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Why We Can't Imagine Death
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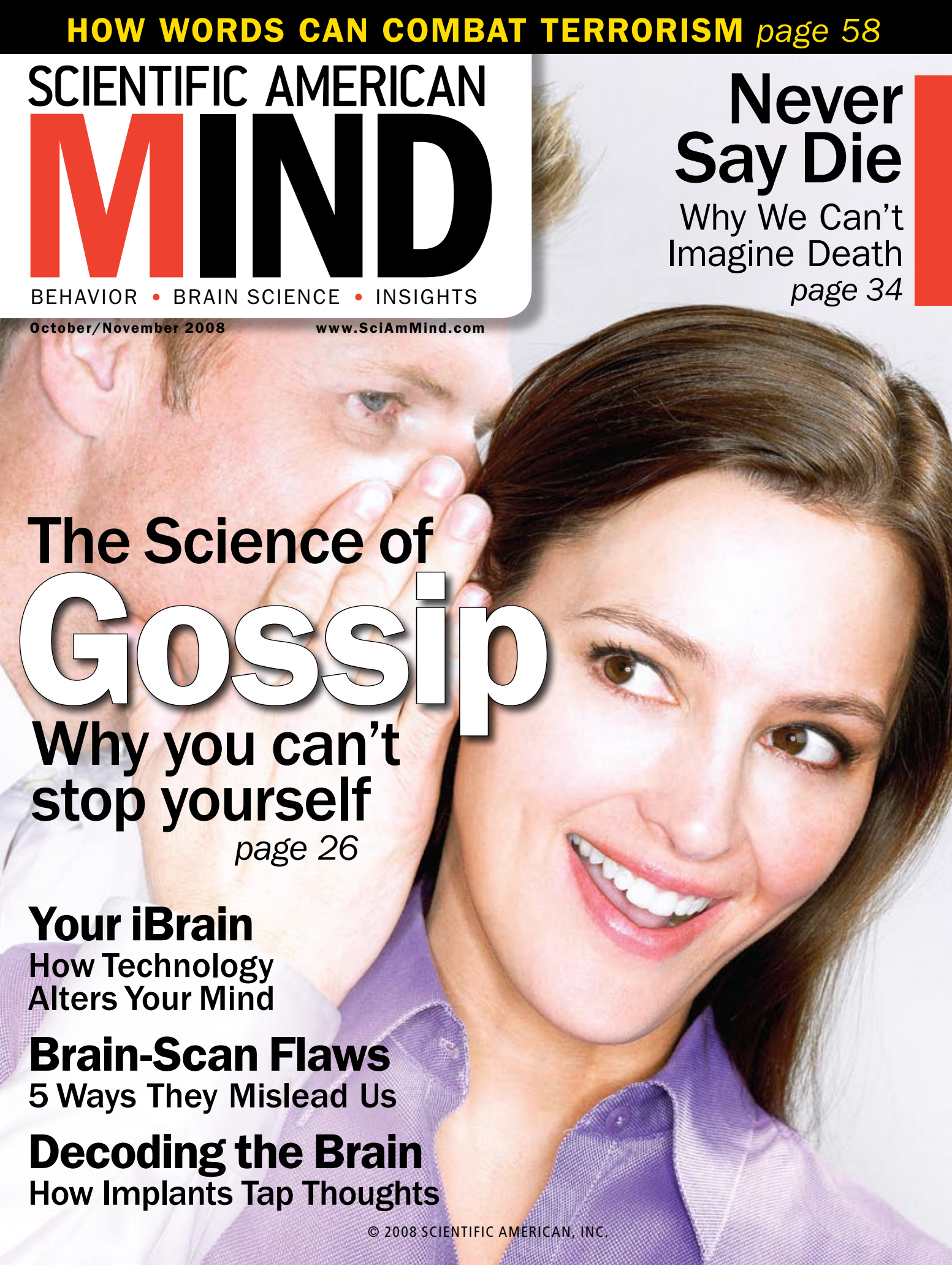

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How Technology Alters Your Mind

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COVER IMAGE BY AARON GOODMAN

Word Power

Psst. Have you heard the latest thing about him? And what she said about it?

Chances are you'd be dying to know about that delectable tidbit of gossip offered by a confidant. We just can't seem to get our fill of such morsels about other people in our social circles.

Science tells us why: gossip is a kind of social grooming that helps our human networks hang together. We share news about friends and relatives, which solidifies our relationships with them. We dish about cheaters or people who wrong someone close to us, which helps to keep potential malefactors in line. We even learn why we are mesmerized by celebrities, whom we mistakenly feel we know intimately because they are in our living rooms on the TV every night. For more, turn to page 26 for psychologist Frank T. McAndrew's cover article, "Can Gossip Be Good?"

As the power of gossip suggests, the words we choose can shape how we individually and collectively consider complex issues. If we speak of the "war" against terrorism, for instance, that implies battlefield solutions. But if we talk about it as a "crime" or a "disease," that suggests approaches that are different—and perhaps ultimately more effective—for combating an intractable nonstate enemy. Each term has benefits and drawbacks, and they may be most effective when used in combination, as experts Arie W. Kruglanski, Martha Crenshaw, Jerrold M. Post and Jeff Victoroff explain in "Talking about Terrorism." The feature starts on page 58.

One of the pleasures of reading *Scientific American Mind* is getting the latest thinking about how our minds work firsthand from the researcher authors themselves. So I'm excited to introduce the newest addition to our regular scientist contributors, neuroscientist Christof Koch. Go to page 18 for his probing column, Consciousness Redux.

Mariette DiChristina
Executive Editor
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ARTISTIC OBJECTION

"Let Your Creativity Soar," the panel discussion led by Mariette DiChristina, was a great article, but I think the experts are a little bit off when they address society's perception of creativity. "Artist" and "creative" are not equivalent. I do not believe Western society has a negative perception of creativity; rather there is a negative perception of financial instability and destructive behavior. It happens that artists and musicians can fall into such states. So although parents may steer their child away from painting or writing as a profession, they probably would encourage their child's creativity in science, computer programming or marketing, all of which can be extremely creative fields.

"rudysplif"
adapted from a comment at
www.SciAmMind.com

COLLABORATION CONFLICT

It is disturbing that psychologist David C. Geary of the University of Missouri–Columbia, quoted in Nicole Branan's "She Never Forgets a Face" [Head Lines], assumes that conflict and competition constitute the evolutionary mechanism that resulted in women's superior recognition of faces. Geary would benefit from reading women's psychology researchers such as Judith Jordan and Jean Baker Miller. Women's social interaction has been shown repeatedly to utilize collaboration over conflict. Face recognition would be a vital tool in that process. I fear "collaboration blindness" by male politicians and business leaders as well as scientists has led us down a narrow path to aggression and, ultimately, violence. I am disappointed that Branan did not include this alternative interpretation.

Mary Ellen Bluntzer
via e-mail

AD HOMINEM ARGUMENTS

I read Yvonne Raley's article "Character Attacks" [Perspectives] with great interest. Thank you for a thoughtfully reasoned and carefully stated presentation.

The ad hominem fallacy sweeps through our social and political lives so pervasively that it is taken for granted, not as a fallacy but as a tool of discrimination. Issues, arguments and positions in economics and politics are so complicated and so easily misrepresented that I fear that those who bother to vote or even to ponder their views on biofuels, power in the Middle East, farm subsidies, the war on drugs, cabbages and kings all too often surrender in desperation to the questions "Who advocates this?" and "Who opposes this?"

Martin Luther King appealed to us to judge people not by the color of their skin but by "the content of their character." And isn't this just what we do when we endorse or contest an idea based on the identity of its advocate? We endorse the content of the character of our chosen advocate and hope for the best. In a way, the representative form of democracy implemented in the U.S. institutionalizes the ad hominem by asking candidates to win our trust and then be allowed to vote on our behalf in the various legislative houses of government.

This is not to say that I applaud this state of affairs. Even if the ad hominem is inescapable, we should apply it knowingly. I took delight in

reading Raley's biographical note at the end of the article: "… she teaches critical reasoning, among other subjects." I have long felt that my high school years would have been better spent with only two subjects: critical reasoning and project management. How to think for yourself and how to get something done. Learn everything else in context of a project, at least before college. Maybe that would not work for everyone, but I cannot think of a more urgently needed skill than critical reasoning in these times. Or any times.

Michael Recknor
Oakland, Calif.

Raley makes two category errors in her article. Attributing poor lawn care to a neighbor's political persuasion is not an ad hominem argument. Rather it is an example of what social psychologists call "attribution theory," in which the same behavior is interpreted differently depending on who is doing it. For example, if I overeat, I am likely to attribute the behavior to tasty food (self-attribution), whereas if I see my overweight neighbor doing the same, I think he has no willpower (other attribution). Moreover, the attributions mentioned by Raley are not personal but sociological in nature and hence not the personal attacks meant by ad hominem—literally "against the person."

The second category error concerns the example of the doctor. Not following our fat doctor's advice to lose weight is what a previous generation of social psychologists working within a persuasive communication paradigm called "the source effect." When given information, we tend to accept or reject the information based on whom we think it is coming from. For example, if we learn that Osama bin Laden says giving charity is an important God-commanded activity, we are much less likely to agree (and give charity) than if we hear the exact same phrase from our local clergy.

Source effects concern the reliability of the provider of the information, not the information itself. They are different from ad hominem attacks in that they concern the impact on the listener, not his rhetorical and illegitimate personal counterattack on the speaker.

Henry Abramovitch
Sackler School of Medicine,
Tel Aviv University

BARROS & BARROS *Getty Images*

Should a person's character matter when we evaluate his or her advice?

RALEY REPLIES: *Abramovitch suggests there are two category mistakes in my essay. The term "category mistake" comes from Gilbert Ryle's 1949 book* The Concept of Mind *(University of Chicago Press). Ryle's famous example is of a person asking, after having been shown the buildings and offices of a university, "But where is the university?" His mistake is to think that the university is the same kind of entity as the buildings and offices of the university.*

Abramovitch thinks that my example of the neighbor's lawn care belongs to the category of attribution theory—a theory concerned with the motivations we attribute to others and how these differ from the motivations we attribute to ourselves. Therefore, he argues, the example is not an ad hominem. Although Abramovitch is right to point to attribution theory as an explanation for the example, this does not preclude its being an ad hominem. Abramovitch offers an explanation for why the speaker said what he did. In contrast, I offer an analysis of the logic of what the speaker said. Abramovitch's analysis is descriptive (it describes what motivates the speaker), whereas mine is normative (it deals with the reasoning errors in the argument). There are explanations for a particular act of speech (the buildings and offices in Ryle's example), but there are also the logical analyses thereof (universities). Neither precludes the other.

Apart from this, Abramovitch construes "ad hominem" too narrowly. Although the Latin ad hominem *is translated as "against the person," the concept of ad hominem is broader than that, as is generally the case with Latin terminology when employed in the sciences. One would be confused if one tried to understand the contemporary usage of* Tyrannosaurus rex *by reading the Latin literally ("tyrant lizard"). No more does every ad hominem have to involve a direct accusation—it just has to unfairly discredit the individual.*

Head Lines

MICHELLE THOMPSON agoodson.com

>> DRUGS

Duped by Doping

Brainpower beats popping pills

Many athletes credit drugs with improving their performance, but some of them may want to thank their brain instead. Mounting evidence suggests that the boost from human growth hormone (HGH), an increasingly popular doping drug, might be caused by the placebo effect.

In a new double-blind trial funded by the World Anti-Doping Agency, in which neither researchers nor participants knew who was receiving HGH and who was taking a placebo, the researchers asked participants to guess whether or not they were on the real drug. Then they examined the results of the group who guessed that they were getting HGH when, in fact, they had received a placebo. That group improved at four fitness tests measuring strength, endurance, power and sprint capacity. The study participants who guessed correctly that they were taking a placebo did not improve, according to preliminary results presented at the Society for Endocrinology meeting in June.

"This finding really shows the power of the mind," said Ken Ho, an endocrinologist at the Garvan Institute in Sydney, Australia, who led the study. "Many athletes are reaping the benefits of the placebo effect, without knowing whether what they're taking is beneficial or not."

And in fact, HGH may not be helpful at all, reveals a recent review published in the *Annals of Internal Medicine.* Endocrinologist Hau Liu of Stanford University and his colleagues looked at 44 studies and found that although HGH did increase athletes' lean body mass, it did not lead to improvements in athletic performance in double-blind trials.

The implications for athletes are serious, according to Ho. Many athletes take a cocktail of supplements, vitamins and drugs, believing that they are enhancing their game. "But it's really the belief in the mind that improves performance" in most cases, Ho says. "Athletes need to be cautious about 'snake oil' merchants."

—Katherine Leitzell

>> ADDICTION

Hooked by Choice

Cocaine changes the brain only after voluntary use

Scientists know that addictive drugs can mess with the brain's circuitry and hijack its reward systems, but a new rat study shows that psychological factors may be more instrumental in causing these changes than a drug's chemical effects are. Cocaine use triggers long-lasting cellular memories in the brain, the study found—but only if the user consumes the drug voluntarily.

Cocaine's chemical effects are not enough to cause dependency.

A team led by Billy Chen and Antonello Bonci, both at the University of California, San Francisco, trained three groups of rats to press levers that delivered cocaine, food or sugar. The researchers injected cocaine into a fourth group. When they examined the rats' brain tissue, they found an increase in synaptic strength within the reward center in those rats that had self-administered sugar, food or cocaine. These cellular memories were short-lived in the sugar and food groups, but in rats that had self-administered cocaine they persisted for up to three months after consumption had stopped. Most interestingly, the brains of rats that had consumed cocaine involuntarily did not show such imprints.

