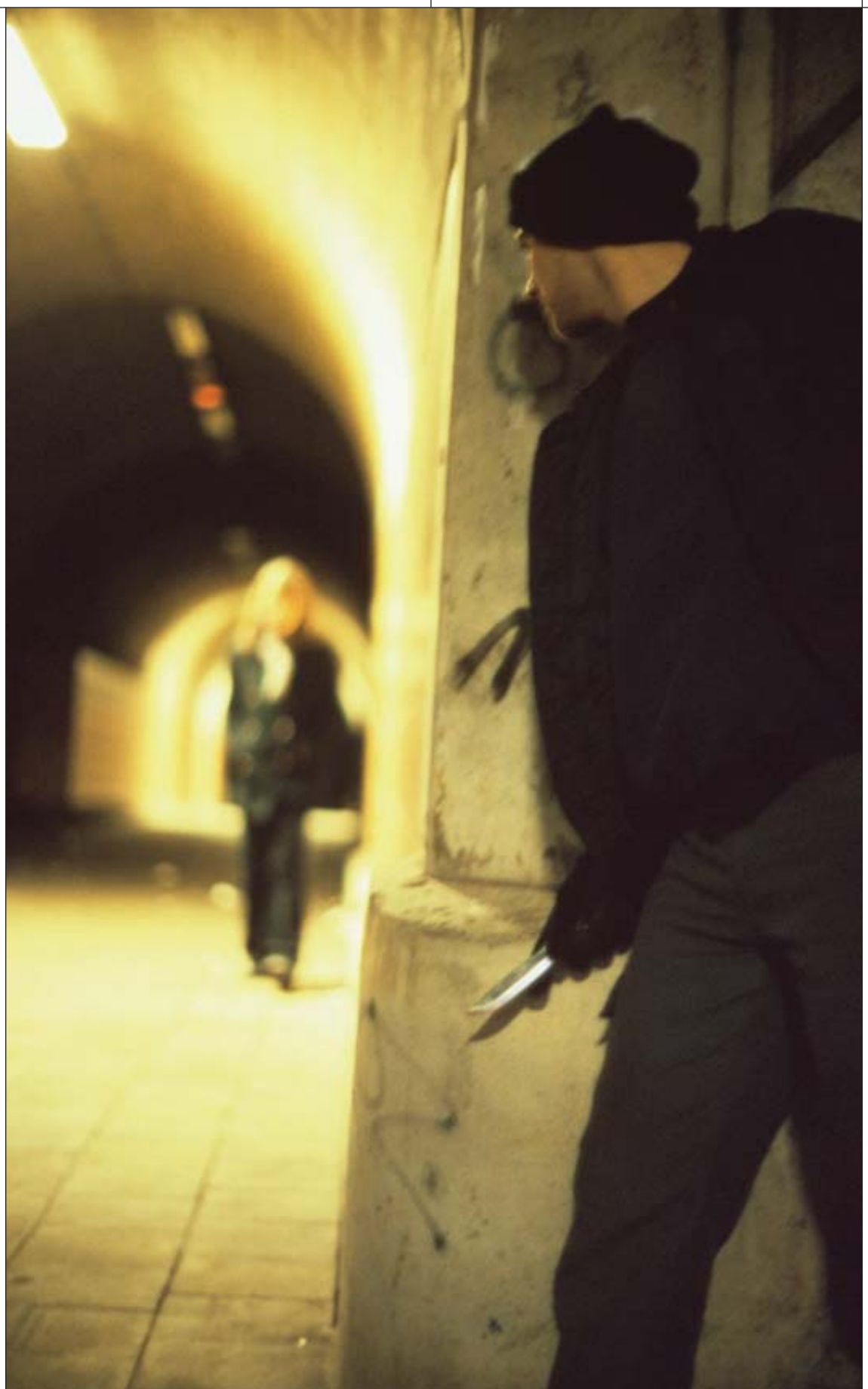
BRAIN SCANS GO LEGAL

COURTS ARE BEGINNING TO ALLOW BRAIN IMAGES AS EVIDENCE, BUT CURRENT TECHNOLOGY IS NOWHERE NEAR TRUSTWORTHY ENOUGH TO DETERMINE OR ABSOLVE GUILT BY SCOTT T. GRAFTON, WALTER P. SINNOTT-ARMSTRONG, SUZANNE I. GAZZANIGA AND MICHAEL S. GAZZANIGA

PHANIE *Photo Researchers, Inc.*

Imagine that you are a judge presiding over the trial of a man named Bill, accused of a grisly murder. The physical evidence is overwhelming, and witnesses have yielded damning testimony. There seems to be no reasonable doubt that Bill committed the murder. Suddenly, the defense asks if it can present images of Bill's brain, produced by magnetic resonance imaging (MRI). Bill's attorneys want to introduce the pictures as evidence that their client has a brain abnormality. They will argue that the abnormality justifies either a verdict of not guilty (because Bill

PREMEDITATION Even if most people with a given brain abnormality engage in crime, that does not mean that an individual should not be held responsible for premeditating his or her act—for intending to harm.



MIKA *zefa/Corbis*

lacked the intent to kill or premeditation to commit murder), or a verdict of not guilty by reason of insanity (because Bill lacked control over his actions), or, at least, a conviction on a lesser offense (because Bill is not fully responsible or possibly just because jurors should feel sorry for people with brain disorders). The prosecution argues that you should not admit the scans, because pictures of Bill's brain and testimony by revered scientists might influence the jury much more than such evidence warrants.

Would you, as judge, allow the brain scans to be exhibited? How would you assess such evidence?

This scenario is not merely theoretical. U.S. courts have been allowing positron-emission tomography (PET) scans of brain metabolism and, more recently, MRI scans of abnormal brain structures or function. In these cases, attorneys have used the images as evidence of brain damage that might impair a defendant's behavior and therefore reduce his or her culpability—the degree to which the defendant should be held responsible for the crime. Strong editorials have been written against these actions. Yet much of the public as well as participants in the court system believe that imaging, particularly the newer anatomical and functional scans produced by MRI, could provide an independent assessment of the root cause of a person's aberrant behavior.

As a result, neuroscientists are invading our courts. Companies such as No Lie MRI, Inc., and Cephos Corporation have been started on the expectation that the legal system will increasingly seek brain scans. Proponents say the images can detect lying by witnesses, prejudice in jurors or judges, and mental incapacities among defendants. If these prospects pan out, neuroscience could greatly influence the direction of our legal system; after all, other forms of advanced scientific technology, such as DNA testing, already work well in courts. Opponents object that such technology removes the human element that is essential to law as we know it. They also fear that brain scans will violate precious rights to privacy and due process.

Although the arguments on both sides are forceful, in Bill's case they come down to a single salient question: Can brain scans reveal a lack of responsibility? We think not. They should not be allowed as evidence in trials, at least not in the foreseeable future. Never say "never," but nothing close to current technology is trustworthy enough for legal settings.

What Made Bill Do It?

Naive faith in the latest imaging technology is misguided at this time. To understand why, consider the questions one must navigate to decide whether this evidence could be truly informative in a criminal trial.

First, if a brain scan indicates an abnormality, then the brain really has an abnormality, right? Wrong. This simple inference overlooks a crucial problem: almost every biomedical test, from MRI to the prostate-specific antigen (PSA) test, can suggest that a condition is present when in actuality it is not. Such cases are called false positives. This problem is not too serious for common medical ailments, such as prostate cancer, when doctors can independently confirm the diagnosis using other tests. The kinds of brain abnormalities that might cause grisly murders, however, are very rare and hard to confirm. When a condition is rare, even a low rate of false positives leaves a relatively large number of errors—not a very reliable means for establishing that the person being scanned has a condition that provokes violence. Even if Bill's scan suggests a brain anomaly, it might be very unlikely that he has any deficit at all.

That is not the only problem. Suppose for the sake of argument that we are absolutely certain that Bill has an abnormality. We still do not know whether that condition caused Bill's criminal behavior. Some people with this kind of irregularity might not be violent at all, whereas others could become violent on a regular basis. With this much variability, even if we assume that Bill does have an abnormality of the right size in the right place, we cannot know that his condition had anything to do with the alleged illegal behavior. Furthermore, even if Bill's condition does cause him to be violent in some way, it still might not cause the particular kind of

> Even if Bill's brain condition causes him to be violent, it might not cause ugly **premeditated murder.**

Responsibility is a social construct, determined by a social group, not a medical test result.

attack in question: ugly premeditated murder.

To be confident that an abnormality such as Bill's plays a causal role in a particular murder, researchers would have to have studied many more murderers than anyone has ever studied. The best an expert witness in a courtroom could do is establish a weak correlation between brain injury and criminal behavior. But without additional information, no scientist could be justified in claiming that Bill's abnormality caused him to become a murderer or prevented him from making a decision to kill on the day in question.

The defense might argue that the brain scan is just one piece of evidence that when combined with psychological or psychiatric assessments, paints a better picture of Bill's mental state at the time of the crime. Yet we do not know what the relation is between the scan and the other assessments. What percentage of people with a certain psychiatric diagnosis will test positive for this abnormality? What percentage of those who test positive for this abnormality will receive that psychiatric diagnosis? Without such information, we cannot say in the least whether the brain scan supports the diagnosis. In this setting, the behavioral findings must stand on their own.

Is Bill Responsible?

Even if these diagnostic problems can be solved, a defendant's medical condition still will not prove any legal status. Assume we know for sure that Bill has a certain brain abnormality and that a high percentage of people with that kind of irregularity commit violent crimes, including murder. Bill might still be culpable.

To see why, imagine that most people with a certain brain condition are thrill seekers. They drive race cars, jump from planes, scale ice cliffs, and so on. These activities are unusual (possibly as unusual as violent crimes), but their correlation with a certain brain condition does not indicate that these individuals do not act intentionally and deliberately or that they suffer a compulsion or delusion that makes them unable to control themselves. Such thrill seekers plan their acts carefully and stop themselves when conditions are too dangerous. That makes them responsible for what they choose to do.

Similarly, even if most people with a given abnormality engage in unusual criminal activities, that abnormality by itself does not indicate that these individuals do not commit their crimes intentionally and deliberately. They are still ca-

GETTY IMAGES

UNDUE INFLUENCE When a new scientific procedure is first admitted in trials, there is significant risk that lay juries and judges will overestimate its value. Proponents must demonstrate that a method is accepted by the scientific community; scientists disagree on the validity of brain scans.

pable of premeditating or planning their acts carefully. This means they have the ability to "form malice aforethought"—the *mens rea* that is a necessary element of the crime of murder—and therefore should not be exculpated during the guilt phase of a trial. Moreover, if the trial is one based on a plea of not guilty by reason of insanity and the evidence is presented in the sanity phase of the trial, such abnormalities would not justify a verdict of not guilty, because these individuals do not necessarily suffer from a compulsion or delusion. Like thrill seekers, they might well be able to control themselves and make decisions easily.

To show that Bill is not responsible, a brain scan would have to indicate not only that Bill has an urge and is likely to commit the crime but also that Bill is unable to control his urge. Brain scans show only what is, however, not what could be. They cannot show that Bill could not have stopped himself from committing the murder. Because responsibility depends on such abilities, brain scans cannot show that Bill is not responsible for what he did.

These stringent standards might seem unsympathetic. Shouldn't we feel compassion for people with brain disorders and help them get better? Of course, we should. But if we allow the defense to use brain scans to dismiss guilt, then should prosecutors not also be allowed to use brain scans to indicate guilt? If a brain scan of a defendant reveals an abnormality and some people with that aberration become violent, then a prosecutor might use that brain scan to convince a jury that a given defendant is guilty. Yet innocent people who suffer from known brain disorders will be even more likely to test positive and be wrongly convicted. Or they might be involuntarily committed to mental institutions if the brain scan is taken as evidence that they are dangerous to society. Anyone who has sympathy for these folks should find this new form of evidence discomforting.

NO RESTRAINT
To absolve guilt, a brain scan would have to show that a perpetrator was unable to control his or her urge. But brain scans show only what is, not what could be.

GETTY IMAGES

(The Authors)

SCOTT T. GRAFTON, WALTER P. SINNOTT-ARMSTRONG, SUZANNE I. GAZZANIGA and MICHAEL S. GAZZANIGA have collaborated on projects involving moral responsibility, cognitive neuroscience, and the interface of law and the mind. Grafton is director of the Brain Imaging Center at the University of California, Santa Barbara. Sinnott-Armstrong is professor of philosophy and of legal studies at Dartmouth College. Suzanne Gazzaniga is deputy district attorney for Placer County, California (the views expressed herein are hers and not necessarily those of the Placer County district attorney). Michael S. Gazzaniga is professor of psychology and director of the Sage Center for the Study of Mind at U.C.S.B.

The Truth about Lie Detectors

Using brain scans to prove lack of culpability in a courtroom trial is fraught with perils. Similar issues arise when considering the use of imaging as lie detectors to implicate or exonerate defendants, even though several research groups and companies say they have perfected such techniques [see "Exposing Lies," by Thomas Metzinger; SCIENTIFIC AMERICAN MIND, October/November 2006].

First of all, despite some wild claims, no lie detection technology is 100 percent accurate. False positives are a persistent problem. Beyond that is the basic complication of intent. People lie when they say something they know is false and intend to deceive. To show that someone is lying, then, a brain scan must detect the knowledge and the intention. There is no way to do this directly. The only way to "show" a lie is to capture some indirect accompaniment of lying. What could that be?

One possibility is that people get nervous when they lie, and brain scans can detect when people get nervous. That clearly will not work. Even truthful defendants can be nervous when interrogated.

A second possibility is that when people lie, they make a judgment that they are doing something wrong. Perhaps brain scans could tell when people make such moral judgments. Researchers have progressed in understanding the neural underpinnings of moral judgment, but none of their work comes close to offering the precision needed for a scan to be considered conclusive. Besides, a sign of a troubling moral judgment could arise simply from defendants thinking that they are being wrongly accused. Or they might think that they are doing something wrong in volunteering for lie detection or in not revealing everything they know, which by law they are not required to do. The mere fact that they are making some moral judgment cannot show they are lying.

Third, when people lie in court they often try to lie convincingly. They need to make sure their lies fit coherently with the facts that have been presented in a trial. That assessment takes time and thought. Brain scans might detect such patterns. Yet even if this works in the lab, it is unlikely to work for defendants. Whether they are lying or not, guilty or not, defendants always need to make sure that what they say fits the larger pattern of information in the case. A small slip can make them look guilty even if they are not.

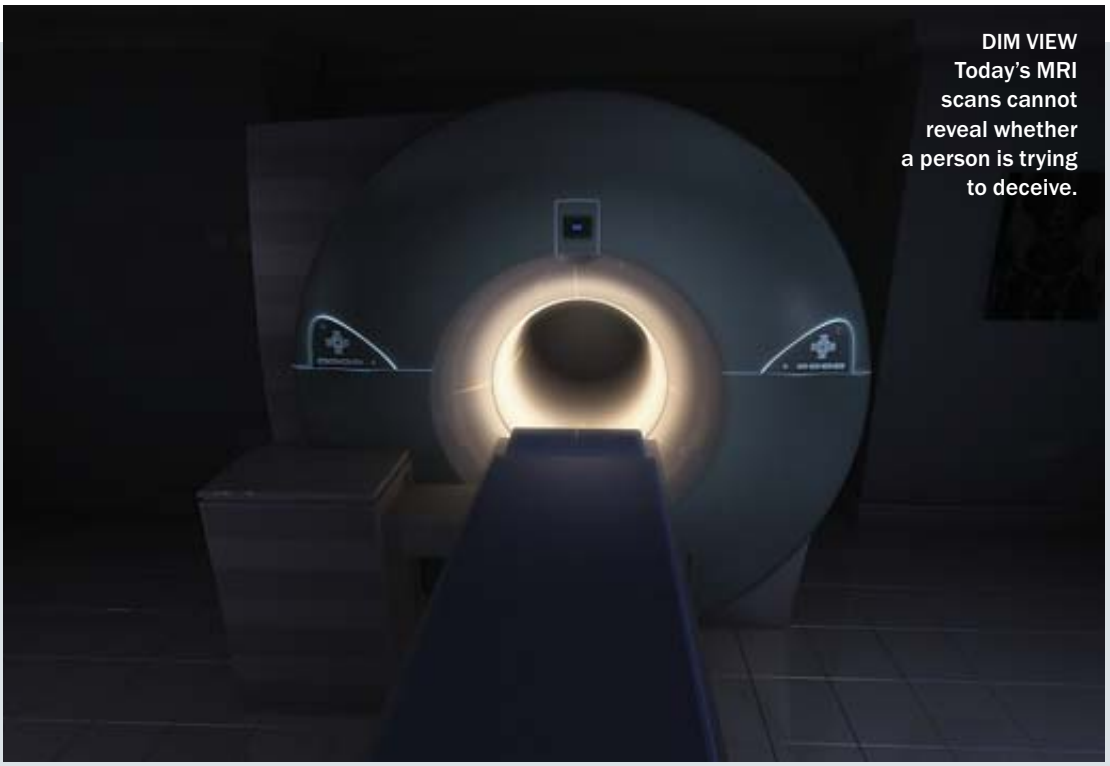
A fourth way that neural lie detection might work is to play on the fact that people have a tendency to tell the truth. They must therefore suppress that tendency when they lie. Perhaps a brain scan could detect that inhibition. But again, even if this holds up in the laboratory it cannot work in real cases. When defendants testify, they do inhibit their natural tendency to blurt out everything they know. They are circumspect about

Who Bears the Burden of Proof?

Even without such technological uncertainty, the outcome of a trial often depends on who is responsible for proving what—which is a matter of law, not science.

The burden of proof can differ depending on the kind of proceeding, the phase of a trial and whether the case is before a federal or state court. Usually the burden does lie with the prosecution, to prove essential elements of a crime during the guilt phase. But a defendant's legal team may attempt to introduce a brain scan as evidence that negates some element of the crime, such as premeditation, or perhaps raises reasonable doubt. Research shows that when a new scientific procedure is first admitted in trials as evidence, there is significant risk that lay juries and judges will overestimate the value of that evidence. This danger is especially high when the procedure involves eye-catching pictures presented by scientists with impressive credentials. To reduce that risk of error, many jurisdictions require defendants who cite new scientific methods to demonstrate that those methods are reliable and accepted by the wider scientific community. That kind of proof will be hard to present for brain scans because of their low predictive value and the lack of consensus among scientists on the validity of these techniques. If the defense cannot carry that burden of proof, then the scientific evidence should not be admitted into the guilt phase of a trial.

Brain scans might instead be cited as evidence of something like insanity during the sanity phase of a trial. Many jurisdictions give the defense the burden of proving that a criminal act resulted from an individual's mental illness or brain condition. It will be difficult for the de-



DIM VIEW
Today's MRI scans cannot reveal whether a person is trying to deceive.

what they say. Many of them also suppress expressions of anger and outrage at accusation. Suppressing natural tendencies is not a reliable indicator of lying, in the context of a trial.

Defenders of neural lie detection will undoubtedly cite tests that indicate their methods are reliable and even hold public demonstrations. Still, the subjects in these experiments will not have their lives on the line, as defendants do. Unlike defendants, the subjects will have been instructed to lie, and they know that their lies will be exposed. Because these situations are so different, evidence of reliability in controlled experiments cannot be extended to actual trials. It is hard to imagine any procedure that will solve all these problems anytime soon. —*S.T.G., W.P.S.-A, S.I.G.* and *M.S.G.*

fense to carry this burden, for the same reasons just given.