The findings illustrate that the pharmacological effects of cocaine alone are not enough to create reward-associated memories, Bonci says. "Instead the motivation for taking the drug seems to be a key component in the process as well."

The team is working to find ways to remove the long-term cellular memory left by voluntary cocaine use, which eventually could help treat addiction in humans by taking away the desire to actively seek the drug, Chen says.

—Nicole Branan

GEORGE LOGAN *zefa/Corbis (top)*; RICCARDO CASSIANI-INGONI *SPL/Photo Researchers, Inc. (bottom)*

>> TECHNOLOGY

Brain-Scan Mystery Solved

Scientists unmask cells that make functional MRI possible

Since its discovery in the early 1990s, functional MRI has been the basis for more than 19,000 studies of the living, working brain. The technique allows scientists an unprecedented glimpse of the brain regions that are most active during particular tasks or states of mind, but it does not do so directly: the scans measure blood flow, which seems to increase around neurons that are firing. Neurons are not directly connected to blood vessels, however, so until now the mechanism underlying fMRI's robust success has been a mystery.

Now a team from the Massachusetts Institute of Technology reveals that the support cells dubbed astrocytes (because of their star-shaped bodies) form the link between neurons and blood vessels. The neuroscientists used a technique called two-photon microscopy, which harnesses light particles to image very small structures, to observe cells in ferrets' brains. As the animals were shown different animated graphics, neurons responded within milliseconds, and astrocytes became active seconds later—matching the time delay that neuroimagers have long known accompanies blood flow to active brain regions. When the M.I.T. team blocked astrocyte function, the ferrets' neurons fired as usual, but blood flow did not increase.

When researchers use fMRI, co-author Mriganka Sur explains, "we are really measuring astrocyte activation. Thus, anything that influences astrocytes is likely to influence fMRI." This finding could add a layer of complexity to the interpretation of fMRI scans, because astrocytes may be subject to a different set of genetic and environmental influences than neurons are. But the more researchers understand about what is really happening when the brain "lights up" in an fMRI scan, the better they will be able to use the technology to learn about human cognition. [For more on the science of fMRI, see page 66.]

—Nikhil Swaminathan

>> GENETICS

Mapping the Spine, Gene by Gene

A new atlas illuminates the backbone of the nervous system

Spinal cord injuries and disorders afflict millions worldwide, from disabled veterans to people with neurodegenerative disorders such as Lou Gehrig's disease, yet there is currently no way to repair a damaged spine. Geneticists at the Allen Institute for Brain Science in Seattle are hoping to change that by developing the first genetic encyclopedia of the spinal cord.

The Allen Spinal Cord Atlas, which will be available online for free in early 2009, will map out which genes are active in which locations along the spine in mice, which share 90 percent of their genetic material with humans.

Researchers are looking forward to using the new tool, based on the success of the Allen Institute's 2006 Brain Atlas. That genetic map led to key insights, such as the link between glioblastoma, the deadliest type of brain tumor, and a gene called *BEX1*. Gregory Foltz of Swedish Medical Center in Seattle saw that *BEX1* was turned off in the brains of his tumor patients, and using the Brain Atlas, he confirmed that the gene is usually active in healthy brains. Foltz realized that when *BEX1* is inhibited, cells grow uncontrollably and can form tumors—and researchers hope to develop treatments that target the malfunctioning gene.

Experts predict the Spinal Cord Atlas will allow for similar insights into the genes that may be useful for treating spinal cord injuries and disorders. *—Victoria Stern*

>> HEALTH

Serotonin and SIDS

Mice reveal how changes to the regulatory system can be fatal

The leading cause of infant death in developed countries, sudden infant death syndrome, is still largely a medical mystery. Past studies have revealed that in the brain stems of more than half of infants who die from SIDS, the neurons that produce serotonin—a chemical responsible for regulating heart rate, body temperature and mood—are overly prevalent and abnormally shaped. Until now, no one has known how these problems might cause death, but a new study reveals clues about what might be going wrong in SIDS and how doctors might prevent it.

Mood researchers at the European Molecular Biology Laboratory in Monterotondo, Italy, were investigating how serotonin levels affected anxiety-related behavior in mice when they got a surprise. They bred the mice to have too many 5-HT_{1A} receptors, which are known to signal neurons to slow down the release of serotonin when the chemical is abundant in the brain. Having more receptors ultimately lowers serotonin levels and overall serotonin activity.

The team was startled to find that nearly three quarters of the mice died before they turned four months old, typically after suffering sudden drops in heart rate and body temperature so drastic that the complications killed the animals. Although the researchers do not yet know what prompts these crises, co-author Cornelius Gross speculates that they occur when serotonin activity cannot ramp up properly. For instance, serotonin systems are turned off during rapid-eye-movement (REM) sleep, so waking is typically accompanied by a rapid increase in serotonin activity. In the mice, Gross explains, the compromised 5-HT_{1A} feedback loop may prevent serotonin neurons from firing when they should, disrupting nervous system function.

If Gross is right, the unexpected findings reveal how a seemingly simple alteration in the serotonin system can lead to infant death. Although SIDS babies have normal 5-HT_{1A} receptors, one of their many other serotonin feedback mechanisms may be malfunctioning in a similar way. If so, the key to preventing SIDS could one day be as simple as finding a way to regulate abnormal serotonin feedback. *—Melinda Wenner*

PASIEKA SPL/*Photo Researchers, Inc. (top)*; TIM HAWLEY *Getty Images (bottom)*

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>> MEDICINE

The Oxygen Dilemma

Without it, cells die. With too much, they die even faster

Oxygen is vital for life—without it, severe brain damage may ensue in as little as three minutes. So doctors routinely treat traumas such as heart attack or stroke by providing victims with more oxygen. Mounting evidence suggests, however, that resuscitating with too much of the gas may actually have a harmful effect. The culprit in brain damage may not be a lack of oxygen but rather its reintroduction into the body.

Researchers at the University of Texas Southwestern Medical Center at Dallas recently found that resuscitating baby mice with pure oxygen caused more brain damage and cerebral palsy–like coordination problems, as compared with mice that breathed air during resuscitation.

"Our results are counterintuitive," says developmental biologist Steven Kernie, lead author of the study. "Many think oxygen doesn't hurt and you can give as much as possible to make up for a deficiency. Our study shows this notion is wrong."

Although Kernie's study does not exactly mimic patient care—physicians usually administer slightly above air's 21 percent oxygen and rarely more than 60 percent—it raises the important possibility that doctors are treating patients the wrong way, says Lance Becker, director of emergency medicine at the University of Pennsylvania School of Medicine, who similarly showed in 2004 that cells were much more likely to die after being reexposed to oxygen than they were when deprived. In fact, Becker explains, physicians do not know how much is too much or whether administering extra amounts actually benefits patients at all.

So why would treating injuries with a molecule that fuels life actually do the reverse? Evidence suggests that pumping in too much oxygen too quickly can strip the molecule of a single electron, creating a free radical. Free radicals, linked to rapid aging, are highly reactive with other molecules, including vital DNA and proteins, the destruction of which can damage or kill cells.

Treating with too much oxygen, therefore, could increase the production of free radicals and make a bad situation even worse. The key is to find that "sweet spot," Becker says—the optimal amount to give a person so he or she can recover with minimal damage.

—Victoria Stern

A Chilly Solution

How can doctors avoid the toxic effects of reintroducing oxygen to the body after a trauma? Hypothermia therapy—lowering a patient's body temperature to decrease metabolic rate and thus the need for oxygen—may be a solution, according to Hasan Alam, a trauma surgeon at Massachusetts General Hospital who established that the therapy worked in critically wounded Yorkshire pigs. The technique is popular for preserving transplant organs and reducing the need for oxygenated blood during heart surgery, but it has not been widely tested in trauma patients. Despite its high-profile use on professional football's Kevin Everett after his paralyzing spine injury in September 2007, hypothermia treatment remains controversial, and studies of its effectiveness are inconclusive. ***—V.S.***

FAST FACTS

- **Eyes** are the windows into the soul, but children with behavioral problems may have trouble interpreting the view. Psychiatrist Carla Sharp of the Baylor College of Medicine found that antisocial children had a harder time deciphering people's emotions when shown photographs of their eyes than typical kids did. The findings support the theory that conduct problems are linked to a child's inability to read emotions.

- **Honeybees** communicate the location of food to one another through waggle dances, in which they move back and forth in a figure-eight pattern. Although Asian and European honeybees have different waggles, new research at Zhejiang University in China shows that when reared in the same colony the two species can understand each other. The finding suggests that the dance—the only example of symbolic communication in invertebrates—is learned rather than innate, providing strong evidence that bees' small brains are capable of advanced social learning.

- **Bright lights** may help ameliorate symptoms of dementia. A typical patient experiences a slew of symptoms in addition to cognitive decline, including trouble sleeping and mood and behavioral problems. Researchers in the Netherlands showed that exposing patients to nine hours of bright indoor light during the day can help remedy sleep problems and depression and, if administered long-term, actually slow cognitive decline.

IFA-BILDERTEAM/JUPITERIMAGES (*top*); ANNE HELAINE *jupiterimages* (*bottom*)

>> BEHAVIOR

Left or Right, Fight or Flight

Magpies favor one brain hemisphere depending on how they intend to approach a threat

If you are trying to predict a magpie's next move, just look into its eyes. A new study found that when these birds view a potential predator, they use either their left or right eye, depending on whether they intend to run away or move closer. These findings reveal clues about how the brain segregates information between its hemispheres.

Neuroscientist Lesley Rogers and her colleagues at the University of New England in Australia observed wild Australian magpies (*Gymnorhina tibicen*) in the presence of a stuffed monitor lizard. Rogers found that before fleeing, birds would fixate on the "predator" with their left eye—which sends nearly all its input to the right side of the brain. But if they were about to approach the lizard for further investigation, they would inspect it with their right eye, thus using the left hemisphere.

Recent studies in humans suggest that the right hemisphere processes information that is novel and potentially threatening, whereas the left hemisphere carries out more methodical analyses. According to Rogers, the allocation of different functions to different hemispheres allows the brain to function more efficiently. "Historically, this [specialization] was thought to explain man's higher cognitive abilities," she says. "But we've shown that even in animals with comparatively simple brains, it affects everyday behaviors in the natural environment."

—Lizzie Buchen

Specialized left and right hemispheres allow the brain to work more efficiently.

>> LANGUAGE

Common Ground

Speakers of different languages share an innate object order preference

Woman

Knob

Twists

This word order (subject, object, verb) may be innate in the brain.

Does the language we speak influence the way we think? Scientists have fiercely debated this question for more than a century. A new study bolsters the case against language's influence by showing that people with different native tongues organize events in the same order—even if that order is different from the one dictated by their native grammar.

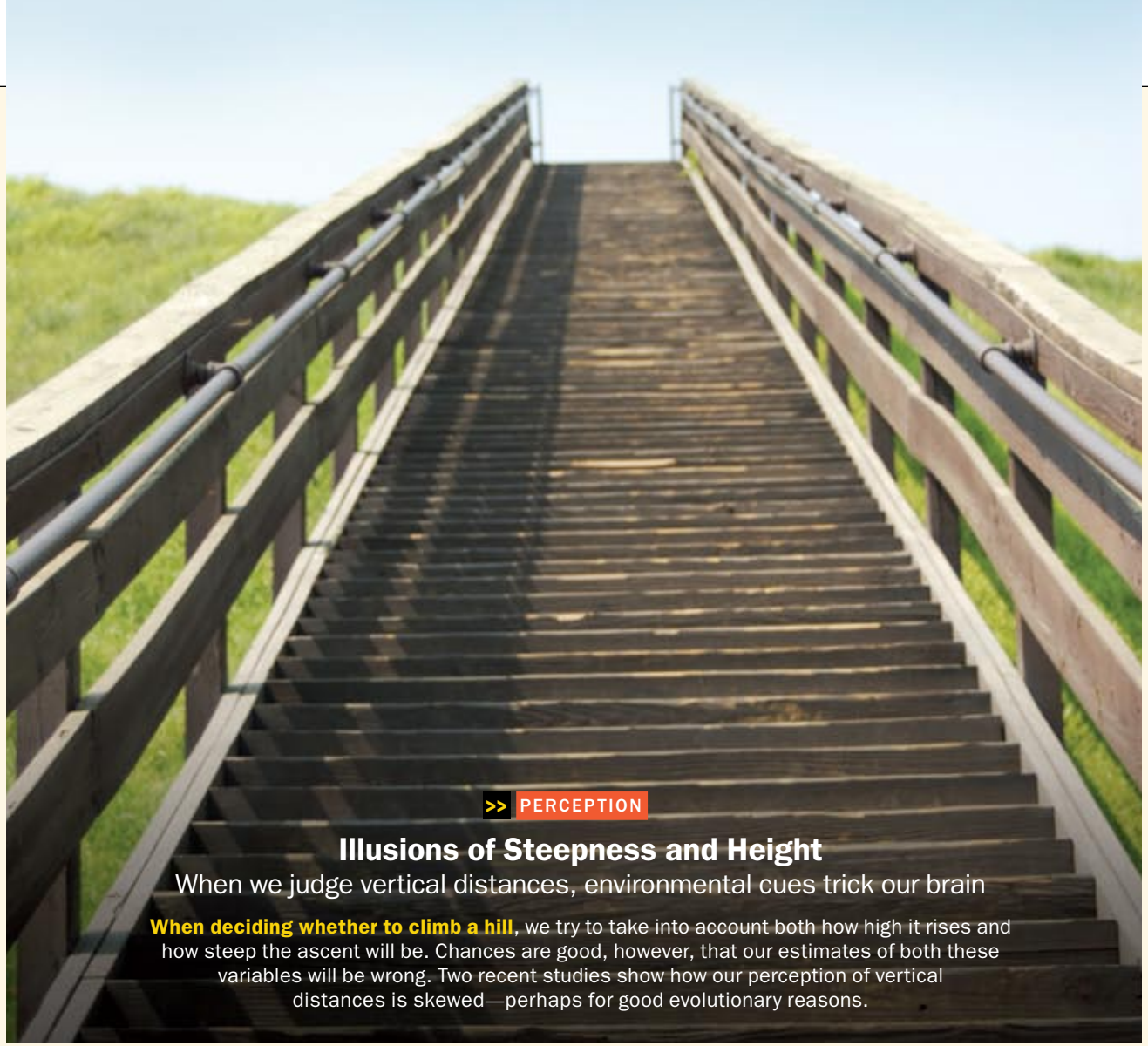
Psychologist Susan Goldin-Meadow of the University of Chicago asked Chinese, English, Spanish and Turkish speakers to describe activities by using only their hands. Turkish is the only language in the quartet that follows subject, object, verb, or SOV, order (as in "woman knob twists"). The other languages adhere to the pattern subject, verb, object ("woman twists knob"). When gesturing, however, all participants used the SOV order, regardless of their native language. The same was true in a noncommunicative task in which volunteers had to put pictures in order.

The results point to the existence of a "natural order" that humans use when representing events nonverbally, the researchers say. Where such a natural order might come from is unknown, but Goldin-Meadow suggests that it may influence developing languages so that they initially use the SOV order—such is the case with a sign language currently emerging in Israel. Languages are subject to other pressures, however, such as the need to be semantically clear and rhetorically interesting. As a language becomes more complex, she explains, these pressures might push it away from the natural SOV order. Today the two dominant orders that were represented in this study are equally frequent and account for roughly 90 percent of the world's languages.

One of the possible consequences of a language that goes against our pattern of representation may be that the brain has to do additional work when speaking it, Goldin-Meadow says. "It could be that there is a small cognitive cost to speaking English."

—Nicole Branan

JUPITERIMAGES (*bird*); JUAN MONINO (*woman*), HASAN SERDAR ÇELIK (*knob*) AND JULIEN GRONDIN (*arrow*) /*Stockphoto*



>> PERCEPTION

Illusions of Steepness and Height

When we judge vertical distances, environmental cues trick our brain

When deciding whether to climb a hill, we try to take into account both how high it rises and how steep the ascent will be. Chances are good, however, that our estimates of both these variables will be wrong. Two recent studies show how our perception of vertical distances is skewed—perhaps for good evolutionary reasons.

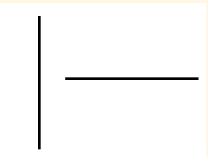
With a Little Help

The walk to and from school can't be uphill both ways, but going it alone might make it seem that way. When judging the steepness of a hill, people overestimated its angle more when alone than when they were accompanied by—or even thinking about—a friend, reports an international group of researchers led by Simone Schnall of University of Plymouth in England. The longer the volunteers had been friends with their companions, the less steep the hill seemed.

The authors hypothesize that psychosocial resources, such as having a trusted friend nearby, help people to see challenges in their surroundings as easier to navigate. In similar studies, subjects who were fatigued, out of shape or wearing a heavy backpack perceived hills as steeper and distances as longer than they really were.

Such built-in perceptual illusions may provide an evolutionary advantage, says Emily Balcetis of Ohio University, who was not involved with the study. Exaggerating a challenge's difficulty, she explains, "might better help you prepare to encounter it." —*Lucas Laursen*

Height Apparent

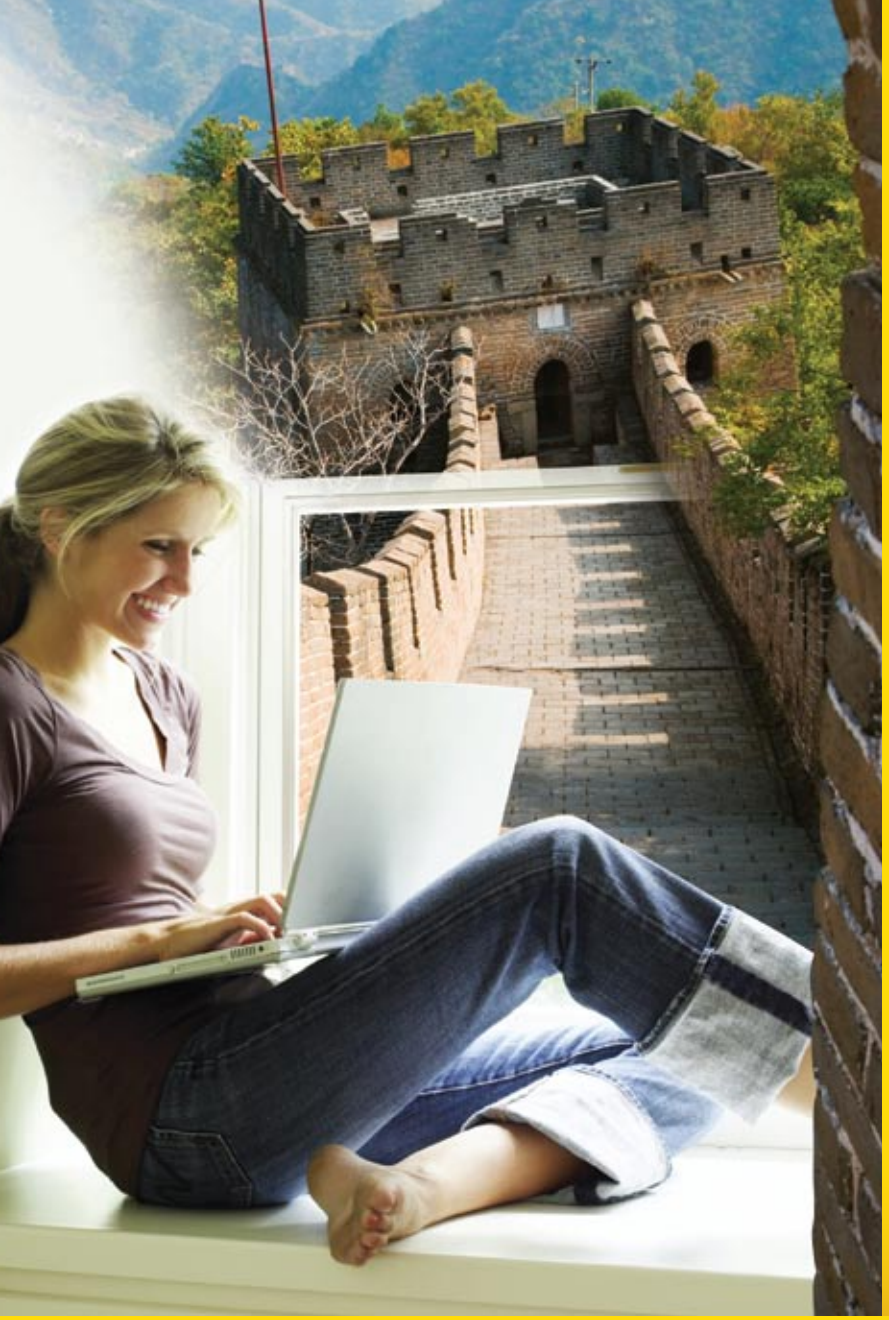


It's a common optical illusion: when you see a horizontal line and a vertical line of equal length, the vertical line always seems longer (*right*). Now it seems this illusion might be an evolved perceptual distortion designed to help us avoid falls, according to researchers who found that we misjudge heights the same way in the real world.

In the experiments, people overestimated vertical distance by 16 to 51 percent as compared with their estimate of the same distance when it was shown along the ground—and the higher the vertical distance, the greater the overestimation. Evolutionary psychologist Russell E. Jackson of California State University San Marcos, who led the study, explains that these findings support his theory of "evolved navigation." The theory predicts that we developed perceptual and navigational mechanisms that steer us toward routes that minimize costs, such as danger.

Although we assume that evolution tends to make our perceptions conform with reality, Jackson says that is not necessarily so, as long as a perceptual distortion has survival value. —*Kurt Kleiner*

GETTY IMAGES



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>> COGNITION

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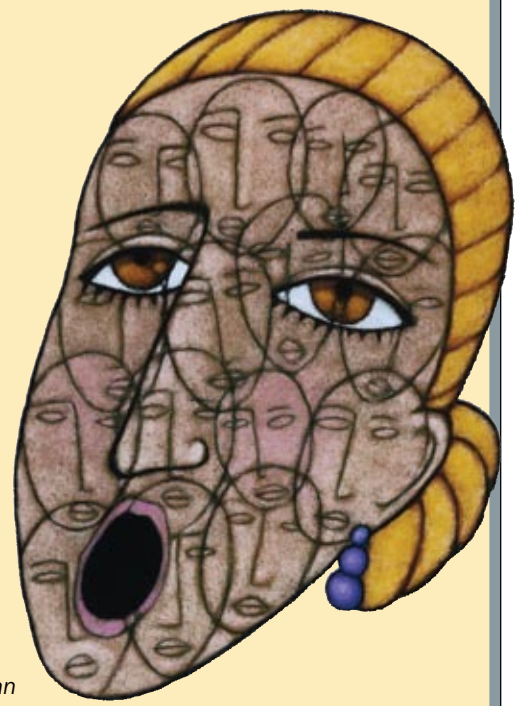


The U.S. houses what percentage of the world's airports? If you asked several people this question and averaged their guesses, you would probably end up closer to the right answer (30.5 percent) than if you asked just one person. This "wisdom of the crowd" effect has long been recognized, but scientists have recently gone a step further by showing that the strategy works even when the "crowd" consists of only one person.

Psychologists Edward Vul of the Massachusetts Institute of Technology and Harold Pashler of the University of California, San Diego, asked 428 participants various trivia questions and then, without warning, asked them to guess again later. On average, a person's combined responses were more accurate than either of his or her guesses alone.

The findings support the notion that cognition may be described as statistical inference, meaning that people base their thoughts and judgments about the world on statistical probabilities, Vul says. When trying to answer a trivia question, people construct a range of possible values based on their knowledge. Each guess then represents one sample from that distribution, he says. For example, people might approach the question about the percentage of airports by imagining a world map showing the distribution of airports, Vul explains, "but because their knowledge is probabilistic the map they construct will be different for each guess."

—Nicole Branan

>> CULTURE

Dressed for Distress

The choice to wear traditional garb affects boys and girls differently

Clothes make the man—and they might also reflect his mind. A new study of London teens reveals that choice of clothing style may affect mental health.

Researchers at Queen Mary, University of London, queried Bangladeshi adolescents attending London schools about their fashion preferences and, two years later, assessed their mental health. The scientists found that the girls who wore traditional Bangladeshi clothing were less likely to suffer later from psychological problems, such as depression, than were those who wore Western-style garments. "We were expecting to find that people who were able to mix with new cultural groups would be better off," says Kamaldeep Bhui, the lead researcher. "I was really surprised to find that traditional identity expressed through clothing was protective."

The trend was reversed, however, in boys; those who preferred integrated clothing had better mental well-being. Bhui believes this gender difference may result from the greater pressure that most societies put on women to conform to traditional cultural practices. And the girls who do wear Bangladeshi clothes could benefit in a number of ways. The expression of identity could itself be psychologically beneficial. Additionally, traditional clothing could keep these girls in a more insular, protective environment than that of more assimilated adolescents. Bangladeshi boys, on the other hand, typically have more freedom to move about the world and, as adults, are expected to enter an integrated workforce, Bhui says.

—Emily Anthes

GETTY IMAGES (*top*); JORGEN SCHYTTE *Peter Arnold, Inc.* (*bottom*)

>> EMOTION

When Time Doesn't Heal

The brain's reward system complicates grief

Losing a loved one is always painful, but for most people time eventually heals the wounds. For about 10 to 20 percent of the bereaved, however, accepting and getting over a loss remains extremely difficult, even years later. Now researchers have come a step closer to elucidating the neurobiological underpinnings of this condition called complicated grief (CG). A new functional MRI study shows that in CG patients reminders of the deceased activate a brain area associated with reward processing, pleasure and addiction.

A team led by Mary-Frances O'Connor of the University of California, Los Angeles, studied 23 women—11 of whom suffered from CG—who had lost a mother or sister to breast cancer in the past five years. While in the scanner, the women saw pictures and words that reminded them of their loved one. Brain networks associated with social pain became activated in all women, but in the CG patients reminders of the deceased also excited the nucleus accumbens, a forebrain area most commonly associated with reward.

O'Connor believes this continued neural reward activity probably interferes with adaptation to the new situation. "When we see a loved one or reminders of a loved one, we are cued to enjoy that experience," she says. "But when a loved one dies, our brains have to adapt to the idea that these cues no longer predict this rewarding experience." Scientists do not yet know why some people adapt better than others do.

O'Connor hopes the findings will lead to new treatment strategies that will "help the brains and minds of CG patients understand that the person is gone." —*Nicole Branan*

>> HEARING

Why Dogs Don't Enjoy Music

Human neurons are extraordinarily sensitive to changes in pitch

Anyone with normal hearing can distinguish between the musical tones in a scale: do, re, mi, fa, so, la, ti, do. We take this ability for granted, but among most mammals the feat is unparalleled.

This finding is one of many insights into the remarkable acuity of human hearing garnered by researchers at the University of California, Los Angeles, Hebrew University of Jerusalem and the Weizmann Institute of Science in Rehovot, Israel.

Izhak Fried of U.C.L.A. and his colleagues worked with epileptic patients who had electrodes implanted in their brain to pinpoint the source of their seizures. Some of the probes linked to the auditory cortex, providing the researchers with a detailed window into sound processing.