The questions of where to place the burden of proof, which evidence to allow and which disabilities are severe enough to preclude punishment are all considerations for society. And these decisions must indeed be made by society, not by neuroscientists. Data about an individual's brain cannot alone settle whether that person should be held responsible. Responsibility is a social construct, determined by a social group, not by a medical or scientific test result. If society chooses to use forms of brain testing as evidence to assess responsibility, then it needs to make these decisions in light of complete and accurate information about the pitfalls of the various methods being proposed.

We cannot predict the future. Better information, techniques and equipment might come along that will someday make brain scans reliable enough to determine the legal implications of a brain abnormality. The problems might be solved with time, but we are nowhere close today. Brain scans of this kind are, after all, only 15 years old. Neuroscientists need much more basic research, experience and thought about imaging before it invades our courts. Until then, brain scans have too little predictive value to be applied in criminal trials. M

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3D4MEDICALCOM Getty Images

One in every 10 Americans suffers from migraines. In recent years, doctors have discovered more about how these nasty headaches occur—and how to dull the pain

THE MADNESS OF MIGRAINE

By Felicitas Witte

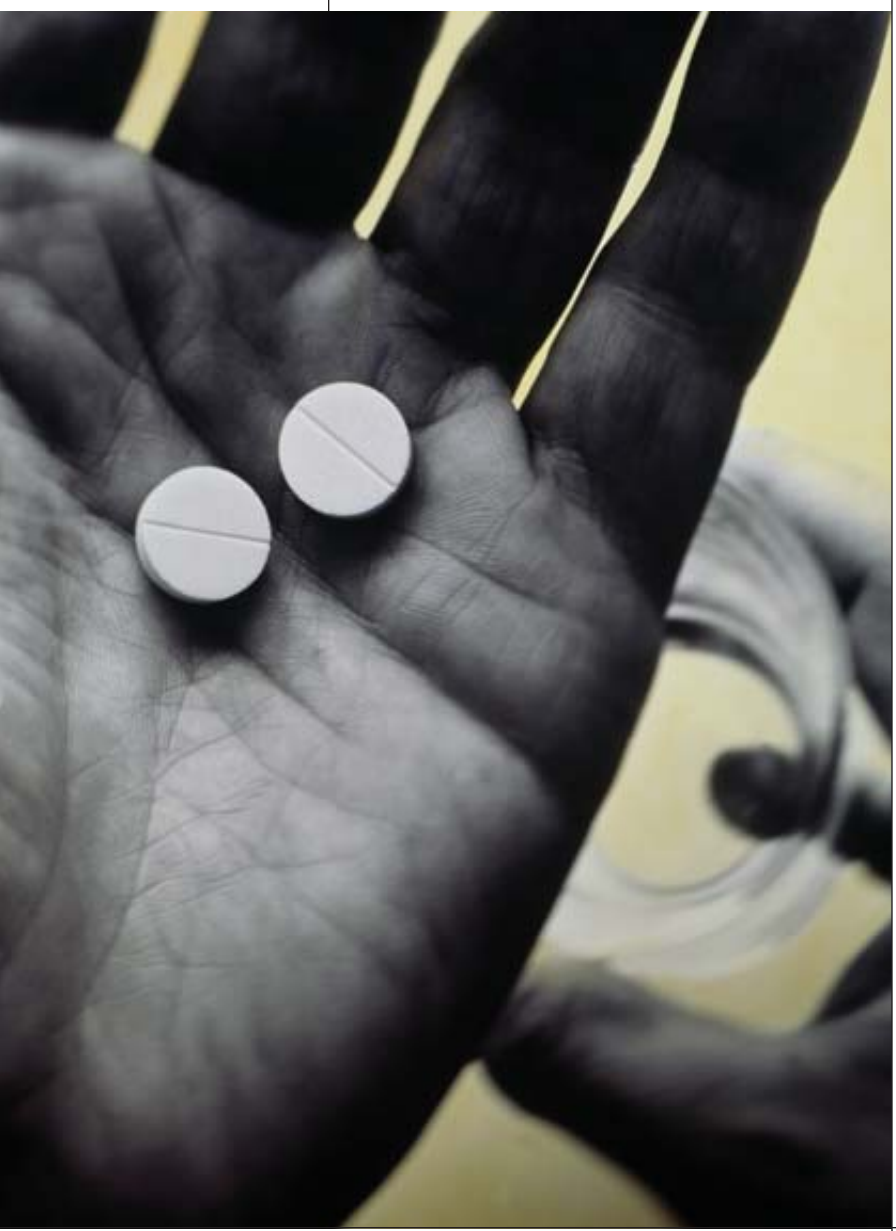
Margit was only 19 when the horrific headaches began. In the middle of training to become a physical therapist, she found that the right side of her head began pounding, as if her skull were about to explode. For a while that first time, she muddled through the day, doing her best to ignore the pain, made worse by the blinding artificial light and stress of the clinic.

LINNEA LENKUS *Getty Images*

But eventually she went home, pulled down the blinds and fell asleep on the couch. When she woke up—15 hours later—she felt weak, but better. Perhaps it was just a fluke.

The same thing happened a month later, though, and the episodes recurred every few weeks for the next two years. Rather than seeing a doctor, Margit tried to hide her pain. She did not want co-workers thinking she was a whiner. She valued her job, which was on the surgical ward of a large city hospital.

Then one day, on her way to the treatment room, yellow zigzags flashed before her eyes, distorting her vision. "I couldn't see straight!" the now 34-year-old recalls. Frightened, she told an older co-worker. "It's just a migraine," the co-worker told her.



Mitigating migraines often means pills for the pain and pills to prevent the attacks.

LAURENCE DUTTON *Getty Images*

About 6 percent of men, 18 percent of women and 4 percent of children get migraines—28 million people in the U.S. alone. Their intense, throbbing pain, which is usually concentrated on one side of the head and often accompanied by nausea and vomiting, typically lasts for hours and can put a person out of commission for up to three days. Movement, light and noise usually intensify the misery of a migraine.

In some patients, migraines announce themselves with an "aura," made up of strange visual sensations such as the appearance of zigzag lines, blind spots or shimmering lights. Migraines may also be preceded by sudden mood changes, speech disturbances and even transient paralysis, according to Guy Arnold, a headache specialist at Charité Medical School in Berlin.

Migraines were long thought to have no serious medical consequences besides the pain, but recent data suggest otherwise. Women who experience auras before a migraine have double the risk of stroke, heart attack and dying from cardiovascular disease, according to a study in the July 2006 *Journal of the American Medical Association* by Tobias Kurth and his colleagues at Brigham and Women's Hospital in Boston. In recent years, researchers also have gained a new, better understanding of the biological origins of migraines. This has led to an expanded arsenal of migraine treatments that provide new hope to people who experience these extraordinary headaches.

Hitting a Nerve

Ancient artistic renderings suggest that the Egyptians suffered from migraines more than 3,000 years ago. Greek physician and philosopher Galen (who lived circa A.D. 129–216) claimed that an excess of "black bile" caused the symptoms. Because of the asymmetry of the pain, he called these headaches *hemicrania* (from the Greek *hemi,* meaning "half," and *kranion,* or "skull"). The word gradually morphed into *hemigrania, emigranea, migranea*—and finally, migraine.

Scientists thought for years that migraines were caused by the contraction and expansion of blood vessels in the head. Now many believe that nerve tissue is the primary culprit. Studies in the 1990s using the imaging technique positron-emission tomography (PET) showed that the attacks seem to arise when nerves deep within the brain stem, the lower part of the brain that abuts the spinal cord, become overstimulated.

Numerous nerves sprout from the brain stem,

including fibers of the massive trigeminal nerve, which supplies sensory information to many parts of the face and head and also controls some facial muscles. When the endings of the trigeminal nerve become overwrought, because of genetic or environmental factors, or both, they release large amounts of chemicals called neuropeptides, according to Peter Storch, who heads the headache clinic at the University of Jena in Germany. This release spawns inflammation in nearby blood vessels and thereby excites pain receptors of the trigeminal nerve, whose signals reach the brain stem, Storch says. At the brain stem, pain-processing centers can become sensitized or overloaded and start firing spontaneously, producing the pain of migraine.

This recent understanding of migraine has led to new treatments. For example, drugs called triptans inhibit the release of the neuropeptides now considered central to the physiology of migraines. Triptans work by docking to specific receptor molecules on the trigeminal nerve—the same receptors that ordinarily bind to the natural nerve messenger serotonin. The attachment of either substance to these receptors stops the nerve from spewing out neuropeptides and thereby interrupts the cascade of pain. Thus, many patients try to stop a nascent migraine in its tracks or reduce its severity with medications containing the active ingredient sumatriptan, naratriptan, rizatriptan or the like. These triptan drugs must be taken right away to have any effect, however.

An Ounce of Prevention …

Better yet, of course, would be to prevent migraines from occurring in the first place. Many patients can identify environmental triggers. For many migraine sufferers, including Margit, stress plays an important role. "The more stress I'm under, the more frequently I get migraines," Margit says.

To relieve stress, doctors often recommend exercises that require endurance. Margit sometimes takes a long jog in the woods, for example. Migraine researcher Storch also suggests a technique called progressive muscle relaxation (PMR) for stress relief. In PMR, a person deliberately tenses—and then relaxes—one muscle group at a time in a specific order. In other cases, though, a person simply has to slow down. "When I recognize that I'm piling on too much stress, I'll downshift for a while," Margit says. Her strategy helps her.

In other people, erratic sleep patterns set off migraines. For these sufferers, getting up at the same time every day—that is, not sleeping in on weekends—can often solve the problem. Too little sleep can spark a migraine, too, so going to bed on time can also be important. And for some, migraine prevention means avoiding something—for instance, cigarette smoke or certain foods, such as red wine or chocolate.

> "When I recognize that I'm piling on too much stress, I'll downshift for a while. That's the best prevention."

In women, up to 60 percent of migraines are set off by the drop in estrogen that precedes the menstrual cycle. Women can often prevent or reduce the severity of these migraines by taking estrogen in patch or pill form beginning two or three days before their menstrual period, which smooths out the natural drop in estrogen. Because the menstrual cycle is often predictable, treatments such as triptans that are usually taken during a migraine can head it off instead, if used within a day or two before a migraine is expected to begin.

If migraines occur more than three times a month or last longer than 72 hours, doctors recommend that a patient take medication at regular intervals to prevent the attacks. Most prophylactic drugs for migraines were developed to treat conditions from epilepsy to depression. Such drugs can often reduce the number of attacks by half or more and lessen the severity of the migraines that still occur.

Researchers have become increasingly interested in the past few years in using antiseizure drugs such as topiramate (Topamax) and valproic acid (Depakote) to prevent migraine attacks. Such drugs dampen the excitability of nerve cells and thereby reduce the sensitivity of the brain to external stimuli, Arnold says.

(The Author)

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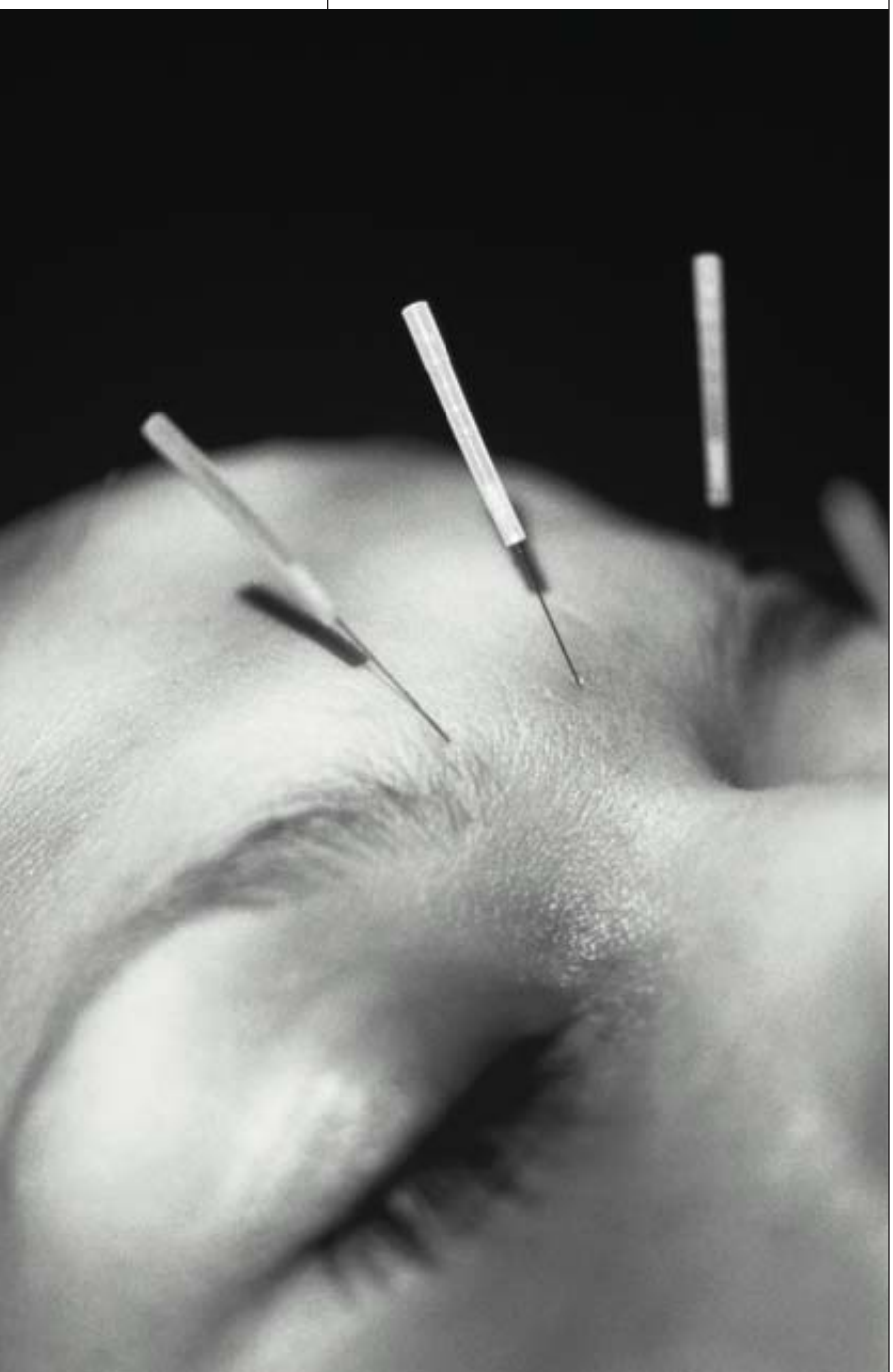
Antiseizure drugs are thought to prevent migraine attacks by calming nerve cells.



Acupuncture, or even a fake form of it, can help keep migraines at bay, some studies show.

DONNA DAY *Getty Images*

The U.S. Food and Drug Administration approved topiramate for migraine prevention just two years ago, after Stephen D. Silberstein of Thomas Jefferson University Hospital in Philadelphia and his colleagues reported its effectiveness in a large-scale clinical trial. The researchers found that doses of topiramate of 100 milligrams or more shrank migraine frequency by almost half—from more than five headaches per month to just over three in the roughly 370 patients who took topiramate for the six-month study period; in contrast, a placebo pill produced a much smaller change. In 2006 neurologist Alan M. Rapoport and his team from the New England Center for Headache in Stamford, Conn., extended these findings, showing in a study of more than 550 patients that topiramate's benefits lasted for up to 14 months. In both studies, the drug did sometimes cause patients to feel fatigue, nausea, and numbness in one or more body parts. Some also lost a lot of weight.

Yet migraine researchers such as Storch consider such problems more palatable than the excessive weight gain that comes with beta blockers, which slow certain nerve impulses, or calcium antagonists, which ease blood flow; both are high blood pressure medications that are also used to prevent migraines. But some patients gain so much weight on these drugs that they stop taking them, Storch says.

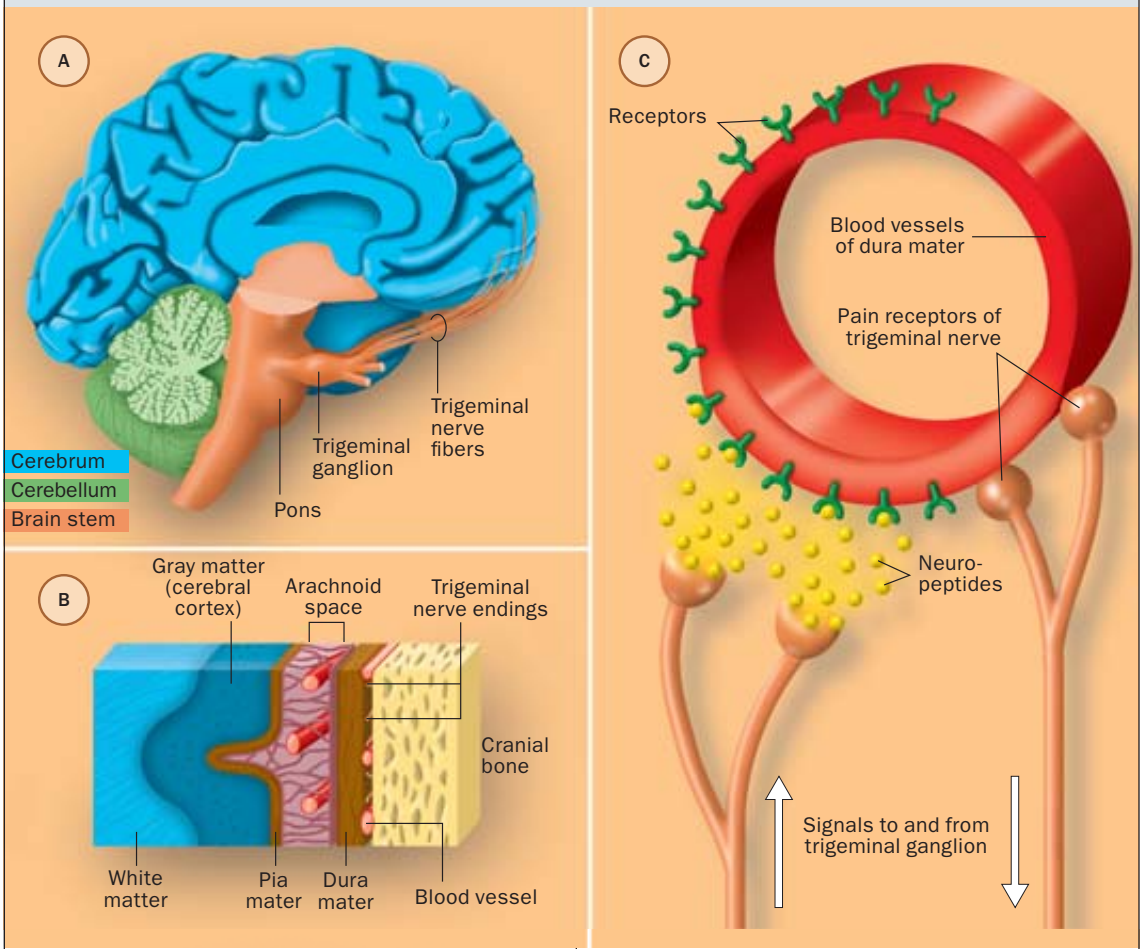
Pressure Points

For patients who either cannot take or prefer to avoid drugs, migraines may succumb to a variety of alternative remedies. Klaus Linde of the Center for Complementary Medicine Research at the Technical University of Munich and his colleagues tested acupuncture against these throbbing demons. They assigned more than 300 migraine patients to either one of two eight-week regimens—12 sessions of acupuncture or 12 sessions of sham acupuncture, in which the needles are not placed in the classical acupuncture points—or to a spot on the waiting list. They found that both needle treatments made a big difference: about half the people in those groups found that it cut their "headache days" in half. In contrast, only 15 percent of people on the waiting list saw similar improvement.