The study revealed that groups of exquisitely sensitive neurons exist along the auditory nerve on its way from the ear to the auditory cortex. In these neurons natural sounds, such as the human voice, elicit a completely different and far more complex set of responses than do artificial noises such as pure tones. In this mixed environment humans can easily detect frequencies as fine as one twelfth of an octave—a half step in musical terminology.

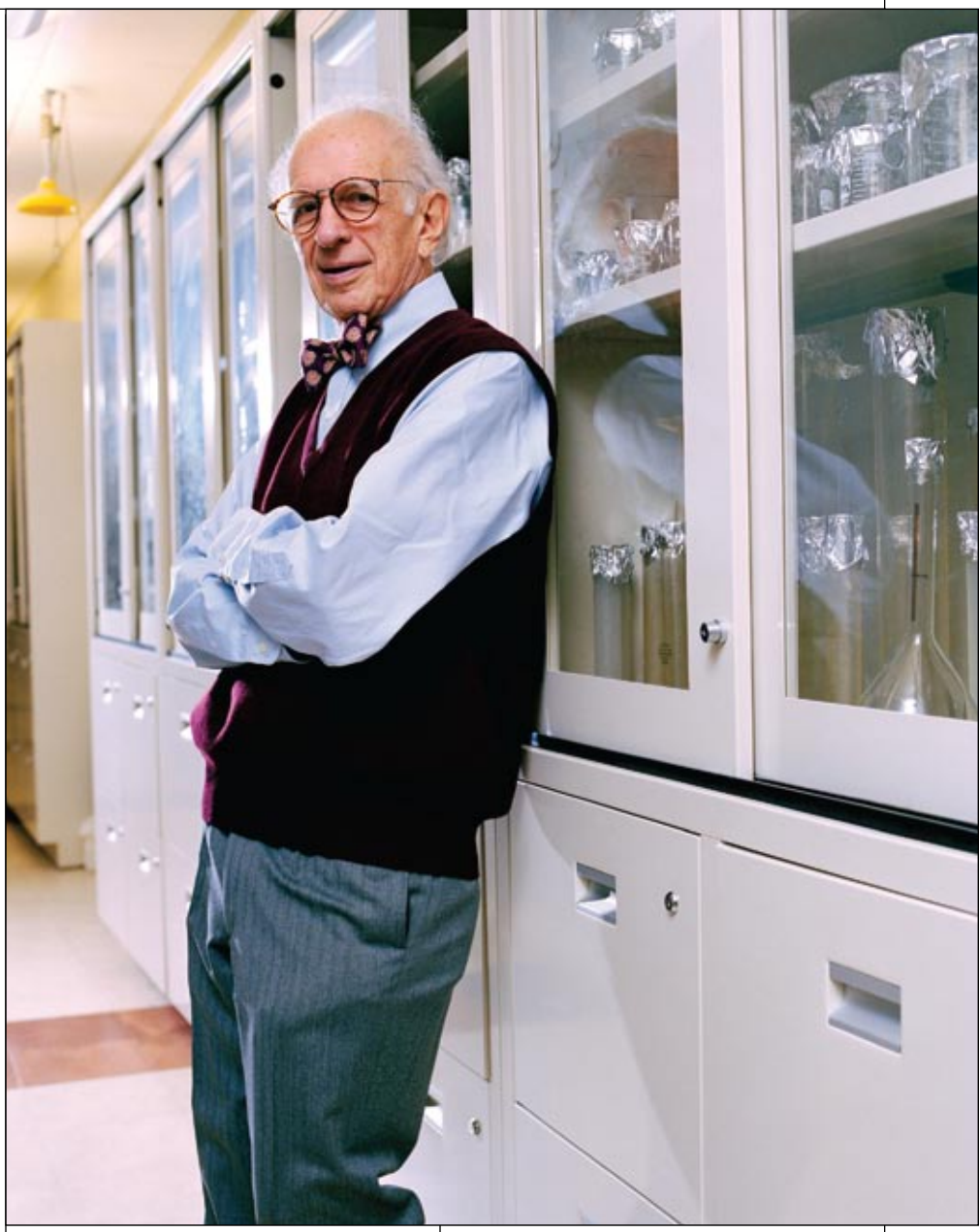
The vexing question is: Why? Bats are the only mammal with a better ability to hear changes in pitch than humans do. Predatory species such as dogs are not nearly as sensitive—they can discriminate resolutions of one third of an octave. Even our primate relatives do not come close: macaques can resolve only half an octave. These results suggest the fine discrimination of sound is not a necessity for survival.

More likely, the researchers speculate, humans use their fine hearing to facilitate working memory and learning capabilities, but more research is needed to explore this puzzle. —*Sandy Fritz*

JUPITERIMAGES (*top*); JOE McDONALD *Getty Images* (*bottom*)

Speaking of Memory

World-renowned neuroscientist Eric Kandel discusses Freud's legacy, memory's foibles and the potential of drugs that boost brainpower INTERVIEW BY STEVE AYAN



ERIC MCNATT

Over the past 50 years Nobel laureate Eric R. Kandel has shaped our understanding of the basic mechanisms of memory through his studies of the primitive sea slug Aplysia *[see "Eric Kandel: From Mind to Brain and Back Again," by David Dobbs, SCIENTIFIC AMERICAN MIND; October/November 2007]. First a student of history and literature and later a psychiatrist, the Vienna-born Columbia University professor and Howard Hughes Medical Institute investigator has emerged as one of the most prominent brain researchers of the century.*

SCIENTIFIC AMERICAN MIND: Do you see the humanities and natural sciences as separate realms, or can they be unified?

ERIC KANDEL: I think they can—and the biology of the mind is one of several possible bridges between them. But unfortunately, today people from different academic backgrounds do not meet and talk to each other so much. This was once quite different. For example, in Vienna at the end of the 19th century, uncovering the unconscious was a project shared by scientists, artists and writers alike. People such as [writer and doctor] Arthur Schnitzler, [painters] Gustav Klimt and Egon Schiele, and [artist, poet and playwright] Oskar Kokoschka exchanged their ideas with scientists and other intellectuals and scientists in literary circles.

MIND: Do you regard Freud as a scientist?

KANDEL: His aim was clearly scientific, but his methods weren't. Until 1894 Freud tried to develop a neurobiological view of the mental apparatus. But because of the limited knowledge of his time, he finally gave up on that idea. Although Freud kept on working in a fairly systematic way, his ideas lacked an empirical foundation. But to my mind, the problems with psychoanalysis arose with those who came later. Freud's followers should have tried to verify at least some of Freud's postulates using empirical methods. Instead they treated him as if he were a guru. Nevertheless, we have profited from Freudian ideas. For example, he bridged the gap between mental disease and mental health, seeing the same unconscious mechanisms at work in both.

MIND: Why is the unconscious so fascinating to us?

KANDEL: Because 80 to 90 percent of what we do is unconscious. When we

speak, we use presumably correct grammatical structures while paying little if any conscious attention to this grammar. And we act in lots of other ways without having the slightest clue what we are actually doing. Much of our urge to understand the unconscious arises from the spooky feeling that there is something within us governing our actions.

MIND: How does the modern understanding of unconscious processes differ from Freud's?
KANDEL: Freud first proposed one fundamental driving force, the libido, and later, in response to the horrors of the First World War, added the "death impulse" Thanatos. These are very broad categories that brain research cannot really deal with. But Freud did not think there was a unified unconscious. Instead he came up with a topology of different forms: the implicit unconscious representing motor and perceptual skills, the preconscious filled with material we can readily become aware of, and the dynamic unconscious in which, for example, instinctive impulses are suppressed. With modern neuroimaging techniques, we are finally able to discover what the brain is doing during conscious or different forms of unconscious processing.

MIND: We tend to think of memory as a kind of library that holds a record of events and facts that can be retrieved as needed. Is this an accurate metaphor?
KANDEL: No, memory is not like that at all. Human memory reinvents itself all the time. Every time you remember something, you modify it a little bit, in part dependent on the context in which you recall it. That is because the brain's storage is not as exact as written text. It is always a mixture of many facades of the past event: images, pictures, feelings, words, facts and fiction—a "recollection" in the true sense.

MIND: Have you ever found it hard to imagine yourself, your personal identity and memory as made up of molecules and the firing of neurons?
KANDEL: No, I like this idea. Some people think that finding out about the biological mechanisms behind our mental world takes the mystery out of it. I never felt that way. When you find out how Austrian expressionist Kokoschka scraped the paint onto the canvas with his finger, does that knowledge make his art less interesting? I don't think so. It is the same with the mind and body. Knowing that the heart is a muscular pump pushing the blood in our vessels doesn't make the heart less wonderful either.

MIND: How do you think brain research techniques might seep into everyday life? Do you think the brains of suspects in court or even job applicants might one day be routinely screened?
KANDEL: That should not be allowed in a democratic society. And the same holds true for DNA or fingerprints or any other kind of private biological information. The government has no right to that information. But this should not prevent us from developing powerful methods to study the mind and brain. Everything can be misused. It is society's job to ensure that it is not.

MIND: What do you think about brain enhancement, an area that is quite familiar to you?
KANDEL: Yes, I helped start a company to try to develop drugs that can improve memory. At the moment there is nothing that has been proved both effective and safe in people for that purpose, although many companies are working toward this goal. Cognitive enhancement should be good for people who have trouble learning and remembering, say, because they are old. I would not recommend that my grandchildren take such drugs, however. There is a much better way for them to improve their minds—and that is to study!

> "Memory **reinvents itself**," Kandel says. "Every time you remember something, you modify it a little bit."

MIND: Do you think brain research will change our culture and the way we think of ourselves?
KANDEL: Slowly but surely it will. It is beginning to do so, as the notion that every mental act comes from the brain becomes common knowledge. The mere fact that most people are no longer [mind-brain] dualists is a major cultural advance.

MIND: One last question: If you were granted one wish, what would it be?
KANDEL: I would like to know how some memories persist forever. How do you remember your first love experience for the rest of your life? Neuroscientist Kausik Si, then a postdoctoral fellow in my lab, and I discovered a protein called CPEB that has the very interesting characteristic of self-perpetuation. That might be a clue to how memory is sustained over long periods. But we don't know for sure yet. M

STEVE AYAN is an editor at *Gehirn & Geist.*

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Rendering the Visible Invisible

Clever experiments reveal how unconscious mechanisms can affect our brain and our behavior BY CHRISTOF KOCH

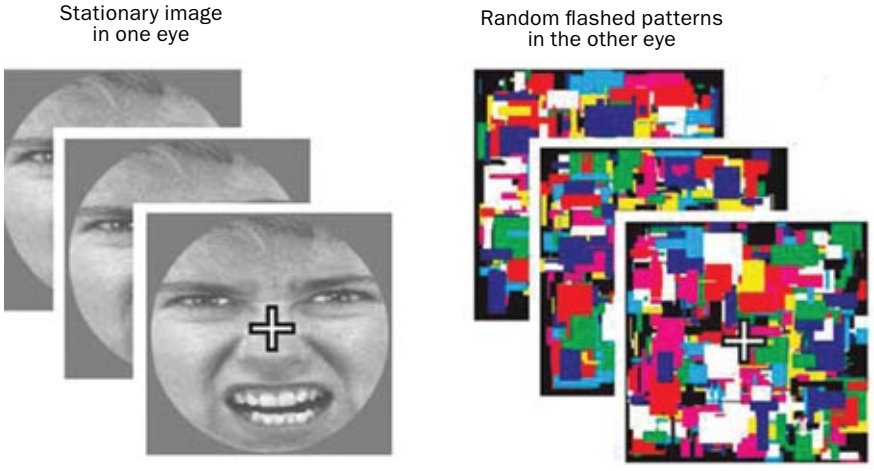
WHAT IS CONSCIOUSNESS? What is this ineffable, subjective stuff—this thing, substance, process, energy, soul, whatever—that you experience as the sounds and sights of life, as pain or as pleasure, as anger or as the nagging feeling at the back of your head that maybe you're not meant for this job after all. The question of the nature of consciousness is at the heart of the ancient mind-body problem. How does subjective consciousness relate to the objective universe, to matter and energy?

Consciousness is the only way we experience the world. Without it, you would be like a sleepwalker in a deep, dreamless sleep, acting in the world, speaking, having babies, but without feeling anything. You would feel nothing, *nada, nichts, rien*. Indeed, in the most famous deduction of Western thought, philosopher and mathematician René Descartes concluded that because he was conscious he existed. That was his only unassailable proof that he wasn't just a chimera. Maybe he didn't have the body he thought he had, maybe he had fake memories (premonitions of *The Matrix*), but because he was conscious he must exist.

Yet the questions go on. Are only people conscious? What about a fetus? What about a neurological patient in a persistent vegetative state, such as Terri Schiavo (who died in 2005), who can't do much more than open and close her eyes? Although many are willing to accord sentience, consciousness, to our beloved cats and dogs, what about apes, monkeys, whales, mice, bees and all the other critters on the planet? Can a fly be conscious? What about artificial consciousness? Is your cool iPhone sentient? Can machines ever become conscious, as is widely assumed in so many science-fiction novels and movies?

Until recently, these questions were purely within the domain of speculative philosophy and fantasy. But over the past decades, science has been making huge strides in exploring the brain. An immense number of psychological, medical, neurobiological and physical stories about consciousness can now be told. Each Consciousness Redux essay will illuminate one facet of one of the most central, enduring and puzzling aspects of the world, subjective feelings.

I am a scientist who seeks rational explanations of ineffable consciousness and of how and why it arises in the brain. But I also realize that our universe is a strange place; there are more things in heaven and earth than are dreamt of in philosophy. So I try to be humble when it comes to one of the most mystifying aspects of this universe—that I wake up each day and find myself conscious, capable of seeing, touching, loving, feeling and remembering. I am not a zombie! Many different traditions besides the modern scientific one have provided answers, and we should not reject them out of hand but listen to them.



A constantly changing set of colored and overlaid rectangles projected into one eye (*right*) suppresses a static image of an angry face shown to the other eye (*left*). An observer with both eyes open sees only the flickering mosaic.

FATMA KONUSKAN (*Koch*); COURTESY OF NAOTSUGU TSUCHIYA (*angry-face experiment*)

Unconscious Influences

As I write these lines, I am flying back from the annual meeting of the Association for the Scientific Study of Consciousness that took place, this year, in Taipei, Taiwan. It's a gathering of hard-nosed philosophers, neurologists, psychologists and neuroscientists concerned with consciousness. One of its high points is an annual award, named in honor of the father of American psychology. The 2008 William James Prize for Contributions to the Study of Consciousness went to Naotsugu Tsuchiya, a young neurobiologist from the California Institute of Technology. What had he done that caught the attention of the prize committee?

In 2005 Tsuchiya invented a technique, continuous flash suppression,

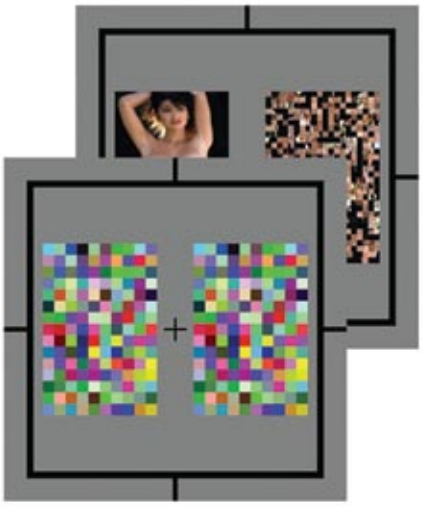
The mind has many nooks and crannies; some are accessible, but most are **hidden from introspection**.

which renders a picture invisible, hiding it from your conscious sight. Yet some part of your brain has access to the image and influences your behavior in untold ways. The way it works is simple. Say Tsuchiya wants to camouflage a picture of an angry male face. With the help of a split computer screen, Tsuchiya projects a faint image of this snarling guy into your left eye. Your right eye sees a rapidly changing set of colored rectangles, one on top of another [*see illustration on opposite page*]. If you keep both eyes open, all you see are the ever changing series of colored patches but no angry face. The constantly flickering colors attract your attention in a way that the static portrait does not. As soon as you close your right eye, the face becomes visible. But otherwise you have no inkling that the face is there, even though your left eye has been staring at it for many minutes. You simply do not see it. So what is the big deal?

Subconsciously Active

Functional brain imaging shows that this angry face still activates a part of your brain that is concerned with fear, the amygdala. That is, at least some sector of your brain knows about the face—as it ought to because an angry male face in front of you might spell big trouble. This brain activity remains unconscious but may influence your behavior or generate a subtle feeling of unease.

Using this technique, psychologist Sheng He, with his student Yi Jiang and their colleagues at the University of Minnesota, made an intriguing discovery. They projected to one eye a photograph of a naked person on one side of the gaze and a scrambled version of the same image on the other side. They then hid both using continuous flash suppression [*see illustration above*]. The paid volunteers who participated in the experiment never saw anything but flashes of color. The psychologists asked the volunteers to guess whether the naked person was in the left or the right part of the image. But they couldn't. Their guesses were no better than chance.



A photograph of a naked woman or man is shown to the left of the gaze in one eye while a scrambled version of the same image is shown to the right of the gaze. Both images are hidden from conscious sight by the ever changing, evanescent colored shapes. Yet sensitive measurements show that an observer does attend, unconsciously, to the invisible photograph depending on the observer's own gender and sexual orientation.

COURTESY OF SHENG HE (*naked-woman experiment*)

He and Jiang demonstrated that the observers attended to the naked picture but not to its scrambled counterpart. Even more interesting, straight males attended to pictures of naked women but were slightly repelled by pictures of naked men. Straight women were attracted to pictures of naked men without showing a consistent repulsion for pictures of naked women. Gay men behaved much like straight women; they unconsciously paid attention to the pictures of the naked men but not to those of women. What is disconcerting about this experiment is that this all took place outside the pale of consciousness. Because the observers never actually saw the naked images, they had no idea they were attracted or repelled by them. This experiment is scary because it seems as if people's sexual orientation could be inferred (statistically) from their unconscious attentional biases. An example of the unconscious mind at work. Freud would have loved it.

What this experiment teaches us is that the mind has many nooks and crannies; some—probably the minority—are consciously accessible, whereas most are hidden from introspection, lost in the vast catacombs of the brain. Yet they can powerfully influence your behavior, making you do things without knowing why. Continuous flash suppression—and other techniques that magicians and psychologists have invented to distract you so you do not see things while looking at them—in combination with functional brain imaging is a delicate tool to map the landscape of the visual unconscious. M

CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology.

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A Perspective on 3-D Visual Illusions

Paint and architectural illusions provide clues to how your brain reconstructs 3-D images

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

IT IS A FACT of neuroscience that everything we experience is actually a figment of our imagination. Although our sensations feel accurate and truthful, they do not necessarily reproduce the physical reality of the outside world. Of course, many experiences in daily life reflect the physical stimuli that enter the brain. But the same neural machinery that interprets actual sensory inputs is also responsible for our dreams, delusions and failings of memory. In other words, the real and the imagined share a physical source in the brain. So take a lesson from Socrates: "All I know is that I know nothing."

One of the most important tools neuroscientists use to understand how the brain creates its sense of reality is the illusion. Historically, artists as well as illusionists have used illusions to develop deep insights into the inner workings of the visual system. Long before scientists were studying the properties of neurons, artists had devised a series of techniques to "trick" the brain into thinking that a flat canvas was three-dimensional or that a series of brushstrokes was actually a still life. Applied to architecture, their work continues to astound.

Visual illusions are defined by the dissociation between physical reality and subjective perception of an object or event. When we experience such an illusion, we may see something that is not there, or fail to see something that is there, or even see something different from what is there. Because of this disconnect between perception and reality, these optical tricks demonstrate the ways in which the brain can fail to re-create the physical world. By studying these failings, we can learn about the computational methods the brain uses to construct visual experience.

Your Lying Eyes

Visual artists often try to imitate reality closely. Realistic painters convey the illusion of reality, volume or distance by making good intuitive use of perspective, color, lighting and shadow. When they are successful, the creation is sometimes difficult to distinguish from the model. Pliny the Elder, in his *Natural History,* narrates the legendary competition between two renowned painters in ancient Greece: Zeuxis and Parrhasios. Each of the artists brought a covered painting to the contest. Zeuxis uncovered his work: he had painted grapes so realistic that birds flew from the sky to peck at them. Convinced of his victory, Zeuxis tried to uncover Parrhasios's painting to confirm the superiority of his work. He was defeated, however, because the curtain he tried to pull back was Parrhasios's painting itself.

Realism in paintings did not start in ancient Greece. Even prehistoric painters used tricks to make their works appear more realistic. For instance, the Altamira bison are strategically painted over bulges of the rock, which enhances the

a

THE GALLERY COLLECTION/CORBIS

Such realistic painting techniques were carried to the limit in **trompe l'oeil**, or illusionism.

b

c

impression of the beasts' volume (*a*).

Such techniques were carried to the limit in trompe l'oeil. Trompe l'oeil, sometimes called illusionism, is a French term that means "to trick the eye." This style of photographic realism first appeared in the Renaissance and flourished in the 17th century in the Netherlands. The lifelike pictures sometimes appeared to literally jump from the frame.

The cupola of the church of St. Ignatius of Loyola in Rome is a great example of Baroque illusionism (*b*). The architect of the church, Orazio Grassi, had originally planned to build a cupola but died before finishing the church, and the money was used for something else. Thirty years later, in 1685, Jesuit artist Andrea Pozzo was asked to paint a fake dome on the ceiling over the altar. Pozzo was already considered a master in the art of perspective, but the results he accomplished still could hardly be believed. Even today many visitors to St. Ignatius are amazed to find out that the magnificent cupola is not real, but an illusion.

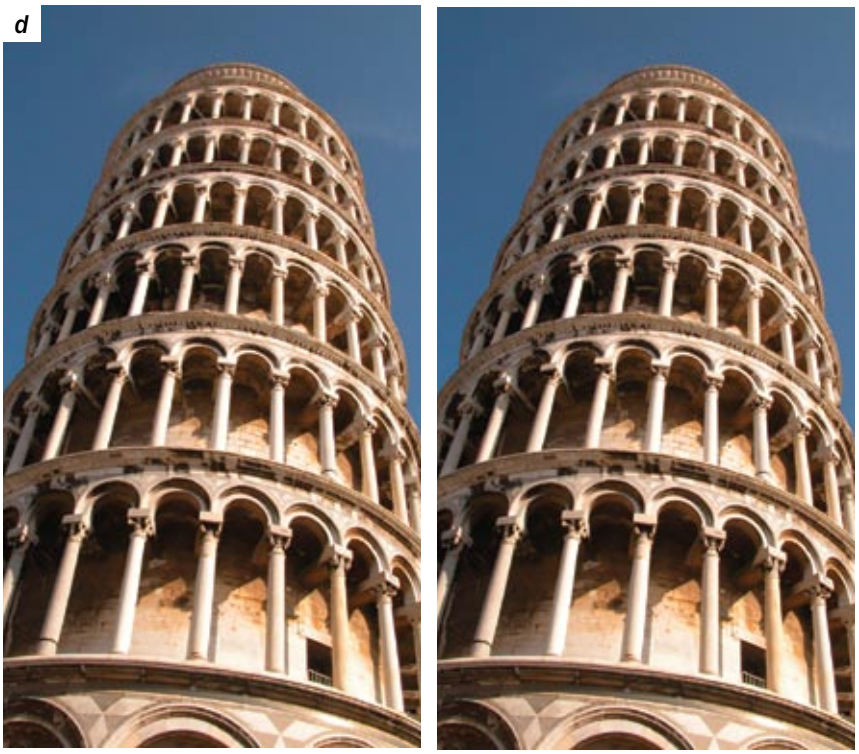
Another spectacular trompe l'oeil illusion is at the Palazzo Spada, a palace in Rome that we visited last summer (*c*). Francesco Borromini created the illusion of a gallery 37 meters long in the courtyard with a life-size sculpture in daylight at the end of the archway. The gallery is actually only eight meters long, and the sculpture is just 60 centimeters tall. Even today artist Julian Beever creates perspective illusions in his sidewalk art.

A Matter of Perspective

The Leaning Tower of Pisa is not famous for its painted trickery, but it offers another architectural example that elucidates the brain's processing. In the Leaning Tower Illusion, discovered by Frederick Kingdom, Ali Yoonessi and Elena Gheorghiu of McGill University, two identical side-by-side images of the same tilted and receding object appear to be leaning at two different angles (*d*).

The Leaning Tower Illusion—which won first prize in the Neural Correlate Society's Best Visual Illusion of the Year Contest in 2007—reveals the way in which the visual system uses perspective to help reconstruct 3-D objects. We say "reconstruct" because the visual system has no direct access to 3-D information about the world. Our perception of depth results from neural calculations based on several rules. Such rules include perspective (parallel lines appear to converge in the distance), stereopsis (our left and right eyes receive horizontally displaced images of the same object, resulting in the perception of depth), occlusion (objects near us occlude objects farther away), shading, chiaroscuro (the contrast of an object as a function of the position of the light source) and sfumato (the feeling

SCALA/ART RESOURCE, NY (*cupola*); ANDREA JEMOLO *Corbis* (*gallery*)



ADRIANA OLMOS; SOURCE: "THE LEANING TOWER ILLUSION: A NEW ILLUSION OF PERSPECTIVE," BY F.A.A. KINGDOM, A. YOONESSI AND E. GHEORGHIU, IN *PERCEPTION*, VOL. 36, 2007 (*Leaning Tower Illusion*); AKIYOSHI KITAOKA (*manga girls*)

of depth created by the interplay of in- and out-of-focus elements in an image as well as from the level of transparency of the atmosphere itself). The Leaning Tower Illusion shows that the brain also uses the convergence angle of two reclining objects as they recede into the distance to calculate the relative angle between them.

The illusion does not occur when we view two leaning Japanese manga girls (*e*), even though the two cartoon images are tilted. The reason is that the cartoon girls do not appear to recede in depth, so our brain does not expect that they would converge into the distance. This phenomenon demonstrates that the brain applies its depth perception tool kit only in specific situations.

3-D from 2-D

Just as the painter creates the illusion of depth on a flat canvas, our

(Further Reading)

◆ **Consciousness: Neurophysiology of Visual Awareness.** Stephen L. Macknik and Susana Martinez-Conde in *New Encyclopaedia of Neuroscience.* Edited by Larry R. Squire. Elsevier (in press).

brain creates the illusion of depth based on information arriving from our essentially 2-D retinas. Visual illusions show us that color, brightness and shape are not absolute terms but are subjective, relative experiences actively created by complicated brain circuits. This is true not only of visual experiences but of any sensation. Whether we experience the feeling of "redness," the appearance of "squareness," or emotions such as love and hate, these are the results of the electrical activity of neurons in our brain.