In a follow-up study of nearly 1,000 patients, researchers from the University of Duisberg-Essen in Germany reported in 2006 that both acupuncture and fake acupuncture are just as good at preventing migraines as beta blockers, calcium channel blockers and antiepileptic drugs are. Researchers surmise that the needle therapy's suc-

Anatomy of Agony

Migraines typically arise from hyperexcitation of certain nerve cell nuclei in the brain stem (*a*). The endings of the trigeminal nerve (*b* and *c*) then release increased amounts of neuropeptides (*c*), which results in an inflammatory reaction of the blood vessels in the dura mater (*b* and *c*), the hard membrane that surrounds the cranial capsule from the inside. This stimulates pain receptors of the trigeminal nerve, whose endings run through the dura mater and whose signals ultimately reach the brain stem. The consequence: pulsing headaches. —*F.W.*



cess comes in part from its ability to relax the patient and provide him or her with a lot of personal attention.

Other nondrug techniques for taming migraines include biofeedback, in which patients learn to control body functions that are normally automatic, such as breathing and heartbeat, often with the help of a feedback machine and a therapist, and a lesser known relaxation method called autogenic training. In the latter approach, patients practice specific exercises that make the body feel warm, heavy and relaxed. These techniques often allow patients to target the tension in the blood vessels, which can ameliorate their headaches. Some practiced patients can even use them to get immediate relief from pain.

Margit heads off her migraines in less formal ways. She listens far more closely to her body's signals than she did before her headaches began, and she shuns activities at work or at home that might bring on excess stress. When such efforts fail and a migraine looms, she also knows what to do: she heads for darkness and quiet. Then she sleeps. M

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ART FOR SCIENCE *Gehirn & Geist*

Why Do We Cry?

Other animals howl when they are in distress, but only humans weep tears of sorrow—or joy

By Chip Walter

Nature is loaded with odd traits and behaviors. There are elephant trunks, the widely separated eyes of hammerhead sharks, and the wacky, effervescent mating dances that sandhill cranes do. But nothing is quite as strange as human crying.

CHRISTOPHER ZACHAROW *Getty Images*

The youngest infants cry without tears, to communicate needs or distress.

CRISTINA PEDRAZZINI *Photo Researchers, Inc.*

Women cry five times a month or so and men about once every four weeks.

It does not seem odd to us, of course. We do it often enough ourselves and witness someone else doing it nearly every day. According to one study of more than 300 men and women conducted in 1980s at the University of Minnesota, women cry five times a month or so and men about once every four weeks. And the first thing a baby does when it enters the world is bawl to let everyone know it has arrived healthy and whole. It is not the howling itself that makes our crying unusual; it is the tears that go along with it. Other animals may whimper, moan and wail, but none sheds tears of emotion—not even our closest primate cousins. Apes *do* have tear ducts, as do other animals, but their job extends only to ocular housecleaning, to bathe and heal the eyes. But in our case, at some point long ago, one of our ancestors evolved a neuronal connection between the gland that generates tears and the parts of the brain that feel, sense and express deep emotion.

Like all genetic mutations, the one that led to tears was a mistake. But it was a mistake that worked. If the wayward gene had not enhanced the survival of the creatures that inherited it, natural selection would have long ago kicked it to the curb. The question is: What advantages come with our special brand of teary-eyed crying? Re-

cently researchers have begun to piece together some answers, and along the way they are uncovering some surprising insights into what makes us tick.

The reasons we cry are many. They range from the primitive—a simple signal of pain or distress—to the mysterious, a sophisticated and highly developed form of communication that bonds humans in ways no other creature can experience. Ultimately this type of bond helped our ancestors survive and thrive and in time allowed our species to emerge as the most successful and cognitively complex of all the creatures on the planet.

Hoots and Howls

Complex behaviors often have simple roots. Crying is one of them. Like other animals, we humans yowl to signal distress, and we start in infancy. During their first three or four months, before babies learn to smile or laugh or gesture, they cry often and with ear-piercing effectiveness. Later, as they edge closer to the first year of life, they cry less often, and they work out other ways to express what they want, such as pointing, grunting, or tossing spoons and food around. (Some babies cannot cry emotional tears until they reach three to six months of age or so.)

Infants develop different cries that send specific messages as they grow older—shrieks and screams of pain, or cries of separation, discomfort or hunger. Each serves as a kind of rudimentary vocabulary that precedes a baby's first words. They all trace their origins to the hoots and howls that other animals, including primates, still use as their primary way of communicating. This fact probably explains why electromyographic studies, which record the electrical activity of skeletal muscles, show that the nerves that operate the mentalis muscle (the one that makes our chins quiver when we are on the verge of tears) or put the lump in our throats or depress the corners of our lips (with the depressor anguli oris muscle) when we are upset are nearly impossible to control consciously. Scientists have also found that babies born without structures above the midbrain can cry, an indication that the roots of crying run deep into our evolutionary past to a time long before the apparatuses of speech and conscious thought emerged.

Cocktails for Crying

Our reasons for crying grow more varied as we enter adulthood. The deeper emotions that maturity brings seep into the mix, and the messages communicated by our cries extend beyond simple physical discomfort or the basics of survival. This transition does not mean physiology is no longer at work. It is, and it now has become more deeply tied to higher brain function and our increasingly subtle emotional needs. And the change means that tears themselves play a larger role as a signal to others that the emotions we are feeling are strong and genuine.

Emotional tears are one of three kinds of tears we produce. The other two share a similar

FLIP NICKLIN *Minden Pictures*

Animals use tears only for "housekeeping"—to bathe or heal eyes.

Distressed animals may cry, but without emotional tears.

chemistry, although they perform different functions. Basal tears bathe our eyes each time we blink. Reflex tears well up when we get poked in the eyes or when the fumes from the onions we are cutting irritate them. But emotional tears have a makeup all their own—one that provides some clues about their function. William H. Frey II, a biochemist at the University of Minnesota, has found that they carry 20 to 25 percent more types of protein and have four times the amount of potassium than reflex tears, as well as 30 times the concentration of manganese than human blood serum. They are also loaded with hormones, such as adrenocorticotropin (ACTH), which humans produce when under stress, and prolactin, which controls the neurotransmitter receptors in the lacrimal glands that release tears.

(The Author)

CHIP WALTER is an internationally published science author who writes about the perplexing behavior of *Homo sapiens* and the technologies they create. His latest book is *Thumbs, Toes and Tears—And Other Traits That Make Us Human* (Walker Books, 2006).

Frey believes these chemical cocktails are linked to the moods and emotions associated with crying. High concentrations of manganese, for example, occur in the brains of people suffering from chronic depression. Excessive ACTH indicates increased anxiety and stress. And higher levels of prolactin in women's bodies may explain why they cry more often than men do, especially after puberty.

Because so many hormones exist in emotional tears, Frey has speculated that crying is the body's way of flushing out the chemicals that are present when we are experiencing strong feelings. This is why, he says, we sometimes counsel one another, "Go ahead. Have a good cry."

But not all scientists agree. It is difficult to prove that tears alone can flush enough hormones from our bodies to provide the sense of relief we often feel after crying. Our tear ducts simply are not that big or that efficient. Even a good, long, heaving bout of sobbing produces only a thimble full of hormone-laden tears. So is some other mechanism at work that leads to the relief we feel when we cry?

Maybe, and it may not be all that mysterious. You might call it the Goldilocks principle. All natural systems struggle to maintain a state of equilibrium in the face of the forces around them. They work to remain neither too hot nor too cold, neither too active nor too lethargic. If the environment swings them in one direction, they counter by pulling back to the middle, "normal" ground as quickly as possible. Rain forests, guppies and humans all seek out their comfort zones. The very same primal need to maintain a middle ground may help explain why we cry.

The autonomic nervous system controls so-called mindless operations such as breathing and heartbeat as well as the basic functioning of organs such as the kidneys and brain. The autonomic nervous system itself is divided into two subsystems, the sympathetic and the parasympathetic. The role of both in crying is controversial but intriguing. The sympathetic nervous system prepares us for fight or flight—physically, mentally and emotionally. When we are scared, the sympathetic nervous system fires off messages that prepare our body to stand its ground and do battle—or to skedaddle. The parasympathetic nervous system then pulls us back to normalcy afterward.

Since the 1960s researchers have theorized that we cry because we are upset, not because we are seeking relief, and that our sympathetic nervous system must therefore govern weeping. But

FRANS LANTING *Minden Pictures*

> Perhaps we do not cry because we are upset but because we are trying to get *over* being upset.

just as many scientists have held the opposite view. They argue that crying is an involuntary way of calming down. There have been plenty of studies, but none has been conclusive because it is difficult to induce and measure genuine grief and crying in a laboratory. Nevertheless, researchers such as James J. Gross of Stanford University have tried and subsequently have speculated that even though crying does seem to upset us, and those around us, it may ultimately have a calming effect. Other studies have shown that if the nerves central to the sympathetic system are paralyzed, patients cry more; when important parasympathetic nerves are damaged, they cry less. Those findings suggest that we do not cry because we are upset but because we are trying to get *over* being upset. In other words, crying resets the breaker on our emotional circuit.

If that is the case, then crying exemplifies the Goldilocks principle, physiologically at least. After all, following every fight or flight, every close call or every tense situation, we have to settle down. If we did not, we would blow an aorta or have a stroke and that would be the end of that. Given the dangers our ancestors coped with, a means for calming down would have been not only useful but also downright necessary; otherwise they might have been wiped out in a series of cerebrovascular accidents or a rash of coronary thromboses.

Jungle Truth

None of these findings precisely explains why we cry tears. Why should crying "hot tears" of emotion, as Shakespeare's Lear put it, make good evolutionary sense? They blur our vision and add to the vulnerability that our scrambled emotions have already created. Our social nature may provide a clue. No primate is more deeply bonded to other primates than humans are to one another. Our kind grew up on the savanna, not in the jungle, and had no shortage of dangers to encourage cooperation for survival. But we also compete with one another. Anyone who has been involved

GETTY IMAGES

Springing upward before fleeing enhances survival by sending a message to a predator: "I am too fast for you to catch." Likewise, human tears of emotion send signals that help to bond social groups together for survival.

At some point in human evolution, tear ducts somehow became connected to the emotional centers in the brain.

in office politics or high school cliques knows that. Our higher intelligence has only made our coalitions and competitions more complex. So our affairs, as they evolved from early hominid to human, must have favored traits that improve communication, from subtle body language and facial expressions to speech and … tears.

In 1975 Amotz Zahavi, a biologist at Tel Aviv University, conceived an interesting theory about how animal behaviors and traits that seem detrimental to survival often turn out to be perfectly useful. Why, for example, does a peacock have an enormous and colorful tail when the tail slows the bird down, draws the attention of predators and interferes with flying? Or why does a gazelle, when it senses a lion is about to attack, bound straight up into the air like a pogo stick before making its exit?

These traits and behaviors are examples of what Zahavi called the "handicap principle." On the surface they come at a high price—they require energy and resources and attract dangerous amounts of attention. But, Zahavi speculated, they also send powerful messages. Take the gazelle's first vertical bound, which puts it at an immediate disadvantage: it has lost precious moments that it could have used to distance itself from the predator that intends to make a meal of it. But such a leap also says, "I am so fast and can jump so high, you will never catch me. So don't waste your energy." Often the lion or cheetah poised for the kill absorbs the message, performs a quick, primal cost-benefit analysis and walks away in search of less vigorous prey.

Tears may serve a similar purpose in a species as intensely social as ours. They are noticeable, and the blurred vision they cause is a hindrance. That makes them costly. Because tears appear only when a person feels very deep emotions, they are not easy to fake. They send an unmistakable, Zahavian signal that the feelings behind them are absolutely real and, therefore, should be taken seriously. Tears, after all, reveal us at our most vulnerable. When we have reached the point where we are crying, the walls are down and our defenses have been breached. The intense emotional bonds forged partly by the binding ties of crying may have helped human communities band together more successfully than they would have otherwise.

Crying Wolf

Mothers tend to respond quickly to the tearless crying of their infants, who are so clearly helpless. But later, in toddlerhood, the situation changes. Crying, like all forms of communica-

tion, can be (and is) used to manipulate. Children, even as they grow older, want the attention of their parents. Because crying has been their most effective way of getting it, they continue to do it, even when they do not absolutely need help for basic survival.

Dario Maestripieri, a primatologist at the University of Chicago, has found that infant rhesus macaques share this behavior. They cry out to their mothers in infancy and tend to howl and whimper even more around the time their mothers wean them. At first, macaque mothers come running, but as the cries increase they respond less, because so many of the alarms turn out to be false. Eventually the macaque moms grow more skeptical, and the infants cry less because it does not bring the reassuring attention they seek. As a result, the young monkeys also grow more independent, which in the long run improves their chances of survival.

In the case of people, tears give mothers an extra tool for detecting if a toddler is crying wolf. Every parent has experienced the tearless crying (a.k.a. whining) of a child who is unhappy and wants attention but is not really in trouble. Parents quickly learn to look for real tears if a child cries, a sure sign that their toddler truly needs help.

Soothsaying

Randolph R. Cornelius, a psychology professor at Vassar College and an expert on human crying, has done some of the most interesting research on tears as a kind of instinctual soothsayer. Since 2000 Cornelius and his students have been gathering still photographs and video images from news magazines and television programs recorded all over the world, all of them of people crying real and visible tears. When they find a particularly appropriate image, they prepare two versions: one, the original, with tears, and another with the tears digitally erased.

Cornelius and his colleagues then sit down with volunteers one at a time in front of a computer monitor to watch a slide show. Each slide presents two pictures: one tearful, the other a different picture with the tears secretly erased. No participants are allowed to see the same picture with *and* without tears. The investigators then ask each participant to explain what emotion the person in each photograph is experiencing and how he or she would respond to a person with that particular expression.

The test's observers universally registered that people in pictures with wet eyes or tears rolling down their cheeks were feeling and expressing deeper emotions—mostly sadness—than those who were tearless. But when participants looked at pictures in which the tears had been digitally removed, they were confused about what people were feeling and guessed everything from grief to awe to boredom. Cornelius's conclusion: tears append a crucial communicative dimension to our crying. They add one more true and powerful arrow to the quiver from which we draw our many forms of human communication.

Raw Emotion and High Intelligence

During the past six million years, enormous changes have taken place in our ancestral lineage, much of it from the neck up. Our brains doubled in size and then doubled again. Our faces also have changed, and with them so have our ways of conveying emotion. The rich, expressive musculature evolved by chance but remained with us because it helped us more precisely communicate with, and sometimes manipulate, one another. The parts of the brain associated with the experience and expression of emotion somehow became connected, quite literally, to the lacrimal gland that sits above each of our eyes.

Complex relationships beg for similarly complex forms of communication. For our kind, language was one mighty adaptation that served that purpose. Tears, with the strong, highly visible messages they send, became another. They married raw emotion with a human brain capable of reflecting on those howling, primal feelings. They help us express overwhelming emotions that well up from the primal side of us and linger beyond the reach of words. We all know the feeling, whether it is profound sadness, frustration, joy, pride or pain. Tears take us where syntax and syllables cannot. Without them, we would not be human. M

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IT TAKES 2 TO...

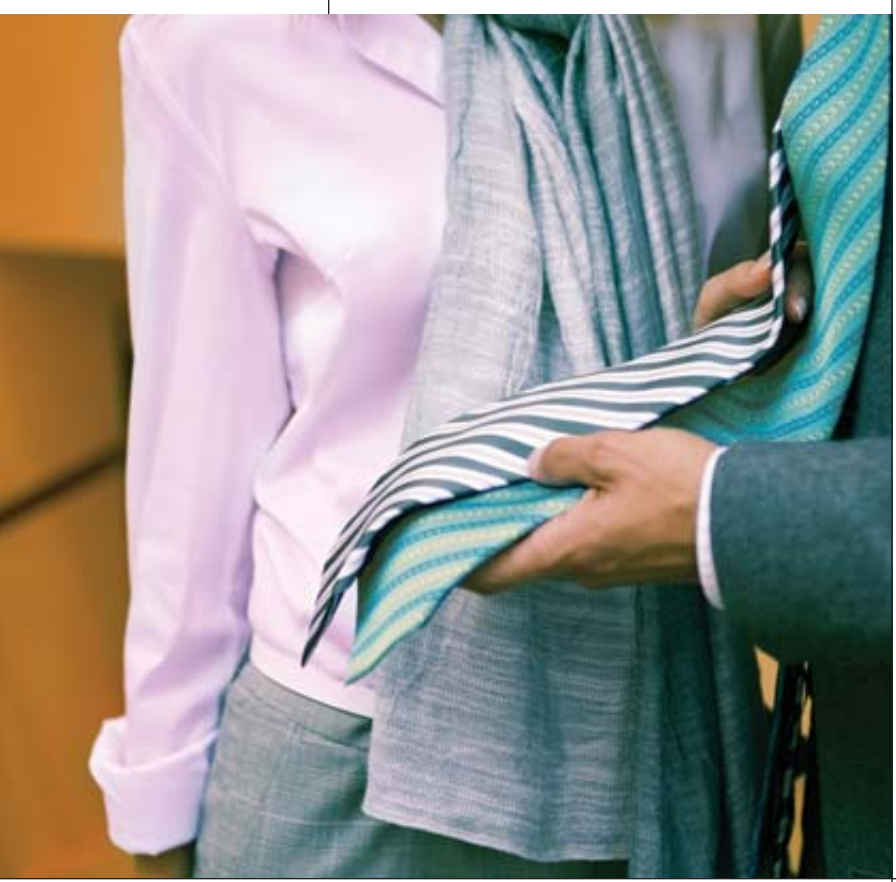
EVEN THE MOST MUNDANE TASKS PEOPLE PERFORM TOGETHER REQUIRE THEM TO COORDINATE THEIR EFFORTS. RECENTLY RESEARCHERS HAVE STARTED TO ASK EXACTLY HOW WE COOPERATE BY NATALIE SEBANZ

DAVID SACKS *Getty Images*

Maria Nieves and Juan Carlos Copes are passionate about Argentine tango. They have been dancing together for 40 years and are among the best-known dance pairs in the world. Copes was once heard to say that if he had not found Nieves—someone to whom he is remarkably attuned—he would need four different partners to fully explore the tango's expressive spectrum. Anyone who has ever done pairs dancing will understand just how difficult it is to forge a merger out of differing styles and capacities, while coordinating movements with near perfection in space and time.

These coordination problems fascinate researchers who study cooperation. Whereas Copes and Nieves have learned to harmonize their movements to an extraordinary extent, it is clear that ordinary people are constantly attuning to one another, even during the most mundane daily activities. We set the table together, carry a large package or navigate between other drivers in heavy traffic. As Harvard University social psychologist Floyd Henry Allport recognized more than 80 years ago, such daily acts of cooperation are anything but trivial. In the end, two or more persons must coordinate and fine-tune their thoughts and actions. And, unlike dancers, we often have no opportunity to rehearse this choreography.

Prior knowledge and cultural conventions help sometimes. Let us assume that you are told to meet a stranger in Paris tomorrow. Except for the date "tomorrow in Paris," you know absolutely nothing. In such cases, people tend to orient themselves to the salient points in space and time. To maximize the chances that your paths will cross, you would be more likely to head toward the Eiffel Tower than to some nameless alley. In addition, you would be more likely to go there at noon than at 3:50 A.M.—on the assumption that the other person would do likewise.