In the movie *The Matrix*, Morpheus asks Neo: "What is real? How do you define real? If you're talking about what you can feel, what you can smell, what you can taste and see, then real is simply electrical signals interpreted by your brain." What the movie doesn't tell us is that even when Neo awakens from the fake world of the "Matrix" into the "real world," his brain will continue to construct his subjective experience, as all of our brains do, and this experience may or may not match reality. So in a way, we all live in the illusory "matrix" created by our brain. Years before *The Matrix*, neurologist and Nobel laureate Sir John Eccles wrote: "I want you to realize that there exists no color in the natural world, and no sound—nothing of this kind; no textures, no patterns, no beauty, no scent."

Or in the words of Spanish playwright Pedro Calderón de la Barca:

"What is life? A frenzy.
What is life? An illusion,
A shadow, a fiction,
And the greatest profit is small;
For all of life is a dream,
And dreams are nothing
but dreams." M

STEPHEN L. MACKNIK is director of the Laboratory of Behavioral Science, and SUSANA MARTINEZ-CONDE is director of the Laboratory of Visual Neuroscience, both of which are at the Barrow Neurological Institute in Phoenix. They thank the Mind Science Foundation (www.mindscience.org) for its generous support.

(calendar)

October

12 Face your fears at **Goose Bumps! The Science of Fear**, a traveling exhibition developed by the California Science Center. Kids can experience the scary emotion in a safe environment as they learn how their brain and body work together to confront danger. Visit Boston's Museum of Science to get your heart pumping in hands-on activities, including an interactive video game where the player learns how fear helps animals survive in nature.
Boston
www.fearexhibit.org/about_exhibit

15 On this day in 1963, Yale University psychologist Stanley Milgram published his groundbreaking article, "Behavioral Study of Obedience," in the *Journal of Abnormal and Social Psychology.* The **infamous Milgram experiment**, in which subjects believed they were delivering increasingly painful high-voltage shocks to other participants for giving incorrect answers, demonstrated people's willingness to obey an authority figure even when asked to do something reprehensible. Milgram's findings helped to inform debates about how atrocities such as the Holocaust could have happened.

23–26 Can vitamins or folic acid prevent stroke and dementia? Should doctors treat patients in early stages of Parkinson's disease, when drug side effects may be worse than the symptoms they alleviate? Neurologists from around the world will debate these and other questions at the **2nd World Congress on Controversies in Neurology**, hosted this year in the ancient Greek city of Athens.
Athens
http://comtecmed.com/cony/2008

November

10 The first broadcast of **Sesame Street** aired on this day in 1969. In a pioneering move, the show's creators employed the latest principles of developmental psychology to teach academic and social skills. They tailored math and vocabulary lessons, for instance, to the ability of the typical two- to five-year-old and interspersed short, varied segments to engage that age group's attention span appropriately. The show continues to rely on the latest psychological science as a basis for its success today.

11–30 **Frost/Nixon**, a play by Peter Morgan, who also co-wrote the award-winning screenplay for *The Last King of Scotland,* reenacts the famous 1977 interview in which British talk-show host David Frost extracted an on-air apology from Richard Nixon regarding his role in the Watergate scandal. The play's power lies in its insight into the thrill of public confession—and the complex intersection of politics and psychology in the media.
Washington, D.C.
www.culturecapital.com/event.php?id=2554

An illusion of depth

15 Trompe l'oeil (literally, "trick the eye") painting has intrigued viewers for centuries. In **Illusions in Art for Young Eyes** at the Leigh Yawkey Woodson Art Museum, contemporary master Eric Conklin borrows tools such as conical mirrors from 17th-century Dutch artists and mathematical principles from ancient Egyptian architecture to create a sense of depth when there is none or to imply volume when only area exists.
Wausau, Wis.
www.lywam.org/exhibitions

Take Action for **Alzheimer's**

November is **National Alzheimer's Disease Awareness Month**. With life expectancy at a record high of 78.1 years, this most common form of dementia is now the sixth leading cause of death (recently surpassing diabetes) in the U.S. But with medications available to ease symptoms and hundreds of clinical trials under way, many remain optimistic about a cure. Here are a few ways you can get involved.

November 18

Detecting Alzheimer's disease in its beginning stages may be critical for treating the illness. **National Memory Screening Day**, organized by the Alzheimer's Foundation of America, promotes early diagnosis. Last year almost 21,000 people took advantage of this free and confidential memory-screening service in more than 700 sites countrywide.
www.nationalmemoryscreening.org

Ongoing

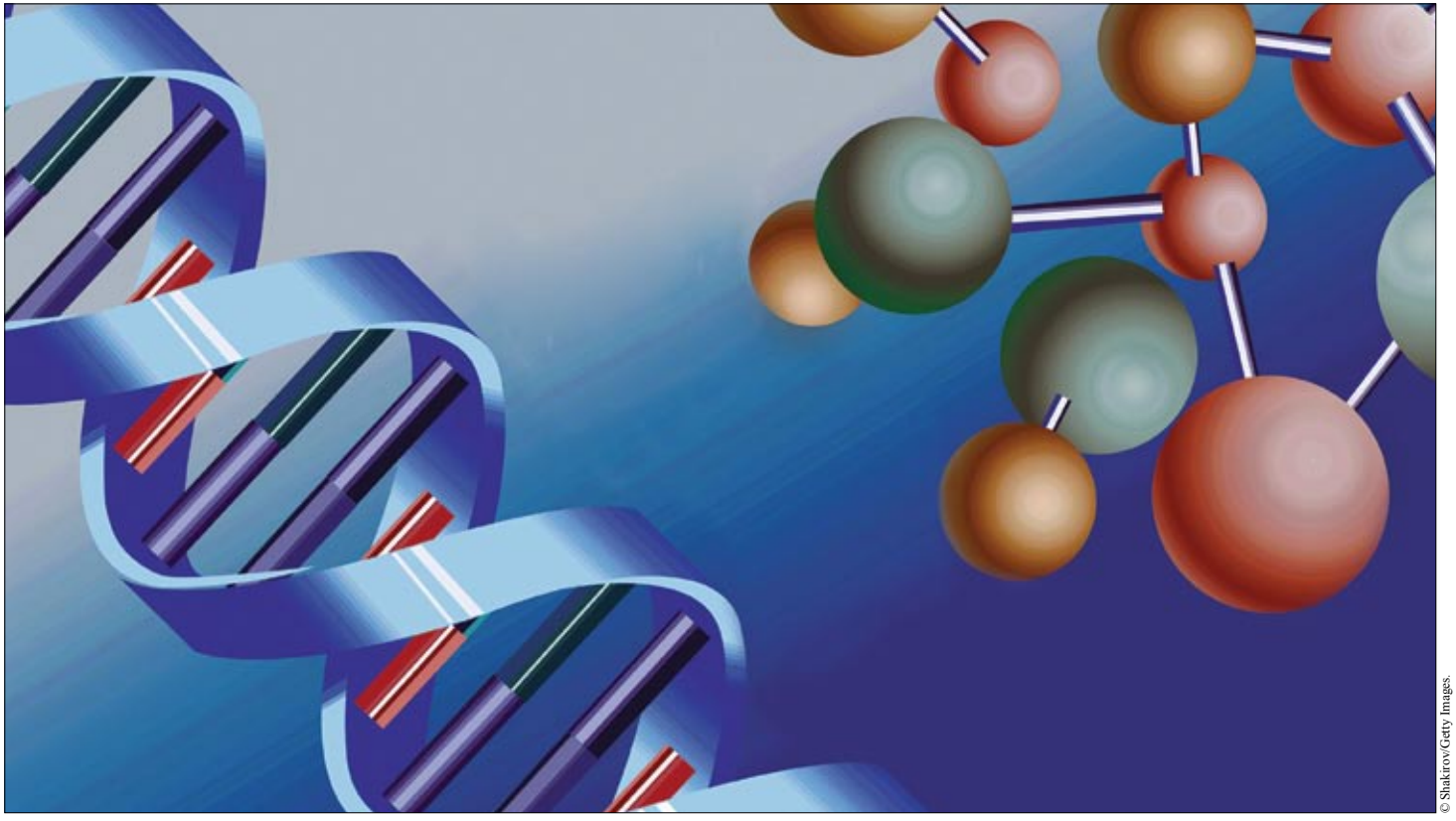
The search for treatments would not be possible without the help of volunteers willing to take part in rigorous studies. Whether you are an at-risk adult or the caregiver of a loved one with dementia, **consider enrolling in a clinical trial** to test new prevention strategies, medications or behavioral therapies. Find a trial in your area by using the National Institutes of Health's worldwide data bank.
http://clinicaltrials.gov/ct2/search

Ongoing

The **Alzheimer's Association Memory Walk**, which encompasses marches year-round in cities throughout the U.S., is the nation's largest event centered on raising money and awareness to fight the disease. This year more than 200,000 people are predicted to participate. Visit the Web site to volunteer, join a team or learn more.
www.alz.org/memorywalk/overview.asp

COURTESY OF LEIGH YAWKEY WOODSON ART MUSEUM (*trompe l'oeil painting*); HANS-ULRICH OSTERWALDER SPL/*Photo Researchers, Inc.* (*Alzheimer's image*)

Compiled by Rachel Dvoskin and Victoria Stern. Send items to editors@SciAmMind.com



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9. The Regulation of the Brain by Hormones
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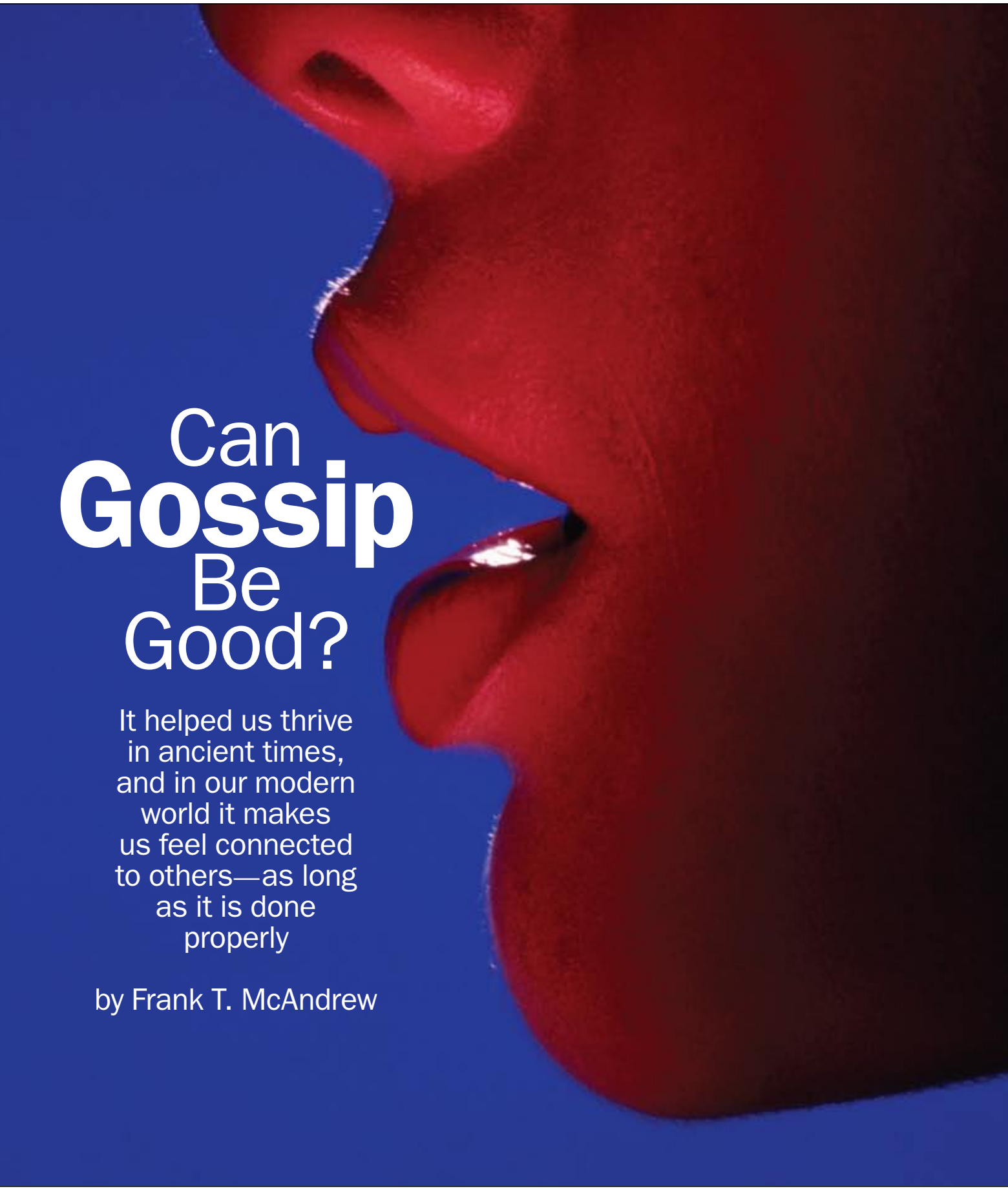
PETE TURNER *Getty Images*

In the past few years

I have heard more people than ever before puzzling over the 24/7 coverage of people such as Paris Hilton who are "celebrities" for no apparent reason other than we know who they are. And yet we can't look away. The press about these individuals' lives continues because people are obviously tuning in. Although many social critics have bemoaned this explosion of popular culture as if it reflects some kind of collective character flaw, it is in fact nothing more than the inevitable outcome of the collision between 21st-century media and Stone Age minds.

When you cut away its many layers, our fixation on popular culture reflects an intense interest in the doings of other people; this preoccupation with the lives of others is a by-product of the psychology that evolved in prehistoric times to make our ancestors socially successful. Thus, it appears that we are hardwired to be fascinated by gossip.



Can Gossip Be Good?

It helped us thrive in ancient times, and in our modern world it makes us feel connected to others—as long as it is done properly

by Frank T. McAndrew

Gossip serves a function in human society similar to the grooming of companions found in nonhuman primates.

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Only in the past decade or so have psychologists turned their attention toward the study of gossip, partially because it is difficult to define exactly what gossip is. Most researchers agree that the practice involves talk about people who are not present and that this talk is relaxed, informal and entertaining. Typically the topic of conversation also concerns information that we can make moral judgments about. Gossip appears to be pretty much the same wherever it takes place; gossip among co-workers is not qualitatively different from that among friends outside of work. Although everyone seems to detest a person who is known as a "gossip" and few people would use that label to describe themselves, it is an exceedingly unusual individual who can walk away from a juicy story about one of his or her acquaintances, and all of us have firsthand experience with the difficulty of keeping spectacular news about someone else a secret.

Why does private information about other people represent such an irresistible temptation for us? In his book *Grooming, Gossip, and the Evolution of Language* (Harvard University Press, 1996), psychologist Robin Dunbar of the University of Liverpool in England suggested that gossip is a mechanism for bonding social groups together, analogous to the grooming that is found in primate groups. Sarah R. Wert, now at the University of Colorado at Boulder, and Peter Salovey of Yale University have proposed that gossip is one of the best tools that we have for comparing ourselves socially with others. The ultimate question, however, is, How did gossip come to serve these functions in the first place?

An Evolutionary Adaptation?

When evolutionary psychologists detect something that is shared by people of all ages, times and cultures, they usually suspect that they have stumbled on a vital aspect of human nature, something that became a part of who we are in our long-forgotten prehistoric past. Evolutionary adaptations that enabled us not only to survive but to thrive in our prehistoric environment include our appreciation of landscapes containing freshwater and vegetation, our never-ending battle with our sweet tooth and our infatuation with people who look a certain way.

FAST FACTS

The Power of Gossip

1» In recent years researchers have turned to the study of gossip—our predilection for talking about people who are not present. Why is news about others so irresistible?

2» As it turns out, gossip serves a useful social function in bonding group members together. In the distant past, when humans lived in small bands and meeting strangers was a rare occurrence, gossip helped us survive and thrive.

3» Our modern-day infatuation with celebrities reveals the ancient evolutionary psychology of gossip in sharp relief: anyone whom we see that often and know that well becomes socially important to us.

It is obvious to most people that being drawn to locations that offer resources, food that provides energy, and romantic partners who appear able to help you bear and raise healthy children might well be something that evolution has selected for because of its advantages. It may not be so clear at first glance, however, how an interest in gossip could possibly be in the same league as these other preoccupations. If we think in terms of what it would have taken to be successful in our ancestral social environment, the idea may no longer seem quite so far-fetched.

As far as scientists can tell, our prehistoric forebears lived in relatively small groups where they knew everyone else in a face-to-face, long-term kind of way. Strangers were probably an infrequent and temporary phenomenon. Our caveman ancestors had to cooperate with so-called in-group members for success against out-groups, but they also had to recognize that these same in-group members were their main competitors when it came to dividing limited resources. Living under such conditions, our ancestors faced a number of consistent adaptive problems such as remembering who was a reliable exchange partner and who was a cheater, knowing who would be a reproductively valuable mate, and figuring out how to successfully manage friendships, alliances and family relationships.

Gossip helps bond social groups together and is a tool for comparing ourselves socially with others. How did gossip come to serve these functions in the first place?

The social intelligence needed for success in this environment required an ability to predict and influence the behavior of others, and an intense interest in the private dealings of other people would have been handy indeed and would have been strongly favored by natural selection. In short, people who were fascinated with the lives of others were simply more successful than those who were not, and it is the genes of those individuals that have come down to us through the ages. Like it or not, our inability to forsake gossip and information about other individuals is as much a part of who we are as is our inability to resist doughnuts or sex—and for the same reasons.

A related social skill that would have had a big payoff is the ability to remember details about the temperament, predictability and past behavior of individuals who are personally known to you; there would have been little use for a mind that was designed to engage in abstract statistical thinking about large numbers of unknown outsiders. In today's world, it is advantageous to be able to think in terms of probabilities and percentages when it comes to people, because predicting the behavior of the strangers with whom we deal in everyday life requires that we do so. This task is difficult for many of us because the early wiring of the brain was guided by different needs. Thus, natural selection shaped a thirst for, and a memory to store information about, specific people; it is even well established that we have a brain area specifically dedicated to the identification of human faces.

For better or worse, this is the mental equipment we must rely on to navigate our way through a modern world filled with technology and strangers. I suppose I should not be surprised when the very same psychology students who get glassy-eyed at any mention of statistical data about human beings in general become riveted by case studies of individuals experiencing psychological problems. Successful politicians take advantage of this pervasive "power of the particular" (as cognitive psychologists call it) when they use anecdotes and personal narratives to make political points. Even Russian dictator Joseph Stalin noted that "one death is a tragedy; a million deaths is a statistic." The prevalence of reality TV shows and nightly news programs focusing on stories about a missing child or the personal gaffes of politicians is a beast of our own creation.

Is Gossip Always Bad?

The aspect of gossip that is most troubling is that in its rawest form it is a strategy used by individuals to further their own reputations and selfish interests at the expense of others. This nasty side of gossip usually overshadows the more benign ways in which it functions in society. After all, sharing gossip with another person is a sign of deep trust because you are clearly signaling that you believe that this person will not use this sensitive information in a way that will have negative consequences for you; shared secrets also have a

AP PHOTO

Successful politicians, such as President Bill Clinton, who rely on the power of narratives about individuals to make their points take advantage of our brain's preference for news about people we know over faceless statistics.

way of bonding people together. An individual who is not included in the office gossip network is obviously an outsider who is not trusted or accepted by the group.

There is ample evidence that when it is controlled, gossip can indeed be a positive force in the life of a group. In a review of the literature published in 2004, Roy F. Baumeister of Florida State University and his colleagues concluded that gossip can be a way of learning the unwritten rules of social groups and cultures by resolving ambiguity about group norms. Gossip is also an efficient way of reminding group members about the importance of the group's norms and values; it can be a deterrent to deviance and a tool for punishing those who transgress. Rutgers University evolutionary biologist Robert Trivers has discussed the evolutionary importance of detecting "gross cheaters" (those who fail to reciprocate altruistic acts) and "subtle cheaters" (those who reciprocate but give much less than they get). [For more on altruism and related behavior, see "The Samaritan Paradox," by Ernst Fehr and Suzann-Viola Renninger; Scientific American Mind, Premier Issue 2004.]

Gossip can reveal unwritten rules. Individuals who violate the group's expectations become frequent targets of gossip, which encourages them to become better citizens.

Gossip can be an effective means of uncovering such information about others and an especially useful way of controlling these "free riders" who may be tempted to violate group norms of reciprocity by taking more from the group than they give in return. Studies in real-life groups such as California cattle ranchers, Maine lobster fishers and college rowing teams confirm that gossip is used in these quite different settings to enforce group norms when an individual fails to live up to the group's expectations. In all these groups, individuals who violated expectations about sharing resources and meeting responsibilities became frequent targets of gossip and ostracism, which applied pressure on them to become better citizens. Anthropological studies of hunter-gatherer groups have typically revealed a similar social control function for gossip in these societies.

Anthropologist Christopher Boehm of the University of Southern California has proposed in his book *Hierarchy in the Forest: The Evolution of Egalitarian Behavior* (Harvard University Press, 1999) that gossip evolved as a "leveling mechanism" for neutralizing the dominance tendencies of others. Boehm believes that small-scale foraging societies such as those typical during human prehistory emphasized an egalitarianism that suppressed internal competition and promoted consensus seeking in a way that made the success of one's group extremely important to one's own fitness. These social pressures discouraged free riders and cheaters and encouraged altruists. In such societies, the manipulation of public opinion through gossip, ridicule and ostracism became a key way of keeping potentially dominant group members in check.

GETTY IMAGES

Favored Types of Gossip

According to one of the pioneers of gossip research, anthropologist Jerome Barkow of Dalhousie University, we should be especially interested in information about people who matter most in our lives: rivals, mates, relatives, partners in social exchange, and high-ranking figures whose behavior can affect us. Given the proposition that our interest in gossip evolved as a way of acquiring fitness-enhancing information, Barkow also suggests that the type of knowledge that we seek should be information that can affect our social standing relative to others. Hence, we would expect to find higher interest in negative news (such as misfortunes and scandals) about high-status people and potential rivals because we could exploit it. Negative information about those lower than us in status would not be as useful. There should also be less interest in passing along negative information about our friends and relatives than about people who are not allies. Conversely, positive information (good fortune and sudden elevation of status, for example) about allies should be likely to be spread around, whereas positive information about nonallies should be less enticing because it is not useful in advancing one's own interests.

For a variety of reasons, our interest in the doings of same-sex others ought to be especially strong. Because same-sex members of one's own species who are close to our own age are our principal evolutionary competitors, we ought to pay special attention to them. The 18-year-old male caveman would have done much better by attending to the business of other 18-year-old males rather than the business of 50-year-old males or females of any age. Interest about members of the other sex should be strong only when their age and situational circumstances would make them appropriate as mates.

The gossip studies that my students and I have worked on at Knox College over the past decade have focused on uncovering what we are most interested in finding out about other people and what we are most likely to spread around. We have had people of all ages rank their interest in tabloid stories about celebrities, and we have asked college students to read gossip scenarios about unidentified individuals and tell us about which types of people they would most like to hear such information, about whom they would gossip and with whom they would share gossip.

> Gossip can help identify "gross cheaters" (those who fail to reciprocate altruistic acts) and "subtle cheaters" (those who reciprocate but give much less than they get).

In keeping with the evolutionary hypotheses suggested earlier, we have consistently found that people are most interested in gossip about individuals of the same sex as themselves who happen to be around their own age. We have also found that information that is socially useful is always of greatest interest to us: we like to know about the scandals and misfortunes of our rivals and of high-status people because this information might be valuable in social competition. Positive information about such people tends to be uninteresting to us. Finding out that someone already higher in status than ourselves has just acquired something that puts that person even further ahead of us does not supply us with ammunition that we can use to gain ground on him. Conversely, positive information about our friends and relatives is very interesting and likely to be

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Information about those who are of our same sex and near our age is more interesting to us than news about people of the opposite sex who are much older or younger than we are.

(The Author)

FRANK T. McANDREW is Cornelia H. Dudley Professor of Psychology at Knox College. He is a social psychologist with research interests in environmental and evolutionary psychology, and he is a fellow of the Association for Psychological Science.

Why the obsession? In our ancestral environment, any person about whom we knew intimate details was, by definition, socially important to us.

used to our advantage whenever possible. For example, in studies that my colleagues and I published in 2002 and in 2007 in the *Journal of Applied Social Psychology*, we consistently found that college students were not much interested in hearing about academic awards or a large inheritance if it involved one of their professors and that they were also not very interested in passing that news along to others. Yet the same information about their friends or romantic partners was rated as being quite interesting and likely to be spread around.

We have also found that an interest in the affairs of same-sex others is especially strong among females and that women have somewhat different patterns of sharing gossip than men do. For example, our studies reveal that males report being far more likely to share gossip with their romantic partners than with anyone else, but females report that they would be just as likely to share gossip with their same-sex friends as with their romantic partners. And although males are usually more interested in news about other males, females are virtually obsessed with news about other females.

This fact can be demonstrated by looking at the actual frequency with which males and females selected a same-sex person as the most interesting subject of the gossip scenarios we presented them with in one of our studies published in 2002. On hearing about someone having a date with a famous person, 43 out of 44 women selected a female as the most interesting person to know this about, as compared with 24 out of 36 males who selected a male as most interesting. Similarly, 40 out of 42 females (versus 22 out of 37 males) were most interested in same-sex academic cheaters, and 39 out of 43 were most interested in a same-sex leukemia sufferer (as opposed to only 18 out of 37 males). In fact, the only two scenarios among the 13 we studied in which males expressed more same-sex interest than females did involved hearing about an individual heavily in debt because of gambling or an individual who was having difficulty performing sexually.

Why Such Interest in Celebrities?

Even if we can explain the intense interest that we have in other people who are socially important to us, how can we possibly explain the seemingly useless interest that we have in the lives of reality-show contestants, movie stars and public figures of all kinds? One possible explanation may be found in the fact that celebrities are a recent occurrence, evolutionarily speaking. In our ancestral environment, any person about whom we knew intimate details of his or her private life was, by definition, a socially important member of the in-group. Barkow has pointed out that evolution did not prepare us to distinguish among members of our community who have genuine effects on our life and the images and voices that we are bombarded with by the enter-

> Keeping up on the lives of actors, politicians and athletes can make a person more socially adept during interactions with strangers or in the virtual world.

tainment industry. Thus, the intense familiarity with celebrities provided by the modern media trips the same gossip mechanisms that have evolved to keep up with the affairs of in-group members. After all, anyone whom we see *that* often and know *that* much about *must* be socially important to us. News anchors and television actors we see every day in soap operas become familiar friends.

In our modern world, celebrities may also serve another important social function. In a highly mobile, industrial society, celebrities may be the only "friends" we have in common with our new neighbors and co-workers. They provide a common interest and topic of conversation between people who otherwise might not have much to say to one another, and they facilitate the types of informal interaction that help people become comfortable in new surroundings. Hence, keeping up on the lives of actors, politicians and athletes can make a person more socially adept during interactions with strangers and even provide segues into social relationships with new friends in the virtual world of the Internet. Research published in 2007 by Charlotte J. S. De Backer, a Belgian psychologist now at the University of Leicester in England, finds that young people even look to celebrities and popular culture for learning life strategies that would have been learned from role models within one's tribe in the old days. Teenagers in particular seem to be prone to learning how to dress, how to manage relationships and how to be socially successful in general by tuning in to popular culture.