Keep it simple: turquoise or green? If one person starts calling it one thing, the other will usually follow suit: "Green."

ALTRENDO IMAGE/GETTY IMAGES

Deciding on Turquoise

The basis for cooperation—the common ground, so to speak—frequently gets built up only during an interaction itself. Cognitive psychologist Simon Garrod of the University of Glasgow and Martin Pickering of the University of Edinburgh in Scotland have studied the role of speech as an instrument for coordination.

The researchers discovered that people tend to agree quickly and involuntarily on common concepts. For example, if two individuals are talking about a turquoise-colored tie and one party says at the outset that it is green, the other party will tend to identify it as green as well. This implicit agreement greatly simplifies understanding because, as turquoise is somewhere between blue and green on the color spectrum, it could be called any number of things, which can easily lead to misunderstanding. Often people even attune their sentence structure and dialect to the other person so that the conversation can go off without a hitch.

But what happens when speech is simply not the appropriate mode? Spoken instructions do not work for activities that require rapid-fire coordination, such as the tango. Words take too long to convey an idea. Over the past several years, researchers have been studying the role nonverbal cues play in the coordination of action and have discovered several mechanisms, most of which occur unconsciously.

For example, people are able to recognize in a flash where another person's attention is focused and to then redirect their gaze to the same object or event. This capacity for "joint attention" develops quite early. Long before their first birthday, babies will follow the gaze of another person. When babies are 12 to 18 months old, they already understand that when someone is looking at the same object as they are, the other person sees the same object at that moment.

Psychologist Herbert H. Clark of Stanford University and Meredyth Krych of Montclair State University have demonstrated just how important joint attention is for cooperative action. The researchers gave pairs of people instructions for building a model out of Lego blocks. One of the two test subjects played the "director," who read out instructions from a prepared manual. It turned out that the pairs worked faster and made fewer errors when the supervisor and the builder not only talked to each other but could see each other and the blocks as well. In contrast, when they were separated by a partition, coordination became considerably more difficult.

Spontaneous imitation acts as a "social glue," promoting feelings of friendliness and togetherness.

A brief glance is also often more than enough to allow us to recognize what another person is doing—and what that action will accomplish. For example, when we see someone picking up a glass of water in a restaurant, we can pretty much predict that she will raise it to her mouth and drink. A number of neuropsychological and brain-imaging studies indicate a close connection between the perception of what others are doing and our own planning and control mechanisms.

A direct connection between observation and the execution of actions was first observed in macaques. The "mirror neurons" in the premotor and parietal cortices of the brain fire not only whenever the monkey executes an action but also when the animal observes other monkeys performing that action. Since these initial findings, numerous studies have shown that the same areas of the human brain are activated when we act *and* when we observe others [see "A Revealing Reflection," by David Dobbs; Scientific American Mind, April/May 2006].

For example, brain researcher Beatriz Calvo-Merino and her colleagues at University College London showed dance films to ballet and capoeira dancers. In all participants, activity was seen in brain regions that are otherwise activated only when the subjects themselves dance. Interestingly, brain activity increased when the test subjects observed their own type of dancing, whereas when a ballet dancer, for example, watched a performance of capoeira, her gray matter cells had a weaker response. The more similar the actions of the observer and the observed, the greater the resonance in the brain's motor system.

A close connection between perception and action may also explain why we occasionally mimic actions, body language and facial expressions. For example, when two friends drink a glass of wine in a restaurant, they may raise their glasses at the same time. Likewise, people often cross their legs when someone they are talking to crosses theirs. This phenomenon of involuntary impersonation may arise from the activation of the brain's action programs with sufficient strength to trigger movements spontaneously.

Our talent for mimicry may serve an important purpose. Some studies imply that spontaneous imitation acts as a "social glue," promoting feelings of friendliness and a sense of togetherness. Studies conducted by Tanya L. Chartrand and her colleagues at Duke University, for example, have shown that people tend to assess those who frequently ape their movements during a conversation as friendlier; people who do not echo actions are viewed as less agreeable. Chartrand also showed that people who feel socially excluded from group activities tend to mimic others more often—presumably to get back in their good graces. When our actions resemble those that we observe in others, it is taken as a sign of unity.

This tendency for coordination with others is so deeply ingrained that people will follow it even when it hampers their ability to perform an assigned task, as suggested by a series of studies that I conducted with my Rutgers University colleague Guenther Knoblich and Wolfgang Prinz of the Max Planck Institute for Human Cognitive and Brain Sciences in Munich. On a computer screen, a test subject viewed a succession of images of a hand, each of which pointed to the left or to the

JOE McBRIDE Getty Images

Things go better with eye contact. Following instructions is more difficult when the supervisor and worker cannot see each other.

(The Author)

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right. Each index finger wore either a red or a green ring. The subject was told to hit a key on her right with her right hand whenever a green ring appeared, to hit the key on her left side with her left hand for a red ring, and, in the process, to ignore the direction of the virtual finger. Nevertheless, most test subjects were influenced by finger direction. If, for example, the hand with the green ring pointed to the left, they tended to hesitate before responding with the key on the right.

"You Are (Always) on My Mind"

We repeated this experiment with two persons sitting next to each other looking at the same monitor. Each test subject could press only one key. The person on the right was instructed to respond only to green rings by hitting her key; the one on the left was responsible for red rings.

The direction in which the index finger pointed affected the test subjects in this experiment as well. They reacted faster when the finger pointed in their direction. Yet when the subjects carried out exactly the same task by themselves—reacting only to red or green—the pointing direction of the finger did not affect their reaction time.

So two people, each of whom assumes part of a task, behave as a single person who is responsible for both parts of that task. Apparently, people pay attention not only to their own instructions but also to the potential actions of the other person. Whenever the hand points to my partner, a mental representation is automatically activated in my brain that relates to the potential action of my partner. There is a lag time before I realize that although the hand is pointing to the other person, I need to react to my color. That is why I will hesitate for a moment before hitting my key. In further studies on healthy test subjects, we showed that the "integration effect" described above is generalized well beyond tasks involving rings, hands and computer monitors.

We wondered whether this impulse to cooperate might be absent in some people as a result of a neurological disorder. People with autism, for example, are often unable to draw conclusions about what others are thinking or feeling in a particular situation—they have trouble attributing mental states to other people. The question was whether this stands in the way of their ability to integrate the actions of others with their own behavior. In collaboration with Luitgard Stumpf of the Integration Center for Autistic Persons in Munich, we used the ring experiment to determine whether autistic adults of normal intelligence take other people into account just as nonautistic persons do, even when their own task does not actually require it.

To our surprise, subjects with autism behaved exactly like the other test subjects. The same task led to different patterns in reaction time, depending on whether the task was done alone or in concert with a second person. We concluded that the basic connections between perception and action, which support social interactions, may be completely intact in autistic persons—even though these individuals have difficulty intuiting the thoughts of others. It will fall to other experiments to show whether people with autism perform as well in collaborative situations that require a higher level of coordination. It may be that the automatic connection between perception and action developed very early in our evolution—even before human beings were able to infer what others were thinking.

Our strong instinct to mimic a partner needs to be suppressed while playing a duet.

TAO ASSOCIATES Getty Images

Our tendency to take others into account may have its roots in our evolutionary history.

Suppressing Imitation

It is interesting to note that some forms of joint action require special effort to ensure that people do not react when it is the other person's turn. The ability to take turns plays a crucial role in conversation, paddling a canoe in unison, or playing a piano duet. Looked at another way, it seems that the strong instinct to mimic must be suppressed to make coordination possible. In our experiments, we were actually able to measure this suppression in the electrical activity of the brain using electroencephalography. A specific electrophysiological component—called Nogo P3—shows the magnitude of inhibition processes needed to suppress an action, such as when the red-ring test subject in a pair sees a green ring and is therefore not supposed to hit his key. Sure enough, more inhibition was recorded when subjects were working in pairs than when they worked alone.

Knowing that a partner will join us in a task can even alter our perception of situations and objects. It has long been known that we perceive things differently depending on our intentions and the resources at our disposal. For example, psychologist Dennis R. Proffitt of the University of Virginia demonstrated that a hill appears steeper when we are carrying a heavy backpack—something any hiker will confirm.

Similarly, someone's estimate of a box's weight will differ, depending on whether the individual has to lift it alone or with someone else. This phenomenon was demonstrated by an experiment conducted by Maggie Shiffrar and me at Rutgers, in which test subjects were asked to estimate the weight of transparent boxes that were filled with different quantities of potatoes. If the subject believed that another participant was going to help lift the box, her weight estimates were actually lower than if she thought she would have to hoist it by herself. Persons in groups underestimate weight across the board, even though their estimates may be on the mark when they do so alone.

These results suggest that we may see the world not only through our own eyes but also through the eyes of the groups we form. We plan our actions guided partly by what we think we can achieve with others. Our tendency to take others into account may have its roots in our evolutionary history. Those who were able to coordinate their actions with others may have had many advantages. One of the first forms of cooperative action might have been activities where two or more people performed the same action at the same time, for example, when they pushed a heavy rock in front of a cave to protect its entrance. Later, individuals may have started to engage in complementary actions, such as when one person chased an animal so that others could catch it.

Research from our lab and others suggests that the challenges posed by these different forms of joint action shaped our perception-action system and our unconscious cognitive processes. In many cases, then, cooperation is not just an exercise of social duty. Rather we simply cannot do otherwise. M

RICH REID *National Geographic*/Getty Images

A hill appears steeper to a heavily laden hiker. But knowing help is on the way makes the load seem lighter.

(Further Reading)

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SEAN MURPHY *Getty Images (teen on bike)*; CREASOURCE *Corbis (teens drinking)*; BENJAMIN PORTER *New York Times/Redux (teens driving)*; MARK PETERSON *Redux (teens smoking)*; IMAGES USED FOR ILLUSTRATIVE PURPOSES ONLY

Is the Teen Brain Too RATIONAL?

With the decision-making areas of their brains still developing, teenagers show poor judgment in risky situations. Thinking less logically may be the answer

By Valerie F. Reyna and Frank Farley

Adolescence is a dangerous time. Some of the most life-threatening risks that people take—drunk driving, binge drinking, smoking, having unprotected sex—are especially common during the teenage years. The following statistics illustrate the enormous toll in human suffering caused by adolescent risk taking:

- Both males and females between the ages of 16 and 20 are at least twice as likely to be in car accidents than drivers between the ages of 20 and 50 are. Auto accidents are the leading cause of death among 15- to 20-year-olds, and 31 percent of young drivers killed in motor vehicle crashes in 2003 had been drinking.
- Three million adolescents contract sexually transmitted diseases every year.
- More than half of all new cases of HIV infection occur in people younger than 25, making AIDS the seventh leading cause of death among 13- to 24-year-olds. Two young people in the U.S. are infected with HIV every hour.
- Forty percent of adult alcoholics report having their first drinking problems between the ages of 15 and 19.
- Evidence of pathological or problem gambling is found in 10 to 14 percent of adolescents, and gambling typically begins by age 12.

In addition to the immediate consequences of risk taking—both for adolescents and for those who suffer from their actions—many behaviors that affect adult health begin and become entrenched during adolescence. So risky activities such as heavy drinking and drug use, which begin as voluntary experimentation, can be perpetuated by addiction. And whereas most teen drinkers, for example, do not progress to alcoholism, virtually all alcoholics started drinking in adolescence.

Preventing risky behavior while it is still a matter of deliberate choice is crucially important—not just for protecting troubled teens but also for society. An obvious answer is early intervention, which is both more successful and less costly than efforts to deal with established addictions later.

Strategies that help to postpone sexual activity, binge drinking and other risky behaviors also have the virtue of giving the forebrain and other neurological structures time to mature. As studies are now showing, the immature adolescent brain may be responsible for much of the risky business that young people engage in.

Over the past two decades, studies using magnetic resonance imaging (MRI) and other imaging techniques have shown that the human brain undergoes major remodeling during childhood and throughout the teen years—anatomical changes that may account for the risk taking, novelty seeking and impulsivity that characterize adolescent behavior [see "The Teen Brain, Hard at Work," by Leslie Sabbagh; Scientific American Mind, August/September 2006]. Gray matter in the brain, for example, begins thinning early in childhood—a sequential maturation process that begins at the back of the brain. Not until early adulthood does this wave of gray-matter thinning finally reach the forebrain areas where planning, reasoning and impulse control occur.

This growing evidence that risk taking may be hardwired into the adolescent brain has influenced the way that we and other psychologists now view troubled teenagers and the standard intervention programs aimed at preventing their risky behavior.

Growing evidence indicates that risk taking may be hardwired into the adolescent brain.

Why Programs Fail

Traditional intervention programs emphasize the importance of giving teens information about risks and allowing them the freedom to decide for themselves what to do. These programs encourage teens to trade off potentially deadly risks against often transient benefits and assume that they will see the light: just tell them the risks of HIV infection and unwanted pregnancy, these programs assume, and teens will not engage in unprotected sex.

Such programs are based on a collection of theories of decision making with names like "the behavioral decision framework" and "the theory of reasoned action." As their names imply, these theories expect that teenagers will weigh risks against benefits and come to the "rational" conclusion about their actions.

Some programs based on these theories have helped reduce risky actions taken by teens. For the most part, however, they have achieved only limited success. In addition to the modest percentage of teens influenced by these intervention efforts, the positive effects of these programs—most of which involve 10 to 20 hours of instruction—typically fade away in a matter of months.

In our view, intervention programs appealing to teen rationality are inherently flawed—and not because teens fail to weigh risks against benefits; as we will see, most teens do so conscientiously. Part of the problem may be that the "unfinished" architecture of their brains hinders adolescents from thinking like adults. Recent studies, for example, show that teens tend to weight benefits more heavily than risks when making decisions. So, after carefully considering the risks and benefits of a situation, the teenage brain all too often comes down on the side of the benefits—and chooses the risky action.

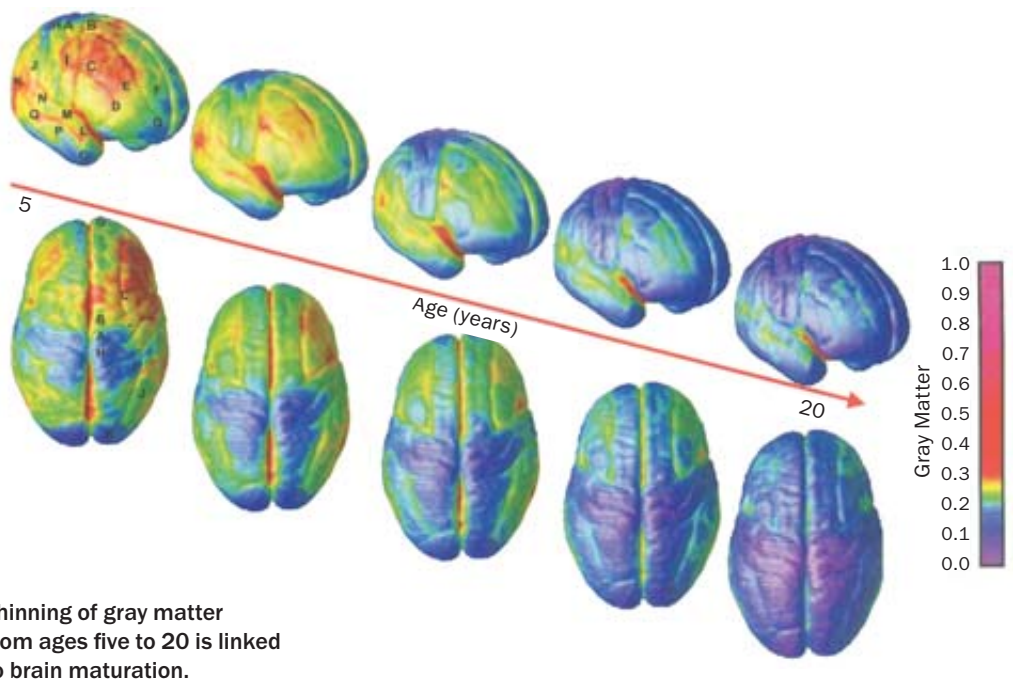
Just as important, traditional intervention programs are flawed because they are based on the notion that teens consider themselves invulnerable—despite evidence now pointing in exactly the opposite direction.

The Invulnerability Myth

For decades, a seductive explanation for risky teen behavior has reigned supreme among both

Less Is More in Brain Development

To trace the development of the human brain, researchers at the National Institute of Mental Health recruited 13 children to undergo magnetic resonance imaging (MRI) brain scans every two years for eight to 10 years. Because MRI scanning reveals the volume of gray matter (composed mainly of nerve cell bodies) in the brain's cortex, the researchers were able to produce a time-lapse sequence of brain development. Shown here are two views—right lateral and top—of how gray matter matures over the cortical surface from the age of five to 20. The color bar on the right represents the volume of gray matter in units. The imaging study reveals progressive "thinning" of gray matter in a wave that starts at the back of the brain and progresses to the front. Those regions that mature last—not until early adulthood—are associated with higher-order functions such as planning, reasoning and impulse control. *—V.F.R. and F.F.*



Thinning of gray matter from ages five to 20 is linked to brain maturation.

SOURCE: "DYNAMIC MAPPING OF HUMAN CORTICAL DEVELOPMENT DURING CHILDHOOD THROUGH EARLY ADULTHOOD," BY NITIN GOGTAY ET AL., IN *PNAS*, VOL. 101, NO. 21; MAY 25, 2004, © 2004 NATIONAL ACADEMY OF SCIENCES, U.S.A.

the public and health professionals alike: teens drive too fast, binge drink and have unprotected sex because they feel they are invulnerable. They must therefore be underestimating their risks, or otherwise they would not take such chances. But studies uniformly dispute the widespread belief that adolescents consider themselves more invulnerable than adults (who, it turns out, are more likely to consider *themselves* invulnerable when compared with teens). And when it comes to risk, studies over the past five years show that teens actually tend to *overestimate* rather than underestimate the true risks of potential actions.

For example, a 2002 study by Susan Millstein and Bonnie Halpern-Felsher of the University of California, San Francisco, found that adolescents were more likely than adults to overestimate risks for every outcome that could be evaluated, including low-probability events (earthquakes and HIV transmission from unprotected sex, for instance) as well as higher-probability events (acquiring sexually transmitted diseases such as gonorrhea and chlamydia).

Another study, published in 2000 by Baruch Fischhoff of Carnegie Mellon University and his colleagues, reported on risk predictions assessed in a nationally representative sample of 3,544 adolescents from the 1997 National Longitudinal Study of Youth. Adolescents' risk estimates for "die from any cause—crime, illness, accident and

The perceived benefits of an action tend to outweigh and offset its risks.

so on" in the next year or by age 20 were much higher than shown by statistical data. Recent data collected by one of us (Reyna) underline these differences between perceived and actual risks when it comes to sexually transmitted infections.

Interestingly, teens' overestimation of risk appears to decline after early adolescence, and evidence suggests that experience may be responsible: engaging in risk taking without incurring immediate consequences may encourage complacency.

If adolescents often overestimate risks and do not think of themselves as being invulnerable, then why do they engage in risky behaviors? A number of studies indicate that when adolescents are mulling over risk taking, the perceived benefits of the action tend to outweigh and offset the perceived risks. For example, in a 2002 study of young (fifth to ninth grade) adolescents, Julie H. Goldberg of the University of Illinois at Chicago and her colleagues at the University of California, San Francisco, found that the perceived benefits of alcohol outweighed perceived risks in predicting the students' drinking behavior six months later.

It now becomes clearer why traditional intervention programs fail to help many teenagers. Although the programs stress the importance of accurate risk perception, young people already feel vulnerable and overestimate their risks. And programs fail to alert teens about the allure of benefits, even though the teenage mind emphasizes the benefits of a potentially dangerous situation over its risks.

Some teens have certainly been "scared straight" by traditional intervention programs. But for the most part, such programs have not done much to deter risky behavior—and, even worse, they may actually be encouraging it.

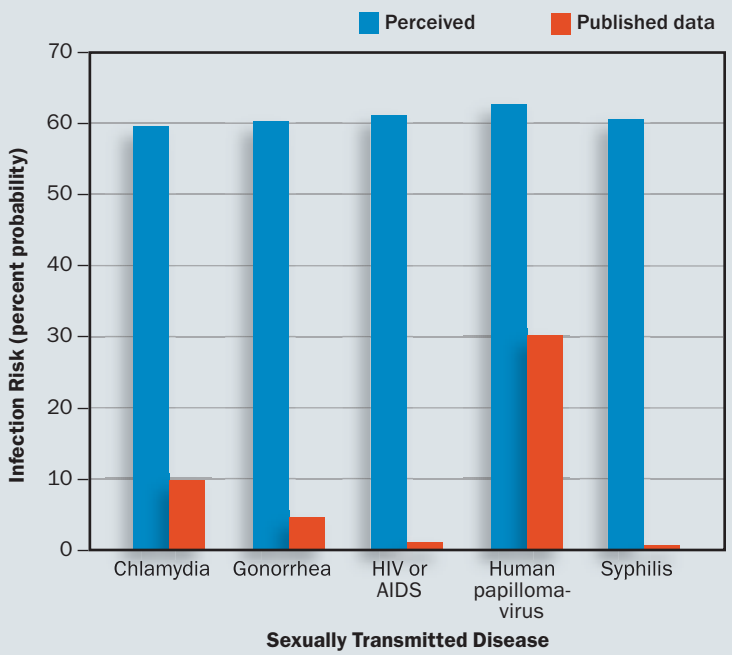
Consider the adolescent who puts his odds of becoming infected with HIV through a single act of unprotected sex at 50–50 … and then learns through his intervention program that his true risk is one in 500 at most. The program's emphasis on inundating teens with risk information could well backfire, making them more rather than less likely to have unprotected sex or engage in other risky actions.

To improve the success of intervention efforts, we are testing a strategy fundamentally different from the one that traditional programs are based on: rather than asking teens to rationally balance risks and benefits, we are training them to think less logically and more intuitively—the way mature adults do, in other words.

Accentuate the Intuitive

This new strategy is based on a theory jointly proposed about 20 years ago by one of us (Reyna) and Charles Brainerd, now at Cornell University. Called fuzzy-trace theory, it originally was regarded as quite radical. Today, however, it can be described as an "establishment" theory of cognitive development because research has confirmed so many of its surprising predictions. It offers an explanation for the evolution of behaviors and memories from childhood, through adolescence and on to adulthood based on changes that occur in the way we reason. A decade ago fuzzy-trace theory predicted and discovered the counterintuitive finding that some false memo-

Exaggerating Risks



When 254 students in the ninth to 12th grades were asked about the likelihood that a sexually active teenage girl would contract a sexually transmitted disease, they assumed that her risk of infection was much higher than it actually is.

SOURCE: "RISK AND RATIONALITY IN ADOLESCENT DECISION MAKING: IMPLICATIONS FOR THEORY, PRACTICE, AND PUBLIC POLICY," BY V. F. REYNA AND F. FARLEY IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST*, VOL. 7, NO. 1; SEPTEMBER 2006

One Girl's Intervention Experience

The following is a conversation with a 15-year-old girl who had previously had an unintended pregnancy and now participates in the intuitive, gist-enhanced intervention program that we devised. —*V.F.R. and F.F.*

Q: Why do you feel you made ill-advised decisions in the past?

A: It was partly because of the friends I hung out with and also because we assumed that doing what we did—having sex, not bothering with condoms—wasn't bad.

Q: How has the program affected your responses to potentially risky situations?

A: I think specifically I learned how important it is to use a condom, and the program really opened my eyes to how common STDs [sexually transmitted diseases] are and how cautious I need to be to avoid them.

Q: Has the intervention made you feel more in control of your life?

A: Yes, because in talking about all the different ways to say "no," I've actually used them, which makes me feel much more comfortable.

And I feel confident. I don't feel stupid by saying "no." And even if people think I'm stupid, that's their problem.

ries are more stable over time than true memories, among other novel findings.

Fuzzy trace is a so-called dual-processes theory positing that people rely on two quite different ways of reasoning to reach conclusions about situations confronting them. The first way is a deliberative, analytical approach that relies on details, such as those collected during rote exercises and fact memorization. This verbatim style of reasoning involves the kind of computational processing assumed by risk-intervention programs, when risks are traded off precisely against rewards. Far from being analytical, the second or "fuzzy" style of reasoning occurs unconsciously and above all involves intuition, allowing people to penetrate quickly to the gist, or bottom line, of a situation. (The word "trace" in fuzzy-trace theory refers to the mental pictures, or traces, that collectively constitute memory.)

Fuzzy-trace theory's different modes of reasoning—verbatim and gist—are by no means mutually exclusive and can actually operate in the same person at the same time. But each predominates at different stages of life in normal human development.

Legendary developmental psychologist Jean Piaget contended that we start off as intuitive children who become analytical adults. Fuzzy-trace theory reverses things, proposing instead that the verbatim mode of reasoning reigns during childhood and adolescence. Then, with maturity, gist thinking takes over as we make decisions that disregard distracting details and instead are filtered through our experience, emotions, worldview, education and other factors.

The intuitive, gist-based approach to decision making tends to yield a "simple" answer—a black-and-white conclusion of good or bad, safe or hazardous, for example. Yet gist appears to be the more advanced form of reasoning, because the tendency to base decisions on gist increases with age, experience and expertise, as shown by research with children and adults.

Fuzzy-Trace Theory and Risk

When it comes to handling risks, fuzzy-trace theory predicts that mature decision makers will not deliberate about the degree of risk and the magnitude of benefits if a nontrivial chance of a catastrophic or health-compromising outcome exists. In contrast, the verbatim-based, analytical approach of adolescents faced with a risky situation would be expected to take longer. And indeed, studies comparing the reaction times in milliseconds for adults and adolescents to questions such as "Is it a good idea to set your hair on fire?" and "Is it a good idea to drink a bottle of Drano?" show that adults respond faster than teens.

In recent years, colleagues have suggested that fuzzy-trace theory could be applied to the vexing problem of adolescent risk taking. We have taken up the challenge, and our research suggests that adding a gist-based component to intervention programs serves a useful purpose. We believe that emphasizing intuitive rather than "logical" reasoning in potentially risky situations could help many—but not all—adolescents avoid engaging in risky behavior.

(The Authors)

VALERIE F. REYNA and FRANK FARLEY have studied risk for a quarter of a century. Reyna is co-director of the Center for Behavioral Economics and Decision Research and professor of human development and of psychology at Cornell University. Farley is L. H. Carnell Professor at Temple University and former president of the American Psychological Association.

Two Routes to Risk

We propose that there are two kinds of teens who make similarly risky choices but do so through very different routes. We call these two groups the risky deliberators and the risky reactors.

The risky deliberators encompass the vast majority of teenagers—those who are in the normal developmental stage of adolescence. Before doing something potentially dangerous, risky deliberators rationally trade off risks against benefits, just as risk-intervention programs encourage them to do. And all too often, the risky deliberators come to a conclusion that, for them, is entirely logical: they conclude that the benefits of a risky action outweigh its risks—and intentionally go ahead and do it.

Consider the extreme example of Russian roulette, which was featured so prominently in the movie *The Deer Hunter*. Nick, played by Christopher Walken, has made a considerable amount of money gambling on Russian roulette. We last see him in a gambling den in Saigon sitting opposite his old friend Michael (Robert De Niro) and holding a gun to his head.

Nick clearly was mentally unstable, traumatized by his ordeal in the Vietnam War and addicted to heroin. But for risky deliberators, for the standard intervention programs aimed at helping them (and for economists of a certain stripe), the decision to play Russian roulette could be considered rational if the payoff in dollars were large enough. After all, the benefit could be a fortune that lasts a lifetime … and the risk of dying is only one in six.

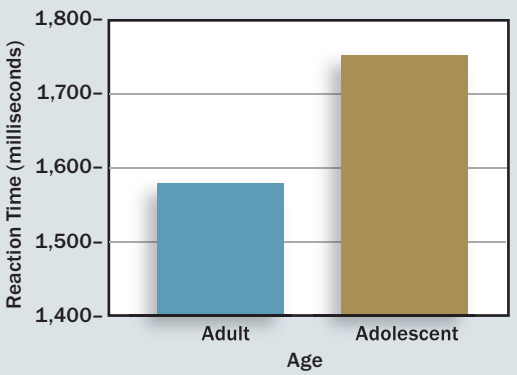
The young risky deliberator has relied on verbatim reasoning that is age-appropriate and logical but that could result in a tragic outcome. Most adults, on the other hand, will look at this scenario—money to win and a gun with a single bullet in the chamber—and ask, "Are you crazy? No amount of money you could offer would get me to put that gun to my head. This is not about the number of dollars or the number of bullets—we're talking about a significant risk of dying here." Adults, of course, are using gist-based thinking to cut quickly through the distractions, grasp the bottom-line meaning and arrive at a simple answer: absolutely not.

Risky reactors, on the other hand, are not thinking deeply or analytically. Instead they act impulsively because of some temptation in their environment. Risky reactors do not *intend* to do something dangerous. But for any number of reasons—including peer-group pressure or the excitement of the moment—they are pulled into risky situations, often against their better judgment.

Fortunately, most risky reactors grow out of their impulsiveness once they reach adulthood. But in the meantime, efforts to influence cognitive development by encouraging intuitive thinking probably will not help these teens, who are responders rather than thinkers. Instead measures for protecting unintentional risk takers should focus on adult supervision or monitoring to minimize opportunities for reacting to temptation.

Risky deliberators—the much larger group of at-risk adolescents—stand a far better chance of benefiting from exposure to intuitive, gist-based

Thinking about the Unthinkable



In studies measuring their reaction time, teens deliberate much longer than adults before answering "no" to questions such as "Is it a good idea to drink a bottle of Drano?"

DANNY WILCOX FRAZIER *Redux* (*photograph*); SOURCE: "RISK AND RATIONALITY IN ADOLESCENT DECISION MAKING: IMPLICATIONS FOR THEORY, PRACTICE, AND PUBLIC POLICY," BY V. F. REYNA AND F. FARLEY IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST*, VOL. 7, NO. 1; SEPTEMBER 2006 (*graph*)

Should the number of bullets matter in deciding whether to play Russian roulette? Making a rational decision may require not thinking analytically.

RON ROVTAR Getty Images

thinking. These teens do engage in reasoning—flawed though the outcomes may be—so we may be able to influence *how* they reason. To that end, we are now testing a gist-enhanced intervention program in a clinical trial involving more than 800 adolescents. Results should be available by the end of 2007 [*see box on page 63, for comments of one at-risk teenager who seems to be benefiting from this gist-based intervention effort*].

We are optimistic that gist-based thinking will one day be widely incorporated into risk-intervention programs, where it could help young people pass unscathed through their dangerous teenage years. For now, we offer the following empirically supported recommendations for helping adolescents avoid taking unhealthy risks:

- Offer risky deliberators well-reasoned arguments for resisting risky behaviors as well as factual information about social norms ("The notion that everyone your age is having sex just isn't true"). Focus on reducing the perceived benefits of risky behaviors—and on increasing the perceived benefits of safer, alternative behaviors.
- Teens may not grasp the concept of "harmful consequences" because of their lack of relevant experience (which can also make them prone to repeated risk taking, if they have so far managed to "dodge the bullets" of negative consequences). Help them to understand the meaning of risk-related truths (the fact that HIV is not treatable with antibiotics means that AIDS cannot be cured) and to derive the gist or bottom line of messages that will endure in memory longer than verbatim facts.
- Reduce risk by retaining or implementing higher drinking ages, eliminating or lowering the number of peers who can accompany young drivers, and reducing exposure to potentially addictive substances (rather than trying to teach minors to drink responsibly, for example).
- Monitor and supervise younger adolescents rather than relying on them to make reasoned choices or to learn from the school of hard knocks; remove opportunities for them to engage in risky behavior.
- Encourage teens to develop positive gists or images of healthy behaviors and negative images of unhealthy behaviors, by exposing them to films, novels, serial dramas or other emotionally evocative media.
- Identify and encourage teenagers to adopt so-called self-binding strategies ("I will not attend unsupervised parties") and help them to practice recognizing cues that signal danger before it is too late to act ("I will not ride with a drinking driver"). **M**

(Further Reading)

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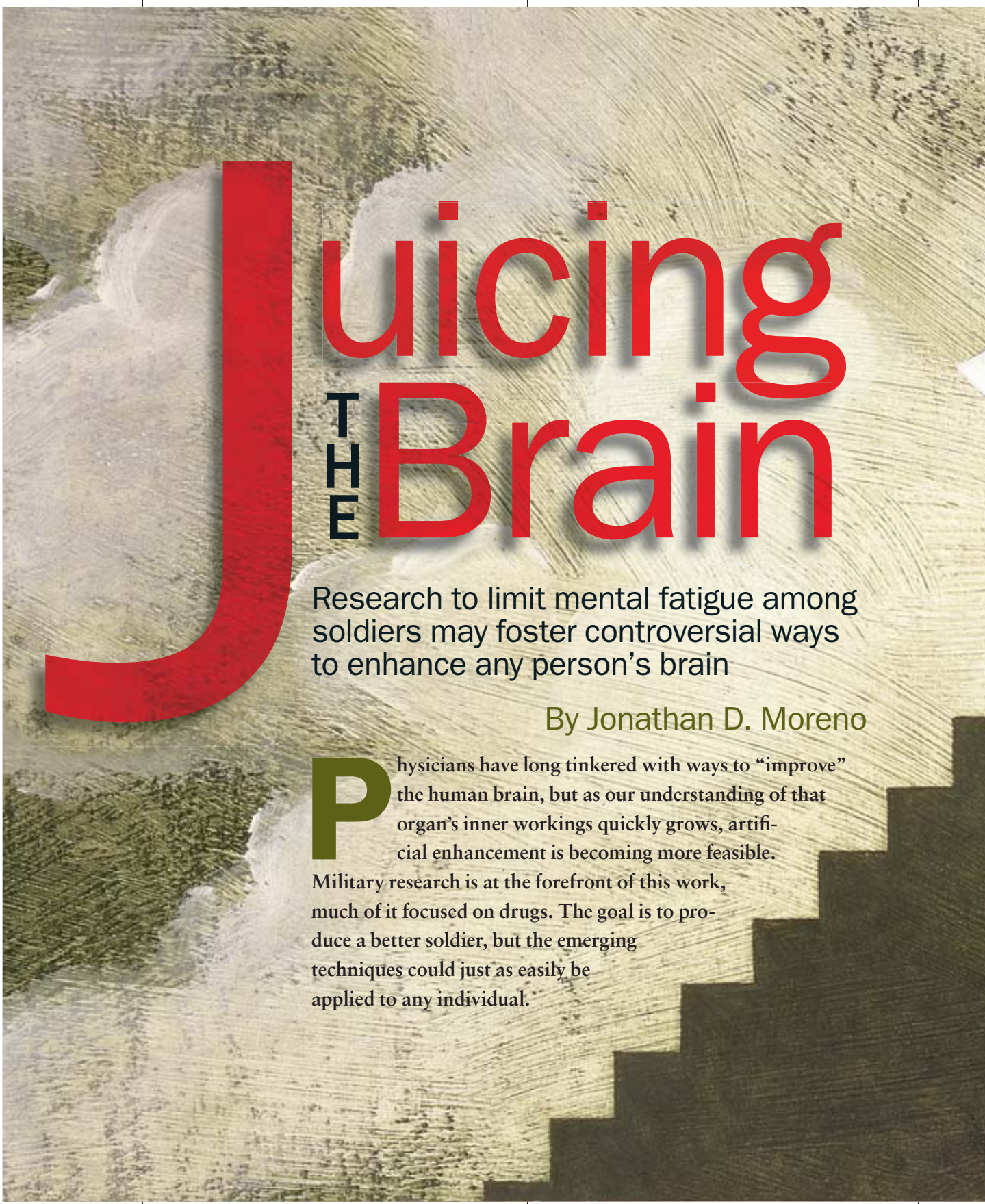


Juicing the Brain

Research to limit mental fatigue among soldiers may foster controversial ways to enhance any person's brain

By Jonathan D. Moreno

Physicians have long tinkered with ways to "improve" the human brain, but as our understanding of that organ's inner workings quickly grows, artificial enhancement is becoming more feasible. Military research is at the forefront of this work, much of it focused on drugs. The goal is to produce a better soldier, but the emerging techniques could just as easily be applied to any individual.

The military wants to juice up personnel's brains because the human being is the weakest instrument of warfare. Although for centuries astonishing and terrifying advances have been made in the technology of conflict, soldiers are basically the same. They must eat, sleep, discern friend from foe, heal when wounded, and so forth. The first state (or nonstate) actor to build superior fighters will make an enormous leap in the arms race. In the short run, researchers are trying to devise aids that would overcome a person's inherent limitations, such as mental fatigue. Long-term results could lead to individuals everywhere who are tireless, less fearful or even better speakers.

Neurostimulation might improve cognition during confusing battles or offset sleep deprivation.

Sleepless in Battle

Reducing human error caused by mental fatigue is crucial because death by "friendly fire" is a shockingly frequent occurrence. These tragic mistakes can partly be attributed to the sleep deprivation that accompanies lengthy deployments. An investigation into a 2002 incident in which two American pilots accidentally killed four Canadian soldiers and injured eight others in Afghanistan provided an unexpected glimpse into the U.S. Air Force's interest in sleep. Unnoticed by many, the pilots' attorneys in the resulting court-martial cases pointed out that their clients had been taking Dexedrine, sometimes called the go pill, otherwise known as speed. It was alleged that amphetamines such as Dexedrine are commonly prescribed to keep pilots alert for 30-hour missions, even though questions have been raised about safety. Use of such drugs can also lead to dependency.

The air force is considering alternatives to amphetamines, in particular a medication that has also gained the attention of long-distance business travelers: modafinil. Marketed as Provigil, it was approved by the Food and Drug Administration in 1998 to treat narcolepsy and to help control sleep disorders associated with diseases such as Parkinson's, Alzheimer's and multiple sclerosis. Modafinil is not a traditional stimulant; rather than bombarding various parts of the brain with arousal signals, it apparently nudges the brain toward wakefulness through specific pathways, perhaps by increasing serotonin levels in the brain stem. The precise mechanism is still not well understood.

The temptation for healthy people to use such a drug is tremendous; some individuals report that a dose leaves them as refreshed as a short nap. Frequent fliers already get prescriptions for the stuff, and it is sure to be the next craze on college campuses among students who want to pull all-nighters or just be able to party hearty for days. Long-distance truck drivers are also obvious candidates for use and, perhaps, abuse.

Workers who shift from day to night schedules and back again are also interested. They often complain of drowsiness during the work period and insomnia when they want to sleep. The Air Force Office of Scientific Research and Cephalon, Inc., in Frazer, Pa., sponsored a study by Harvard University and the University of Pennsylvania in which 16 healthy subjects were treated like shift workers: they were deprived of sleep for 28 hours, then obliged to sleep from 11 A.M. to 7 P.M. for four days and to stay awake those nights. The subjects on modafinil did far better on cognitive tests than those on a sugar pill. Double-blinded, placebo-controlled studies have shown that some subjects can stay awake for more than 90 hours.

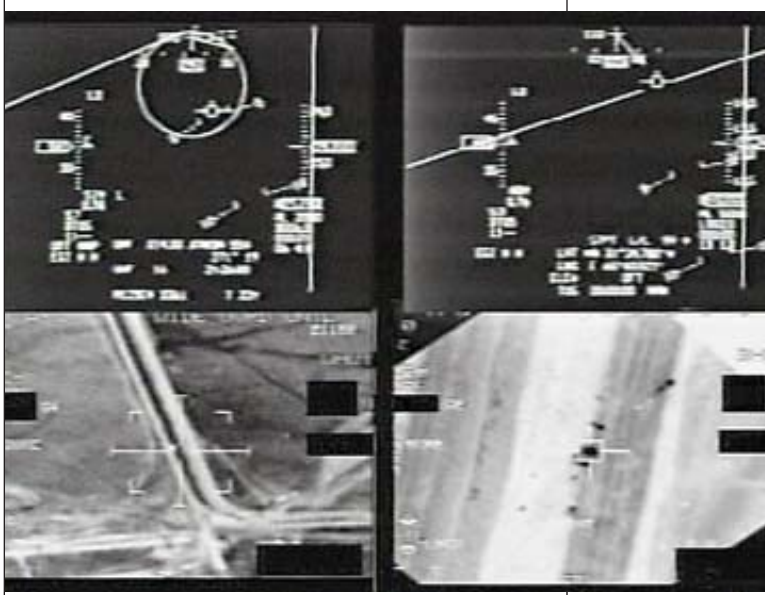
A few news outlets have made unconfirmed claims that American soldiers were using modafinil on the way to Baghdad in 2003. That would not be surprising. Minimizing the need for sleep has been a holy grail for war planners since time immemorial. Guards at China's Great Wall chewed an herb containing ephedrine; Incan fighters munched on coca leaves; 19th-century Bavarian officers gave their men cocaine; soldiers from several countries used amphetamines during World War II; and, of course, armies consume countless tons of caffeine and nicotine. French soldiers took modafinil in the first Gulf War, and the *Guardian* newspaper reported in 2004 that the U.K.'s Ministry of Defense had purchased 24,000 tablets of the drug.

Preventing Mistakes

Despite the interest in modafinil, questions persist. Does it mask natural sleep needs but fall

IMAGES.COM Corbis (preceding pages)

Pallbearers carry the casket of a Canadian soldier who was mistakenly bombed by American pilots in Afghanistan (gun camera views of the incident are below). The pilots' attorneys subsequently alleged that the fliers had been taking the "go pill" to stay alert and that this was common military practice.



JIM YOUNG *Reuters/Landov (top)*; U.S. DEPARTMENT OF DEFENSE *Getty Images (bottom)*

short in keeping people as functional as they think they are? This could be critical for pilots and soldiers, who should not overestimate their readiness. After prolonged use, the endocrine and immune systems may be compromised by lack of sleep, too.

Military scientists are examining the safety issues. One researcher at the air force's Brooks City-Base in San Antonio told *Pentagram*, an online newsletter, that "all indications say modafinil is a safer drug, but we don't know that for sure." But even if the compound proves safe in terms of sound judgment in combat, what about the effects down the road for people who have been on and off the drug for years? The long-term risks associated with sleep deprivation are not well understood either. Evidence indicates that during sleep, memory and learning are consolidated and that the brain refreshes its store of energy.

Studies have shown that people who sleep only four hours a day for an extended period have an increase in insulin resistance, a prediabetic symptom. But without a proven explanation for the purpose of sleep, it is hard to assess the downside of doing without, other than the obvious discomfort that nonsleepers experience—the attendant loss of concentration and the increased accident risks.

An intervention that minimizes the need for sleep yet maintains cognitive capacity would be a significant advantage for a military force. In-

Consumers would spend billions of dollars on drugs that would allow them to work night shifts, party till dawn or simply sleep only when they wanted.

fantrymen commonly subsist on three or four hours of sleep nightly for weeks. Special Forces personnel may be awake for several days during search and rescue operations. The Defense Advanced Projects Research Agency (DARPA) is spending $100 million in grants on "prevention of degradation of cognitive performance due to sleep deprivation." DARPA's Defense Sciences Office has stated that "if you can prevent bad decisions from being made during sleep deprivation, you can dominate the battlefield." It is also interested in how to reverse losses that might occur during sleep deprivation and whether researchers can "expand the available memory space, so that people can retain cognitive function under tremendous stress and sleep deprivation."

The military effort includes investigation of another class of drugs, the ampakines, which show some promise in treating dementia and symptoms of schizophrenia by improving cognition when used with antipsychotic medication. Clinical trials have not found therapeutic value, but results from a company-sponsored study at Wake Forest University using an ampakine drug in sleep-deprived rhesus monkeys were encouraging. The monkeys' performance was reduced 15 to 25 percent when sleep-deprived, and reaction times doubled. But a single dose of Ampakine CX717 eliminated their performance deficit and sleep deprivation changes. An unpublished human trial sponsored by the company that makes CX717 reported that 16 men deprived of a night's sleep did better on memory and attention tests after taking the drug. The scientist who conducted the study said, "We didn't see any adverse events."

How Far Can We Go?

Military work is only the beginning of intense efforts to control sleep-wake cycles. There is a multibillion-dollar demand from civilians who wish to sleep only when they want to sleep. The neuroscientific key lies in a part of the hypothalamus called the suprachiasmatic nucleus (SCN), the brain's biological clock. About the size of a pinhead and nestled deep within the brain, the SCN, composed of 20,000 neurons, acts as the pacemaker for circadian rhythms in mammals. If

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the SCN is cut or removed in animals, their sleep-wake cycle can be profoundly disturbed. And when people are deprived of light, the SCN runs on a 25-hour clock; for some reason that is our innate length of a single day, which helps to explain insomnia and other sleep disorders in those who are blind. Though subject to some variation, the clock can be reset by exposure to light signals transmitted from the retina, which is why we can function on a regular 24-hour cycle.

There are very few hard data showing that prolonged sleep deprivation has truly deleterious effects in humans, according to Harvard neurobiologist Jerome Groopman. Yet University of Pennsylvania researcher David Dinges has raised provocative questions about Boeing Company's plans for a jetliner that would fly around the earth and need to land only once in 20 hours: How should the crew sleep, if at all? What are the rules that apply to sustained work on flights like that? As Dinges says: "Now is the time to have an open and frank discussion on how far we will go as a culture. What are our priorities? How regularly do we want to manipulate our brain chemistry? What are the limits?"

Some insights may come from the animal world. Dolphins seem to keep parts of their brains awake to control their breathing and guide them to the surface for air while the rest of their brain is allowed to sleep. Otherwise they would drown. Positron-emission tomographic (PET) scans are beginning to reveal how their brain architecture accomplishes this feat. If the mechanism can somehow be simulated safely in human brains, it will be hard to keep the method out of the hands of civilians eager to get an edge in a competitive world.

Electricity and Magnetism

Another approach to enhancing cognitive abilities may be electrical stimulation of select brain centers. Physicians at the Rehabilitation Institute of Chicago found that when they implanted electrodes in the motor cortex of stroke victims, patients regained about 30 percent of lost function as compared with 10 percent for other patients. Although the approach is not perfect, the gains for those whose arms had for years hung limply at their sides were wonderful. Some stroke patients with speech difficulties experienced improvement, too. Unfortunately, the doctors do not know exactly why the added electricity works.

An intriguing question is whether electrical stimulation might help uninjured people exceed their normal intellectual capacities. One technique being explored is direct-current (DC) polarization. At a 2004 Society for Neuroscience meeting, researchers from the National Institutes of Health reported that a tiny amount of electricity delivered to the brain through an electrode on the scalp produced measurable improvement in verbal skills. They asked volunteers to name as many words as possible that began with a certain letter. The subjects showed about a 20 percent improvement when the current (two thousandths of an ampere, far less than that needed to run a digital watch) was on.

Because the current ran through the prefrontal cortex, the researchers speculated that the firing rate of neurons was increased, activating cells involved in word generation. The tiny charge seemed to have no deleterious effects, other than to leave certain individuals with an itchy scalp. Moreover, the fact that the technique does not involve surgery makes it more practical than implanted electrodes.

Another noninvasive technique is transcranial magnetic stimulation (TMS). A magnetic coil is placed above the head, and magnetic pulses pass through the cortex. Different kinds of pulses can alter the firing rate of different sets of neurons. Volunteers complain only about a sensation of tapping on the skull as scalp muscles contract and about a popping sound from the magnetic coil.

The therapeutic goal for DC polarization and TMS is to treat patients with stroke or dementia. TMS seems to target specific brain regions more

> Eliminating fear genes could satisfy parents who don't want to give birth to a "sissy."

(The Author)

JONATHAN D. MORENO is director of the University of Virginia's Center for Biomedical Ethics. This article is excerpted with permission from *Mind Wars: Brain Research and National Defense*, by Jonathan D. Moreno. © 2006 Dana Press.

A stroke patient aided by electrical brain stimulation undergoes tests at the National Institute of Neurological Disorders and Stroke; research suggests the technique could improve verbal and motor skills.

MARC ASNIN *Redux*

effectively, but DC polarization appears to carry less risk of inducing seizures. Of course, the long-term effects of frequent exposure to electrical or magnetic stimulation are unknown. Nevertheless, DARPA has awarded research grants to explore whether neurostimulation can improve impaired cognitive performance in confusing battle circumstances or to offset sleep deprivation, perhaps through helmets that deliver the tiny impulses needed.

Like so many potentially brain-enhancing technologies, neurostimulation can easily be oversold. Given how much we value cognition, however, even a modest improvement would be considered important by many people. Long-term problems for military personnel might be hard to identify and could seem worth the risk for even a marginal gain in mental agility in life-or-death situations. As neuroscientist Mark E. Huang of the Rehabilitation Institute of Chicago told the press in 2004: "There are many possibilities that have to be answered ethically. If you want to learn a new language, potentially the stimulator might help. Would I recommend you do it for that purpose? No. But down the road, who knows? Obviously the sky's the limit, and we're still in the infancy stage."

No Fear

Possibilities for mind enhancement indeed abound. A distinguished team of U.S. researchers reported in 2005 that a gene called *stathmin*, which is expressed in the amygdala (the seat of emotion), is associated with both innate and

learned fear. The researchers bred mice without the gene and put them in aversive situations, such as giving them a mild shock at a certain point in their cage. Normal mice exhibited traditional fear behavior by freezing in place, but the altered mice froze less often. And when both types of mice were put in an open field environment—an innately threatening situation—the mice without *stathmin* spent more time in the center of the field and explored more than the control mice.

Do individuals who have lesser *stathmin* expression exhibit less fear? It is unlikely that there is a one-to-one correspondence, because humans are far more psychologically complex than mice, capable of modifying their genetically programmed behavior. Yet it is not difficult to imagine that a military official who overestimates the significance of genetic information will someday propose screening Special Forces candidates, or even raw recruits, for the "fear gene." Indeed, a few years ago the Burlington Northern Santa Fe Railway Company had to pay $2.2 million to employees who had been secretly tested for a gene associated with carpal tunnel syndrome, even though the scientists who developed the testing technique said it could not work for that purpose. The company was trying to see if the workers' medical claims were attributable to their jobs or their genes.

If DNA testing for a fear gene is both scientifically and ethically dicey, what about setting out to create people who lack that characteristic? Would breeding humans without *stathmin* or other genes associated with fear reactions engender more courageous fighters? Would parents sign on for such meddling if they harbored ambitions for a child capable of a glorious military career or just didn't want to give birth to a "sissy"? One problem, however, is that fear or its functional equivalent is one of those ancient properties exhibited by just about every animal. It surely has tremendous survival value. Removing it would be deeply counterevolutionary and would almost certainly generate numerous unintended and undesirable consequences for the individual, let alone thrust humans headlong into a fierce debate about whether enhancing ourselves has gone too far.

Proponents of such artificial enhancements argue that the changes may not be artificial at all. Is there even a valid distinction, they ask, between artificial and "natural" enhancements such as exercise and discipline? Aren't we just trying to gain whatever advantages we can, as we have always tried to do, or are these techniques cheating nature? Can we manage the consequences, or are the risks for the individual and for humanity too great?

These questions are part of an ongoing argument about whether we should use new discoveries in neuroscience and other fields such as genetics to improve ourselves, our descendants and perhaps even the species. If it becomes acceptable to enhance civilians, then it would be hard to explain why national security agencies should be barred from giving war fighters an edge. And if it is not acceptable to enhance civilians, a special case might still be made for tuning up military personnel.

> Is there even a distinction between artificial aids like drugs and "natural" ones like exercise?

National research on enhancement technologies will require the close involvement of advisory bodies with members both in government and outside it, with as much transparency as possible. Whereas some general principles should be articulated and become part of our regulatory framework, much of the hard work will have to be done on a case-by-case basis.

As Dinges notes, the debates are ones we haven't had. Libertarians would argue that government regulation would be overreaching, conservatives would worry about changing human nature, and liberals would worry about inequitable access to whatever advantages neuropharmacology might confer on those who are already relatively well off. All these views deserve to be aired, and the discussion needs to be moved onto our national policy agenda. M

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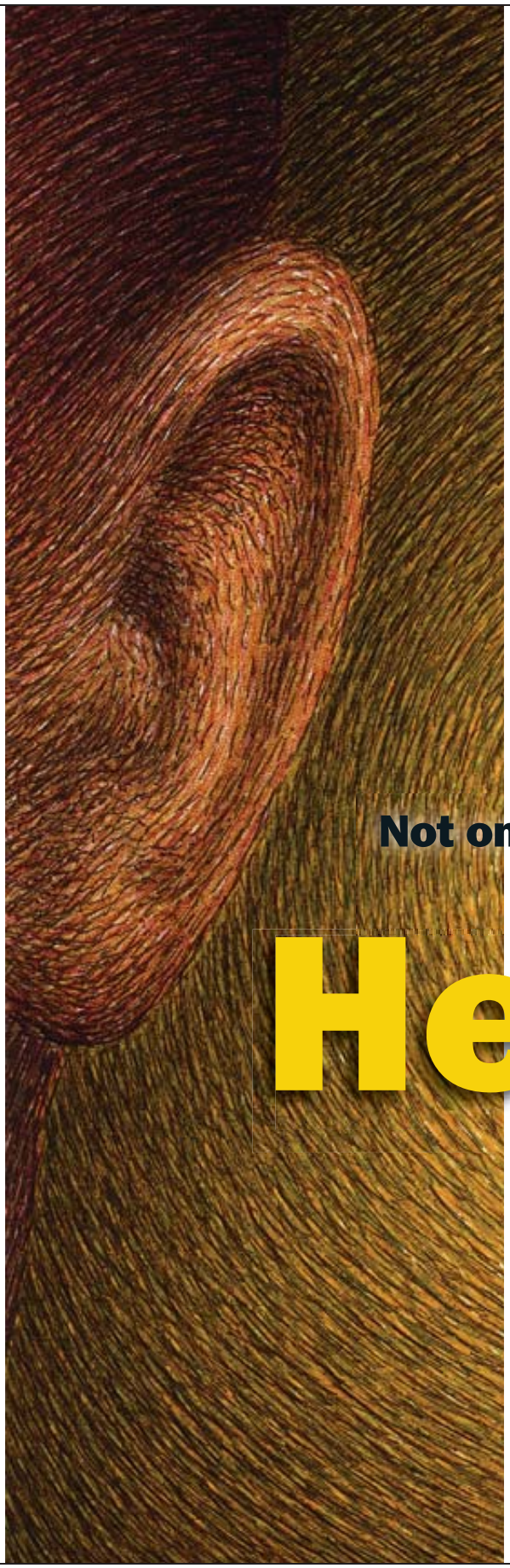


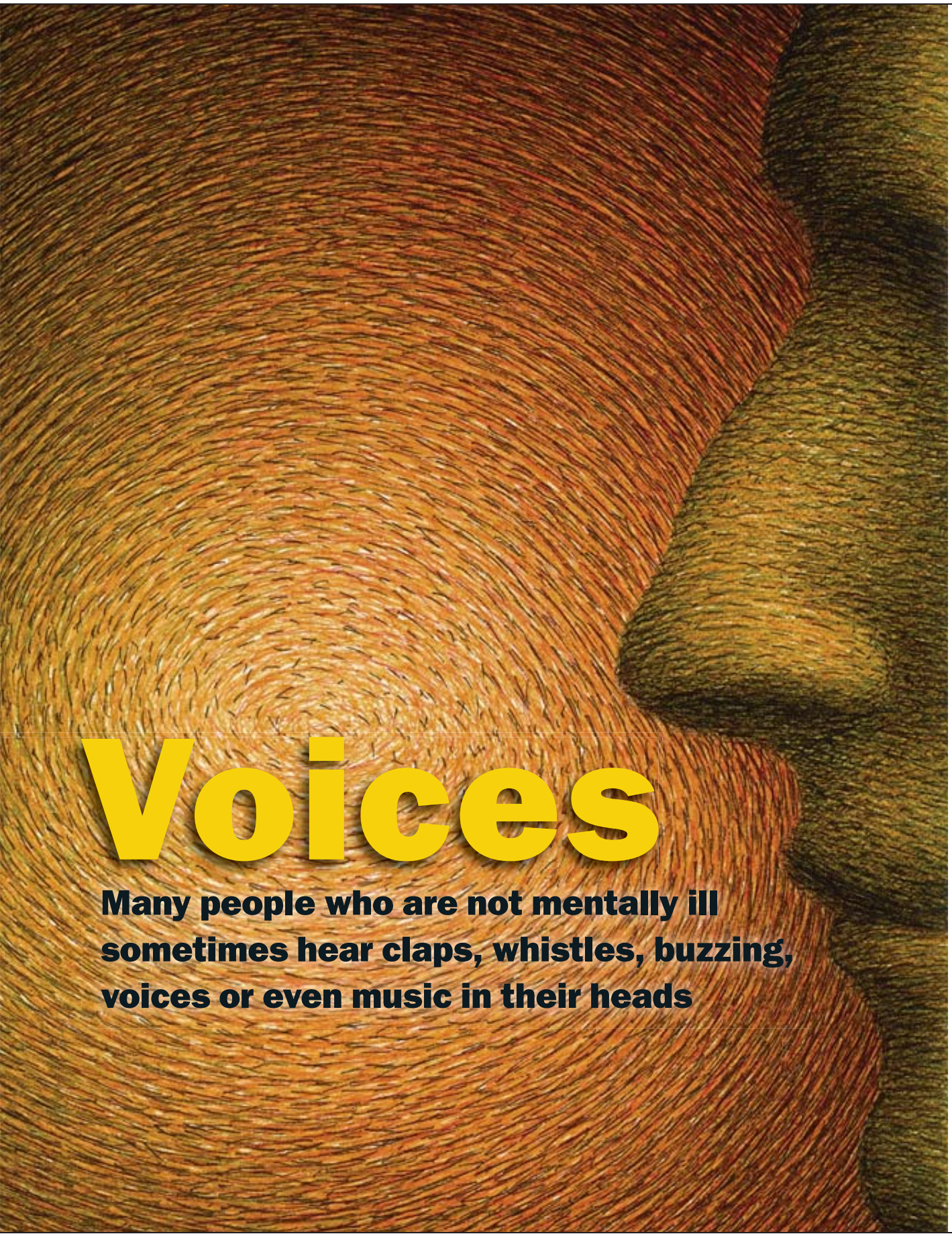
Not only schizophrenics experience auditory hallucinations.

Hearing

By Bettina Thraenhardt

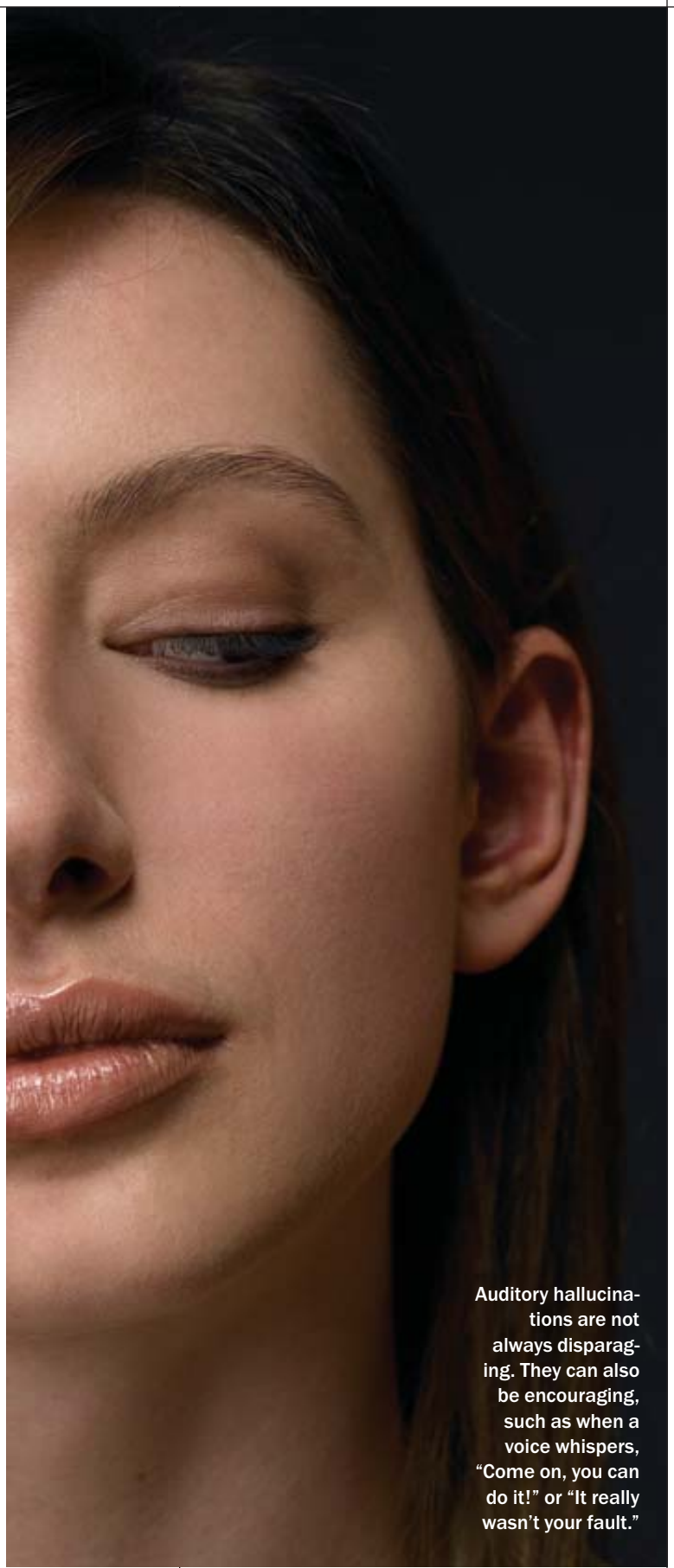
Suddenly she heard someone call her name—"Laurie!"—but no one else was in the room. Feeling irritated, Laurie looked around the apartment. It was empty. Maybe someone was in the hallway? Or at the door? She found no one. Realizing that she was completely alone, Laurie felt chills run up her spine. Was she crazy?

IMAGES.COM *Corbis*



Voices

Many people who are not mentally ill sometimes hear claps, whistles, buzzing, voices or even music in their heads



Auditory hallucinations are not always disparaging. They can also be encouraging, such as when a voice whispers, "Come on, you can do it!" or "It really wasn't your fault."

JONATHAN STOREY *Getty Images*

Perhaps no other symptom is as instantly associated with insanity—some 70 percent of schizophrenics hear voices that regularly interrupt their thoughts, as do 15 percent of those who have mood disorders—but auditory hallucinations are not necessarily a sign of mental illness. They can arise as symptoms in any number of conditions, including Alzheimer's and Parkinson's diseases and temporal lobe epilepsy. In addition, episodes can occur in the absence of any physical or psychological problem.

Although such experiences are heavily stigmatized today, many famous thinkers, poets, artists and scholars of earlier times described hearing voices: a wise demon spoke to Socrates, the saints emboldened Joan of Arc, and an angel addressed Rainer Maria Rilke, inspiring his *Duino Elegies*. The list goes on: Carl Gustav Jung, Andy Warhol, Galileo, Pythagoras, William Blake, Winston Churchill, Robert Schumann and Gandhi, among others, have all reportedly heard voices.

Listen Up

In fact, auditory hallucinations may not be uncommon. Because it is difficult to define the phenomenon with true precision, data on its prevalence differ from study to study. As early as 1983, though, psychologists Thomas B. Posey and Mary E. Losch, then both at Murray State University in Kentucky, found that roughly 70 percent of the 375 college students they questioned admitted to having heard voices at least once. Subjects thought that they had heard deceased relatives, divine beings or their own thoughts. Still others had heard their names, often before falling asleep. Acoustic perceptions during waking or presleep phases—reported by 40 percent of Posey and Losch's subjects—are generally viewed as pseudohallucinations. Thus, by including them in their tallies, these researchers may have produced a high estimate.

Nevertheless, in 1991 a National Institute of Mental Health survey found that nearly 5 percent of the 15,000 American adults who responded had experienced hallucinations—most of them auditory—during a one-year period; only one third of that group also met criteria for a psychiatric diagnosis. According to Thomas Bock, a psychotherapist and director of the outpatient psychosis service at the University Medical Center of Hamburg-Eppendorf, Germany, at least 3 to 5 percent of the population in western Europe and the U.S. hear voices. Schizophrenia, in comparison, affects only about one in 100.

Too Much and Too Little

How do these perceptions come about in the absence of external stimuli? As Bock explains, acoustic hallucinations may arise from "too much inside" or "too little outside." On one side of this theoretical coin, Bock suggests that, psychologically, some affected people may hold too much on the inside. Sufferers have often experienced some kind of trauma as a child or adult, such as neglect, abuse, rape or a severe accident. Many then suffer from unresolved conflicts or find themselves in situations that overwhelm them. In these cases, verbal hallucinations may serve as signals that they need to pay attention to their own inner voice.

From a neurobiological perspective, the notion of "too much inside" makes sense in that some sufferers appear to interpret their own thoughts as alien. Some researchers therefore suspect that the hallucinations involve a failure in a specific feedback circuit in the brain, which normally tells us that "I" am now thinking or speaking, not someone else. This hypothesis—that self-generated speech gets misattributed—seems to apply especially well to hallucinating schizophrenics, about whom researchers have the most information.

Philip K. McGuire and his colleague Louise C. Johns of the Institute of Psychiatry at King's College London tested the model by having several schizophrenic patients, as well as people with no psychiatric history, speak into a microphone. At the same time, the test subjects listened to their voices, distorted by the researchers, through headphones. The participants were asked to press a button if they thought they were listening to themselves. In general, the schizophrenics had greater difficulties identifying their own voices. Those who had active hallucinations most often attributed their speech to an external source, particularly when what they said into the microphone was disparaging or contemptuous.

Studies using brain-imaging techniques have also elucidated the physiological mechanisms that underlie verbal hallucinations. In 1993 McGuire and his colleagues scanned the brains of 12 schizophrenics while they were hearing voices and while they were not. They found that during the hallucinations the greatest increase in brain activity took place in Broca's area, a region involved not in hearing speech but in producing it. Other speech-processing areas of the brain, including the superior temporal gyrus in the left temporal lobe, are under close scrutiny. This gyrus, or bump, is responsible for speech perception and plays a crucial role in the integration of acoustic and speech information. Various researchers, among them Thomas Dierks of the University of Bern in Switzerland, have demonstrated that it also plays a key role in verbal hallucinations.

In 1999 Dierks, who was then at the University of Frankfurt, and his co-workers used functional magnetic resonance imaging (fMRI) to observe the brains of three schizophrenic patients while they were hearing voices. In addition to the superior temporal gyrus, they found activity in the primary auditory cortex, which normally processes sounds from the outside world. No wonder these patients believed their hallucinations were real: their brains responded to them much as they did to actual speech. Several other studies have produced intriguing findings, among them that the left superior temporal gyrus seems consistently smaller in patients with severe acoustic hallucinations. Exactly what this size difference signifies is still the subject of speculation.

On the flip side of Bock's theoretical coin, hearing voices is not always a consequence of neurobiological change. Sometimes the brain simply receives too few stimuli from the outside world. People who hear voices often live extremely withdrawn lives—and the hallucinations, in turn, fuel social rejection. Some sailors and hikers, for example, who have endured stimulus-poor conditions for prolonged periods have reported auditory hallucinations. Indeed, Rilke's angel spoke only after he had lived for two months in isolation at Duino Castle. Deafness, too, can present a kind of isolation. In 1992 Detlef Koempf, a neurologist at the University Medical Center of Schleswig-Holstein, Germany, discovered that musical hallucinations are not uncommon in older people

> Voices sometimes arise after trauma—rape, a severe accident, the loss of a loved one.

(The Author)

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Some sailors and hikers who have endured isolation for prolonged periods report hearing voices.

who have lost some hearing. He hypothesizes that the brain stores auditory information that it has captured over an extended period. If the external output is cut off, the deposited signals may take on a life of their own.

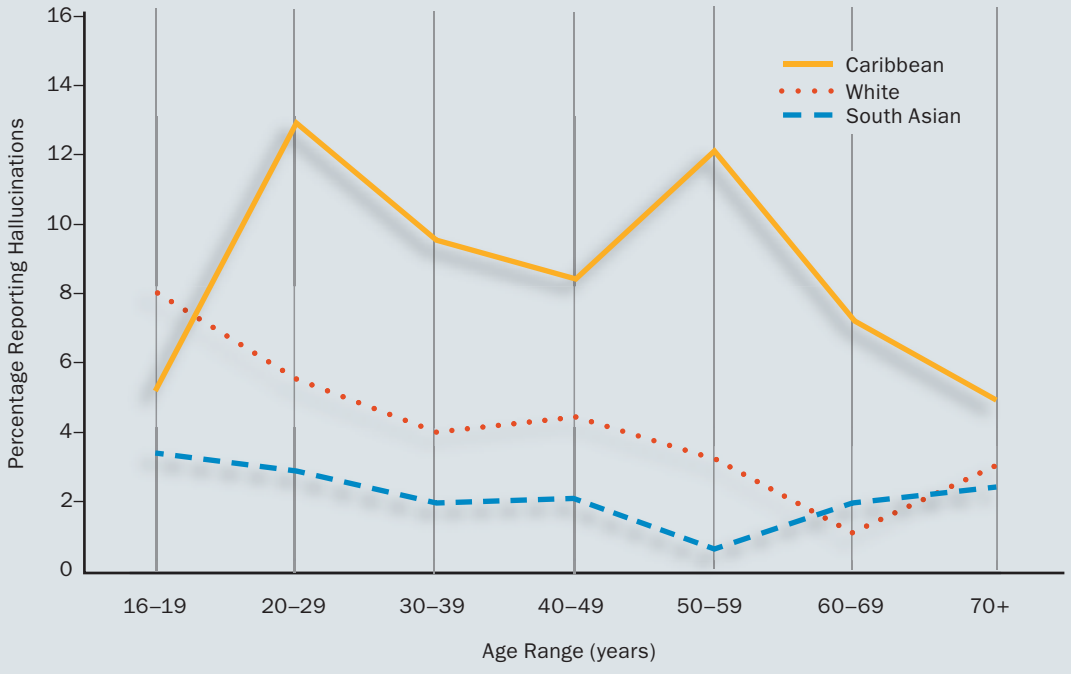
Whether hearing voices presents a medical problem depends largely on how much a person suffers. A Dutch team headed by Marius Romme, then at the University of Maastricht in the Netherlands, found significant differences in the types of auditory hallucinations experienced by schizophrenics and people who were psychiatrically normal. Both groups reported dialogues, running commentary or the vocalization of their own thoughts. The mentally ill, however, far more frequently described negative voices: "You stupid idiot!" or "As usual, you revealed our family secrets!" The other study participants usually heard benign voices that encouraged them: "Come on, you can do it!" or "It really wasn't your fault." In addition, they were more likely to feel that they were in control of the voices.

Hushed Voices

For those who do suffer from their inner voices, researchers are trying to find ways of hushing them. Antipsychotic medications work for some but not all patients. As an alternative, Ralph E. Hoffman and his co-workers at the Yale University School of Medicine have investigated the po-

Cultural Differences

The occurrence of hallucinations varies with age and race, according to a survey of the public in England and Wales. Louise C. Johns of the Institute of Psychiatry at King's College London and her colleagues reviewed data from 2,867 whites and 5,196 members of minority ethnic groups. Hallucinations were most common among teens in the white sample but among those in their 20s and 50s in the Caribbean group. In the South Asian sample, prevalence varied only very little by age. Overall, 4 percent of whites reported hearing or seeing things. In comparison, rates were 2.5 times higher among Caribbeans and half as much among South Asians. —*B.T.*



SOURCE: "OCCURRENCE OF HALLUCINATORY EXPERIENCES IN A COMMUNITY SAMPLE AND ETHNIC VARIATIONS," BY L. C. JOHNS, J. Y. NAZROO, P. BEBBINGTON AND E. KUIPERS IN *BRITISH JOURNAL OF PSYCHIATRY*, VOL. 180; 2002

tential of transcranial magnetic stimulation (TMS), a technique by which they can decrease brain activity in certain regions using magnetic fields. They have applied TMS to the regions involved in speech processing. In 2000 they suppressed acoustic hallucinations in 12 schizophrenic patients by decreasing the arousability of the temporoparietal cortex. In a follow-up study in 2005 they treated 50 patients for nine days with low-frequency impulses and found that verbal hallucinations decreased markedly in more than half the patients—an effect that lasted for at least three months.

Limited Talk Time

Fortunately, it is not always necessary to eliminate the voices completely to decrease the discomfort they cause. Most people who experience acoustic hallucinations attribute a purpose to their voices. How they view their voices—well-meaning or out to destroy them—is almost always a function of what they hear. In 2003 Mark van der Gaag, now at the Free University Amsterdam in the Netherlands, found that only two of 43 patients evaluated their hallucinations differently from what researchers expected. Some patients are convinced that critical voices are actually well-meaning. "As therapists, we need to pay more attention to how a person explains the phenomenon," Bock concludes. Therapists who immediately talk in terms of severe mental illness often only make the problem worse, risking that the patient will withdraw. The sooner a patient begins to talk about the voices, the less power those voices tend to have.

Frequently, it is enough to reframe the voices. Even if they are overwhelmingly negative, other intentions or characteristics may be attributed to them through therapy. According to guidelines developed by Netzwerk Stimmenhoeren, a German organization dedicated to founding self-help groups and supporting the affected, their families and the psychiatric community, the main goal is to make sufferers "masters in their own house" again. Patients can sometimes regain this control not only by listening to the voices but by answering them, concentrating on positive messages and agreeing to specific, limited talking times.

Another mainstay of treatment involves changing a patient's social interactions. Often a person's relationship with his or her voices mirrors those with real people, as Mark Hayward, now at the University of Surrey in England, demonstrated in 2003. If, for example, a person usually subordinates herself to someone else, she will tend to hear dominant voices. The net effect is that the hallucinations become increasingly real. Networks of fellow sufferers may help people reduce the isolation they feel and make strides in recovery. "I got to the point where I couldn't take it anymore," Laurie says, explaining why she dared to "come out." Laurie agreed to make time for her voices in the morning, and, in exchange, they agreed to leave her alone the rest of the day. The approach may seem odd, but it worked. Now, she says, "My voices simply don't scare me anymore." M

ROY McMAHON AND WIEGER POUTSMA *Corbis*

Quiet! Some voices torment sufferers with constant insults. People who hear voices often live extremely withdrawn lives—and the hallucinations, in turn, fuel social rejection.

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Taking a Closer Look

Can moving your eyes back and forth help to ease anxiety?

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

COURTESY OF SCOTT O. LILIENFELD (*top*); COURTESY OF HAL ARKOWITZ (*bottom*); DAVE NAGEL *Getty Images* (*eyes*)

MORE THAN 500 brands of psychotherapy exist, with new ones springing up on a nearly monthly basis. Although a handful of these neophyte treatments have been tested in scientific studies, it is anybody's guess whether the others actually work.

Over the past 15 years or so, one of these new kids on the therapy block has stood out from the pack for the remarkable attention it has received from the media, practitioners and mental health consumers. This treatment carries a mouthful of a label: "eye movement desensitization and reprocessing," and it has made an impressive splash on the psychotherapy scene. Not surprisingly, most therapists refer to it simply as "EMDR," and we'll do the same here.

Like some other psychotherapies, EMDR was the brainchild of serendipity. One day in 1987 Francine Shapiro, a California psychologist in private practice, went for a walk in the woods. She had been preoccupied with a host of disturbing thoughts. Yet she discovered that her anxiety lifted after moving her eyes back and forth while observing her surroundings. Intrigued, Shapiro tried out variants of this procedure with her clients and found that they, too, felt better. EMDR was born.

After an initial published study in 1989, EMDR became the focus of dozens of investigations and scores of presentations at professional conferences. Shapiro initially developed EMDR to help clients overcome the anxiety associated with post-traumatic stress disorder (PTSD) and other anxiety disorders, such as phobias. Nevertheless, therapists have since extended this treatment to a host of other conditions, including depression, sexual dysfunction, schizophrenia, eating disorders, and even the psychological stress generated by cancer.

EMDR therapists ask their clients to hold the memories of anxiety-provoking stimuli, for example, the painful memories of a frightening accident, in their minds. While doing so, clients track the therapist's back-and-forth finger movements with their eyes, much like a person in an old Hollywood movie following a hypnotist's swinging pocket watch. EMDR proponents have invoked a dizzying array of explanations for the apparent effectiveness of the lateral eye movements: distraction, relaxation, synchronization of the brain's two hemispheres, and simulation of the eye movements of rapid eye movement (REM) sleep have all emerged as candidates. In conjunction with their therapists,

(Eye movement desensitization and reprocessing has made an **impressive splash** on the psychotherapy scene.)

EMDR clients also learn to replace negative thoughts (such as "I'll never get this job") with more positive thoughts (such as "I can get this job if I try hard enough").

Few psychological treatments have been as widely heralded as EMDR. Some EMDR proponents have called it a "miracle cure" and "paradigm shift," and ABC's *20/20* proclaimed it an "exciting breakthrough" in the treatment of anxiety. More than 60,000 clinicians have undergone formal training in EMDR, and the EMDR International Association (EMDRIA), a group of mental health professionals dedicated to promoting the technique, boasts over 4,000 members. The organization estimates that this procedure has been administered to approximately two million clients. Moreover, in some American cities, psychotherapists proudly list their certifications in EMDR on their Yellow Page advertisements. But does it work?

The Evidence

The answer is not entirely straightforward. As with all psychotherapies, one can look at the question of whether EMDR "works" in several different ways. Here we will address three important variants of this question:

Does EMDR work better than doing nothing? **Yes**. Numerous controlled studies show that EMDR produces more improvement than absence of treatment, at least for alleviating the symptoms of civilian PTSD, such as those triggered by rape. The evidence regarding EMDR's efficacy for other anxiety disorders is promising but preliminary. EMDR's effects are most marked on self-reported measures of anxiety; its impact on physiological measures linked to anxiety (such as heart rate) is less clear-cut.

Does EMDR work better than supportive listening? **Probably**. Although the research evidence on this front is less extensive, most studies indicate that EMDR produces more improvement than control conditions in which therapists merely listen attentively to a client's problems but do not attempt to intervene directly. (Studies generally show, however, that such supportive listening conditions produce positive effects in their own right.) So the therapeutic effects of EMDR probably cannot be attributed entirely to the beneficial consequences of interacting with a warm and empathic therapist. Something more seems to be going on.

Does EMDR work better than standard behavioral and cognitive-behavioral therapies? **No**. Most behavioral and cognitive-behavioral therapies for anxiety rely on a core principle of change: exposure. That is, these treatments work by exposing clients repeatedly to anxiety-provoking stimuli, either in their imagination ("imaginal exposure") or in real life ("in vivo exposure"). When exposure to either type is sufficiently prolonged, clients' anxiety dissipates within and across sessions, generating improvement.

When scientists have compared EMDR with imaginal exposure, they have found few or no differences. Nor have they found that EMDR works any more rapidly than imaginal exposure. Most researchers have taken these findings to mean that EMDR's results derive from the exposure, because this treatment requires clients to visualize traumatic imagery repeatedly.

Last, researchers have found scant evidence that the eye movements of EMDR are contributing anything to its effectiveness. When investigators have compared EMDR with a "fixed eye movement condition"—one in which clients keep their eyes fixed straight ahead—they have found no differences between conditions. So the panoply of hypotheses invoked for EMDR's eye movements appears to be "explanations in search of a phenomenon."

So, now to the bottom line: EMDR ameliorates symptoms of traumatic anxiety better than doing nothing and probably better than talking to a supportive listener. Yet not a shred of good evidence exists that EMDR is superior to exposure-based treatments that behavioral and cognitive-behavioral therapists have been administering routinely for decades. Paraphrasing British writer and critic Samuel Johnson, Harvard University psychologist Richard McNally nicely summed up the case for EMDR: "What is effective in EMDR is not new, and what is new is not effective." M

> Proponents have invoked a **dizzying array** of explanations for the apparent effectiveness of the lateral eye movements.

SCOTT O. LILIENFELD and HAL ARKOWITZ share an interest in helping the general public to distinguish myth from reality in the field of mental health. Arkowitz is a psychology professor at the University of Arizona, and Lilienfeld is a psychology professor at Emory University. They welcome reader suggestions for column topics: editors@sciammind.com

(Further Reading)

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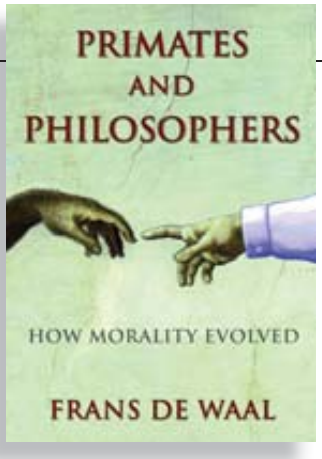
- **Eye Movement Desensitization and Reprocessing (EMDR): A Meta-Analysis.** P. R. Davidson and K.C.H. Parker in *Journal of Consulting and Clinical Psychology,* Vol. 69, pages 305–316; 2001.
- **Eye Movement Desensitization and Reprocessing: A Chronology of Its Development and Scientific Standing.** G. J. Devilly in *Scientific Review of Mental Health Practice,* Vol. 1, pages 113–138; 2002.

Descartes vs. Darwin

Primates and Philosophers: How Morality Evolved

by Frans de Waal. Edited by Stephen Macedo and Josiah Ober. Princeton University Press, 2006 ($22.95)



Frans de Waal believes that humans are, by nature, good and social. A primatologist who has devoted his life to studying chimpanzee behavior, de Waal says we have evolution to thank for our moral behavior, the essential antecedents of which can be found among lower animals.

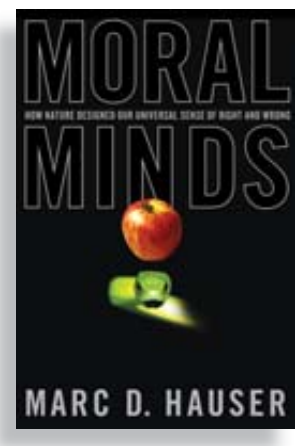
Primates and Philosophers contains the text of lectures de Waal delivered in 2004, together with responses from four philosophers who agree with some of his ideas and reject others. De Waal is reacting to the idea of selfishness, in both evolutionary and philosophical thought. Although we may have "selfish genes," he believes we have evolved as social creatures to care and share. And although Western philosophy emphasizes individual autonomy and rationality, he stresses social bonds and our emotions—and he sees evidence for both in other animals. Mice will forgo food if pushing a lever to get it also delivers a painful shock to another mouse; the same reaction is stronger and longer-lasting for monkeys and even more so for apes. In fact, de Waal says, "the building blocks of morality are evolutionarily ancient," and a clear continuum links animal and human moral behavior.

The book is fascinating, as well as challenging. Its contributors struggle with the very language used to discuss moral behavior in animals—sympathy, feelings, and so on—because these terms are unavoidably so human. The contributors also assume readers will have some familiarity with the ideas espoused by David Hume, Thomas Hobbes, Adam Smith and other philosophers who have written on the origins of human morality.

One of the crucial concepts discussed is psychological altruism: the idea that we can adjust our desires and intentions according to what we perceive to be needs of others. Philip Kitcher, a Columbia University philosopher, does not believe that de Waal's examples from observing chimpanzees fully demonstrate psychological altruism in these apes, and he observes that "a lot more work needs to be done." Much of the argument in *Primates and Philosophers* revolves around the crucial line dividing human from animal moral capacities. De Waal emphasizes what we share with animals; the others pick out the differences, especially when it comes to our motives and intentions—things that experiments are unlikely to divine from a chimpanzee brain.

—Jonathan Beard

Mind Reads



Dangers on a Train

Moral Minds: How Nature Designed Our Universal Sense of Right and Wrong

by Marc D. Hauser. HarperCollins, 2006 ($27.95)

You are driving a train when you see five hikers on the track ahead of you and a siding with a single hiker. Is it okay to flip a switch and send the train onto the siding, killing one hiker but saving five? Most people say yes.

Would it be okay for a doctor to harvest organs from a healthy person to save five patients? Most people say no.

But they often do not have a clue why they think one of these choices is okay and the other is not. And that fact is a clue that we have an innate moral faculty. Like competent speakers who do not understand the grammatical underpinnings of language, people tend to have strong, gut-level opinions about what is moral but are unable to give coherent explanations.

Marc D. Hauser, a Harvard University psychologist, wants to do for morality what Massachusetts Institute of Technology linguist Noam Chomsky did for language—he wants to discover the universal "moral grammar."

Chomsky suggested that humans are born with a "universal grammar," a cognitive capacity that helps us acquire language and shapes the way we apply language rules. Hauser thinks our moral grammar works the same way, helping us isolate moral lessons from our culture and make judgments about right and wrong.

In *Moral Minds,* Hauser reviews what we already know about innate human faculties—for instance, that even infants seem to understand that people and animals have intentions, whereas inanimate objects do not. And he presents evidence that our universal morality is probably based on rules about fairness, proportionality and reciprocity, among other things.

The material is captivating and ranges from philosophy to anthropology to psychology, including some of Hauser's own original work. Hauser's main failing is that he sometimes loses the thread of his argument; he piles on the detail but fails to make it clear how his examples support his argument.

The upshot, though, is that we do not yet know exactly how our moral grammar works or even which cognitive capacities contribute to our moral faculty. Hauser's achievement is to argue convincingly that such a faculty exists and to raise some of the many questions that have to be answered before we will fully understand it.

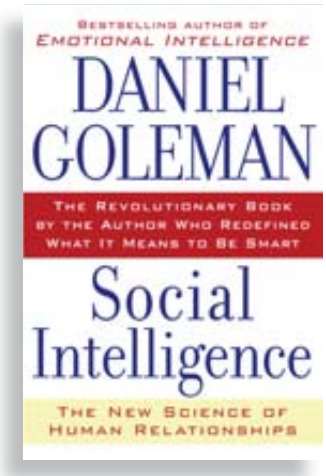
—Kurt Kleiner

I'm OK, We're OK

Social Intelligence: The New Science of Human Relationships

by Daniel Goleman. Bantam Books, 2006 ($28)

We all recognize a special capacity that humans have—some more so than others—to connect with others in a deep and direct way. We see this quality expressed by a performer revving a crowd, a doctor healing a patient or a mother putting a child to sleep. To orchestrate these tasks, a person must sense and stimulate the reactions and mood of another.



In 1995 Daniel Goleman, a Harvard University–trained psychologist and writer for the *New York Times,* published *Emotional Intelligence,* in which he discussed the human ability "to manage our own emotions and inner potential for positive relationships." Now he goes a step further. In *Social Intelligence,* he enlarges his scope to encompass our human abilities to connect with one another.

"We are wired to connect," Goleman says. "Neuroscience has discovered that our brain's very design makes it *sociable,* inexorably drawn into an intimate brain-to-brain linkup whenever we engage with another person. That neural bridge lets us affect the brain—and so the body—of everyone we interact with, just as they do us." Each encounter between people primes the emotions. This neurological pas de deux stimulates our nervous systems, affecting hormones, heart rate, circulation, breathing and the immune system.

Goleman peppers his discourse with anecdotes to illustrate the power of social intelligence. From the countertop of Rosie Garcia, a multitasking baker in New York's Grand Central Terminal, to the tantrum-tainted class of a Texas teacher, he shows how social sensitivity and wisdom can profoundly reshape conflicts. In one encounter in Iraq, a quick-witted U.S. commander turned a Muslim mob's threats into laughter when he ordered his soldiers to kneel, lower rifles and smile—averting a potentially fatal clash.

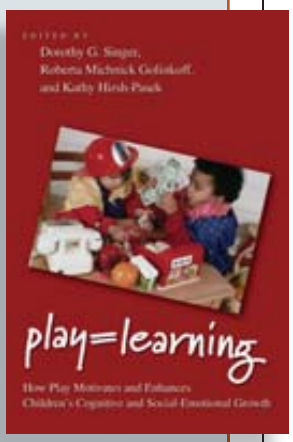
Goleman deftly discusses relevant neural pathways, including the thalamus and amygdala, which together regulate sensory and arousal stimuli. He speaks of spindle cells, which rapidly process social decisions; of mirror neurons, which sense another's movements; of dopamine neurons, which react to pleasure-inducing neurotransmitters that flow freely while two lovers gaze.

The author's introductory tour through this emerging research landscape helps readers grasp core concepts of social neuroscience, illustrating abstractions with poignant anecdotes, without excessive jargon. Goleman also explains how such research may influence our lives. Given our socially reactive brains, we must "be wise," he says, and be aware of the ways that our moods influence the biology of each life we touch. *—Rick Lipkin*

Reading, Writing and Recess

Play = Learning: How Play Motivates and Enhances Children's Cognitive and Social-Emotional Growth

edited by Dorothy G. Singer, Roberta Michnick Golinkoff and Kathy Hirsh-Pasek. Oxford University Press, 2006 ($45)



Play is under attack, argue the child development and learning experts behind this informative anthology. It is a victim of today's trend to focus on a narrow set of cognitive skills, a downed bystander of the Bush administration's No Child Left Behind Act. What has been neglected in this rush to reinvent education, these authors say, is the huge body of research buttressing the relation between types of play, a wide range of learning and school preparedness.

Editors Dorothy G. Singer, Roberta Michnick Golinkoff and Kathy Hirsh-Pasek lament a regression to 19th-century learning approaches, like memorization, in an era with "an emerging creative class that values conceptual knowledge and original thinking." Children must know facts, but it is ironic that teachers now emphasize rote learning at a time when information constantly changes. "The power of knowledge," they write, "comes from *weaving* those facts together in new and imaginative ways."

The power of this volume is its descriptions of the varieties of play—make-believe, storytelling and story-acting, mathematical—and of more than 40 years of research linking play to increased attention spans, creativity, constructive peer interaction and mental health, to list only a few benefits. The authors present surprising and often dismaying reports about recent actions that ignore the literature. We learn of an unprecedented rise in expulsions from prekindergarten classes, perhaps arising from children's frustration as they are taught skills once thought appropriate for youngsters several years older. Academic tutoring for test score gains has lasting negative consequences, according to one author, including poorer study habits and lower achievement.

The anthology grew out of a 2005 conference at Yale University funded by Fisher-Price, and editors and authors of the book have consulted for Fisher-Price and other toy manufacturers over the years. So it comes as no surprise that the book spends a little time examining what is known about the educational value of toys and videos. In a chapter on media, play, infants and toddlers, Fisher-Price manager of child research Deborah S. Weber cites studies of young children whose parents sing along and clap during, and talk to them about, age-appropriate television shows and videos. Teachers found that children who watch TV supported by this adult "scaffolding" were more ready to learn than children left to watch alone.

Though well written, the chapters of *Play = Learning* demand great concentration and challenge the educated lay reader. But it is hard to fault the authors for their thoroughness. They are serious about play and offer convincing evidence that rather than being a distraction from learning, play *is* the thing. *—Karen A. Frenkel*

askthe**Brains**

Why is the brain wired up the way it is—why does the right cortex control the left side of the body, and vice versa?
—Peter Wilson, London

Mark A. W. Andrews, professor of physiology and director of the Independent Study program at the Lake Erie College of Osteopathic Medicine, provides this explanation:

FROM ANCIENT TIMES, many have asked your question. Greek physician Hippocrates, for example, wondered why trauma on one side of the head caused deficits on the opposite side of the body. Around 100 years ago Spanish neuroanatomist and Nobel laureate Santiago Ramón y Cajal first explained this phenomenon in terms of development of the visual system. Although we now know that animals with rudimentary or no visual systems also show "crossover" neural connections, Ramón y Cajal's explanation did identify important concepts and the stimulus-response arena.

Crossover, or decussation, of neurons within the central nervous system is still not fully understood today. Such a phenomenon arises during embryological development. Recent discoveries indicate that neurons, or nerve cells, get their direction from growth factors with names such as roundabout, commissureless, Sax-3, netrin and sonic hedgehog. And, yes, many animals, including fish, worms, fruit flies and all vertebrates exhibit this decussation of nerve tracts. Where does crossover come from? Scientists are looking for the answers in many places.

Tips from simpler animals. Understanding this structural property of the nervous system can begin with clues from evolutionarily ancient creatures. For example, let us consider the response of a worm to a noxious stimulus. The worm bends away, in the opposite direction of the stimulus, by contracting muscle cells on its opposite, or contralateral, side. To activate those contralateral muscle cells, the neuron signals arising from the ipsilateral (near, or facing) side must cross over.

Thus, decussation across the midline of the body gives an animal a survival advantage. As biologists have learned, once such an appropriate survival mechanism develops, it is maintained through "higher" animals (those that arose later in evolutionary history) unless it somehow becomes disadvantageous.

Perception clues. As visual sensory systems evolved, their neurons also developed crossover communication pathways. In most vertebrates, because of the head structure, the eyes are independent and see separate visual fields. That is, the visual inputs from their left and right eyes are completely different, and the brain stitches the views together into a coherent scene. The entire optic nerve crosses the midline to help an animal survive if it sees a danger.

Think of a fish swimming along. Now imagine that a predator suddenly appears near the fish's right side. Light reflected from the predator enters the eye, forming an image on the retina. That image then crosses over via the optic nerve, and the nervous system reacts: muscles on the contralateral side shorten. This effect makes the fish move in a direction opposite that of the stimulus (the sight of a predator).

The situation gets more complex in animals with front-directed eyes and stereoscopic vision, such as humans. The architecture of crossed nerve pathways still exists. But in such cases, only half the nerve impulses from each eye are sent across the midline to help in stereoscopic vision.

Two-sided response. Let us consider what happens in an animal that has limbs. In legless animals such as fish and worms, the impulses sent out by the motor nerves to control muscles do not have to cross the midline. Only the sensory signal crosses, causing muscle activity on the side it crossed to—thus no need to recross. When limbs are present, however, not only does the contralateral side respond, but the ipsilateral side can also respond. To allow this flexibility, motor nerves cross over back to the original side of the stimulus. In other words, with development of limbs, motor nerves as well as sensory nerves decussate. Thus, your brain's left hemisphere primarily controls your right arm and leg, and the right side handles your left arm and leg.

Scientists have also hypothesized that crossed nerve tracts, with their inherent structural asymmetry, might be the result of differential development of the two sides of the brain. The functional asymmetry of the two sides of the brain could help explain the left hemisphere's emphasis on communication, analytical thought and directing movement and the right hemisphere's specialization in dealing with sensory information, spatial relations and creativity. M

Having nerve cell tracts that cross over the midline of the body gives an animal a survival advantage.

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

COURTESY OF MARK A. W. ANDREWS

Head Games

Match wits with the Mensa puzzler

BY ABBIE F. SALNY

1 Make your way from LEND to GIVE in five steps, changing one letter at a time to form an interim word.

LEND

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

GIVE

2 Figure out the value of each letter and replace the question mark with the correct number.

A	C	T	O	N	15
A	C	O	A	N	17
A	C	O	T	N	15
A	C	O	T	O	16
C	T	O	N	T	?
24	19	11	14	8	

3 Fill in the missing number.

March 16 = 38

May 11 = 32

August 5 = 26

September 3 = 24

December 12 = ?

4 Unscramble the 21 letters below to form a four-word idiomatic phrase used by individuals to prove that wealth is no insurance against discontent.

A A B C E E H I M N N N O P P S S T U Y Y

5 A palindrome is a word, phrase or sentence that reads the same backward as forward. This palindrome tells how a mother gave Edna some meat.

M _ _ _ _ _ _ _ _ _ _ _ _ _ M

6 The names of four people are concealed in the lines below. Can you find them?

Although I attempted to be fair, I did issue an order against the length of the sentence.

7 A couplet from a well-known nursery rhyme has been put into very fancy language below. Can you put it back into everyday English?

The rotund gentleman with a rhyming name positioned himself on a perpendicular structure used as a barrier or support from which he was precipitated with severe force.

8 The same five letters can be rearranged to fill in the blanks below.

Every investment manager _ _ _ _ _ that the company's program will help this particular _ _ _ _ _ .

9 Find the word that fills in the blank to make two new words on each line (a different word for each line).

re _ _ _ _ stream

car _ _ _ ace

10 What song do the following stacked words represent?

My house

STOVE

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. Lend, land, lane, line, live, give. (There may be other ways.)
2. 13. A = 5, C = 4, T = 3, O = 2, N = 1.
3. 48. Add the number of the month (January is 1) to the date, then double the result.
4. "Money can't buy happiness."
5. Ma handed Edna ham.
6. Al, Ted, Sue and Helen. (Kudos if you found any others!)
7. "Humpty-Dumpty sat on a wall. Humpty-Dumpty had a great fall."
8. Avers, saver.
9. Main, pal.
10. "Home on the Range."

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