Thus, gossip is a more complicated and socially important phenomenon than we think. When gossip is discussed seriously, the goal usually is to suppress the frequency with which it occurs in an attempt to avoid the undeniably harmful effects it often has in work groups and other social networks. This tendency, however, overlooks that gossip is part of who we are and an essential part of what makes groups function as well as they do. Perhaps it may become more productive to think of gossip as a social skill rather than as a character flaw, because it is only when we do not do it well that we get into trouble. Adopting the role of the self-righteous soul who refuses to participate in gossip at work or in other areas of your social life ultimately will be self-defeating. It will turn out to be nothing more than a ticket to social isolation. On the other hand, becoming that person who indiscriminately blabs everything you hear to anyone who will listen will quickly get you a reputation as an untrustworthy busybody. Successful gossiping is about being a good team player and sharing key information with others in a way that will not be perceived as self-serving and about understanding when to keep your mouth shut.

HANS NELEMAN *Getty Images*

Attempts to suppress gossip because of its potentially harmful effects overlook that it is part of who we are.

In short, I believe we will continue to struggle with managing the gossip networks in our daily lives and to shake our heads at what we are constantly being subjected to by the mass media, rationally dismissing it as irrelevant to anything that matters in our own lives. But in case you find yourself becoming just a *tiny* bit intrigued by some inane story about a celebrity, let yourself off the hook and enjoy the guilty pleasure. After all, it is only human nature. M

(Further Reading)

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The End?

Why so many of us think our minds continue on after we die

by Jesse Bering

Everybody's wonderin' what and where they all came from.
Everybody's worryin' 'bout where they're gonna go when the whole thing's done.
But no one knows for certain and so it's all the same to me.
I think I'll just let the mystery be.

It should strike us as odd that we feel inclined to nod our heads in agreement to the twangy, sweetly discordant folk vocals of Iris Dement in "Let the Mystery Be," a humble paean about the hereafter. In fact, the only real mystery is why we're so convinced that when it comes to where we're going "when the whole thing's done," we're dealing with a mystery at all. After all, the brain is like any other organ: a part of our physical body. And the mind is what the brain does—it's more a verb than it is a noun. Why do we wonder where our mind goes when the body is dead? Shouldn't it be obvious that the mind is dead, too?

And yet people in every culture believe in an afterlife of some kind or, at the very least, are unsure about what happens to the mind at death. My psychological research has led me to believe that these irrational beliefs, rather than resulting from religion or serving to protect us from the terror of inexistence, are an inevitable by-product of self-consciousness. Because we have never experienced a lack of consciousness, we cannot imagine what it will feel like to be dead. In fact, it won't feel like anything—and therein lies the problem.

MICHAEL N. PARAS *Corbis (feet)*; YORIKO FUKUDA *Getty Images (hand)*; YANG YU *iStockphoto (feather)*

The common view of death as a great mystery usually is brushed aside as an emotionally fueled desire to believe that death isn't the end of the road. And indeed, a prominent school of research in social psychology called terror management theory contends that afterlife beliefs, as well as less obvious beliefs, behaviors and attitudes, exist to assuage what would otherwise be crippling anxiety about the ego's inexistence.

According to proponents, you possess a secret arsenal of psychological defenses designed to keep your death anxiety at bay (and to keep you from ending up in the fetal position listening to Nick Drake on your iPod). My writing this article, for example, would be interpreted as an exercise in "symbolic immortality"; terror management theorists would likely tell you that I wrote it for posterity, to enable a concrete set of my ephemeral ideas to outlive me, the biological organism. (I would tell you that I'd be happy enough if a year from now it still had a faint pulse.)

Like a reflection in a hall of mirrors, consciousness seems to extend into infinity.

DAVID PURDY *DK Images*

Yet a small number of researchers, including me, are increasingly arguing that the evolution of self-consciousness has posed a different kind of problem altogether. This position holds that our ancestors suffered the unshakable illusion that their minds were immortal, and it's this hiccup of gross irrationality that we have unmistakably inherited from them. Individual human beings, by virtue of their evolved cognitive architecture, had trouble conceptualizing their own psychological inexistence from the start.

Curiously Immortal

The problem applies even to those who claim not to believe in an afterlife. As philosopher and Center for Naturalism founder Thomas W. Clark wrote in a 1994 article for the *Humanist* (emphases mine):

> Here … is the view at issue: When we die, what's next is *nothing;* death is an abyss, a black hole, the end of experience; it is eternal nothingness, the permanent extinction of being. And here, in a nutshell, is the error contained in that view: It is to *reify* nothingness—make it a positive condition or quality (for example, of "blackness")—and then to place the individual in it after death, so that we somehow fall *into* nothingness, to remain there eternally.

Consider the rather startling fact that you will never know you have died. You may feel yourself slipping away, but it isn't as though there will be a "you" around who is capable of ascertaining that, once all is said and done, it has actually happened. Just to remind you, you need a working cerebral cortex to harbor propositional knowledge of any sort, including the fact that you've died—and once you've died your brain is about as phenomenally generative as a head of lettuce. In a 2007 article published in the journal *Synthese,* University of Arizona philosopher Shaun Nichols puts it this way: "When I try to imagine my own non-existence I have to imagine that I perceive or know about my non-existence. No wonder there's an obstacle!"

This observation may not sound like a major revelation to you, but I bet you've never considered what it actually means, which is that your

FAST FACTS

The Eternal Mind

1» Almost everyone has a tendency to imagine the mind continuing to exist after the death of the body.

2» Even people who believe the mind ceases to exist at death show this type of psychological-continuity reasoning in studies.

3» Rather than being a by-product of religion or an emotional security blanket, such beliefs stem from the very nature of our consciousness.

> Consider the rather **startling fact** that you will never know you have died.

Although we spend periods of our life unconscious, such as when we're in dreamless sleep, by definition we don't actually experience these moments. So when we try to imagine being dead, we have no frame of reference.

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own mortality is unfalsifiable from the first-person perspective. This obstacle is why writer Johann Wolfgang von Goethe allegedly remarked that "everyone carries the proof of his own immortality within himself."

Even when we want to believe that our minds end at death, it is a real struggle to think in this way. A study I published in the *Journal of Cognition and Culture* in 2002 reveals the illusion of immortality operating in full swing in the minds of undergraduate students who were asked a series of questions about the psychological faculties of a dead man.

Richard, I told the students, had been killed instantaneously when his vehicle plunged into a utility pole. After the participants read a narrative about Richard's state of mind just prior to the accident, I queried them as to whether the man, now that he was dead, retained the capacity to experience mental states. "Is Richard still thinking about his wife?" I asked them. "Can he still taste the flavor of the breath mint he ate just before he died? Does he want to be alive?"

You can imagine the looks I got, because apparently not many people pause to consider whether souls have taste buds, become randy or get headaches. Yet most gave answers indicative of "psychological continuity reasoning," in which they envisioned Richard's mind to continue functioning despite his death. This finding came as no surprise given that, on a separate scale, most respondents classified themselves as having a belief in some form of an afterlife.

What *was* surprising, however, was that many participants who had identified themselves as having "extinctivist" beliefs (they had ticked off the box that read: "What we think of as the 'soul,' or conscious personality of a person, ceases permanently when the body dies") occasionally gave psychological-continuity responses, too. Thirty-two percent of the extinctivists' answers betrayed their hidden reasoning that emotions and desires survive death; another 36 percent of their responses suggested the extinctivists reasoned this way for mental states related to knowledge (such as remembering, believing or knowing). One particularly vehement extinctivist thought the whole line of questioning silly and seemed to regard me as a numbskull for even asking. But just as well—he proceeded to point out that of course Richard knows he is dead, because there's no afterlife and Richard sees that now.

So why is it so hard to conceptualize inexistence anyway? Part of my own account, which I call the "simulation constraint hypothesis," is that in attempting to imagine what it's like to be dead we appeal to our own background of conscious experiences—because that's how we approach most thought experiments. Death isn't "like" anything we've ever experienced, however. Because we have never consciously been without consciousness, even our best simulations of true nothingness just aren't good enough.

> From an evolutionary perspective, a coherent theory about psychological death is not necessarily vital.

For us extinctivists, it's kind of like staring into a hallway of mirrors—but rather than confronting a visual trick, we're dealing with cognitive reverberations of subjective experience. In Spanish philosopher Miguel de Unamuno's 1913 existential screed, *The Tragic Sense of Life,* one can almost see the author tearing out his hair contemplating this very fact. "Try to fill your consciousness with the representation of no-consciousness," he writes, "and you will see the impossibility of it. The effort to comprehend it causes the most tormenting dizziness."

Wait, you say, isn't Unamuno forgetting something? We certainly do have experience with nothingness. Every night, in fact, when we're in dreamless sleep. But you'd be mistaken in this assumption. Clark puts it this way (emphasis mine): "We may occasionally have the *impression* of having experienced or 'undergone' a period of unconsciousness, but, of course, this is impossible. The 'nothingness' of unconsciousness cannot be an experienced actuality."

If psychological immortality represents the intuitive, natural way of thinking about death, then we might expect young children to be particularly inclined to reason in this way. As an eight-year-old, I watched as the remains of our family's golden retriever, Sam, were buried in the woods behind our house. Still, I thought Sam had a mind capable of knowing I loved her and I was sorry I didn't get to say goodbye. That Sam's spirit lived on was not something my parents or anyone else ever explicitly pointed out to me. Although she had been reduced to no more than a few ounces of dust, which was in turn sealed in a now waterlogged box, it never even occurred to me that it was a strange idea.

Is this dog dead or sleeping? Urban four-year-olds and children from hunter-horticulturalist societies are equally good at telling the difference.

T. KLEITZ *Plainpicture/Jupiterimages*

Yet if you were to have asked me what Sam was experiencing, I probably would have muttered something like the type of answers Gerald P. Koocher reported hearing in a 1973 study published in *Developmental Psychology.* Koocher, then a doctoral student at the University of Missouri–Columbia and later president of the American Psychological Association, asked six- to 15-year-olds what happens when you die. Consistent with the simulation-constraint hypothesis, many answers relied on everyday experience to describe death, "with references to sleeping, feeling 'peaceful,' or simply 'being very dizzy.'"

A Mind-Body Disconnect

But Koocher's study in itself doesn't tell us where such ideas come from. The simulation-constraint hypothesis posits that this type of thinking is innate and unlearned. Fortunately, this hypothesis is falsifiable. If afterlife beliefs are a product of cultural indoctrination, with children picking up such ideas through religious teachings, through the media, or informally through family and friends, then one should rationally predict that psychological-continuity reasoning *increases* with age. Aside from becoming more aware of their own mortality, after all, older kids have had a longer period of exposure to the concept of an afterlife.

In fact, recent findings show the opposite developmental trend. In a 2004 study reported in *Developmental Psychology,* Florida Atlantic University psychologist David F. Bjorklund and I presented 200 three- to 12-year-olds with a puppet show. Every child saw the story of Baby Mouse, who was out strolling innocently in the woods. "Just then," we told them, "he notices something very strange. The bushes are moving!

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An alligator jumps out of the bushes and gobbles him all up. Baby Mouse is not alive anymore."

Just like the adults from the previously mentioned study, the children were asked about dead Baby Mouse's psychological functioning. "Does Baby Mouse still want to go home?" we asked them. "Does he still feel sick?" "Can he still smell the flowers?" The youngest children in the study, the three- to five-year-olds, were significantly more likely to reason in terms of psychological continuity than children from the two older age groups were.

But here's the really curious part. Even the preschoolers had a solid grasp on biological cessation; they knew, for example, that dead Baby Mouse didn't need food or water anymore. They knew he wouldn't grow up to be an adult mouse. Heck, 85 percent of the youngest kids even told us that his brain no longer worked. Yet most of these very young children then told us that dead Baby Mouse was hungry or thirsty, that he felt better or that he was still angry at his brother.

One couldn't say that the preschoolers lacked a concept of death, therefore, because nearly all of the kids realized that biological imperatives no longer applied after death. Rather they seemed to have trouble using this knowledge to theorize about related mental functions.

From an evolutionary perspective, a coherent theory about psychological death is not necessarily vital. Anthropologist H. Clark Barrett of the University of California, Los Angeles, believes instead that understanding the cessation of "agency" (for example, that a dead creature isn't going to suddenly leap up and bite you) is probably what saved lives (and thus genes). According to Barrett, comprehending the cessation of the mind, on the other hand, has no survival value and is, in an evolutionary sense, unnecessary.

In a 2005 study published in the journal *Cognition*, Barrett and psychologist Tanya Behne of the University of Manchester in England reported that city-dwelling four-year-olds from Berlin were just as good at distinguishing sleeping animals from dead ones as hunter-horticulturalist children from the Shuar region of Ecuador were. Even today's urban children appear tuned in to perceptual cues signaling death. A "violation of the body envelope" (in other words, a mutilated carcass) is a pretty good sign that one needn't worry about tiptoeing around.

Religion is not the cause of afterlife beliefs; rather such cultural forces enhance and embellish our innate psychological tendency to believe the mind lives forever.

(The Author)

JESSE BERING is director of the Institute of Cognition and Culture at Queen's University Belfast in Ireland, where he studies how the evolved human mind plays a part in religious thinking. His new book, ***Under God's Skin***, is forthcoming from W. W. Norton in the spring of 2010.

The Culture Factor

On the one hand, then, from a very early age, children realize that dead bodies are not coming back to life. On the other hand, also from a very early age, kids endow the dead with ongoing psychological functions. So where do culture and religious teaching come into the mix, if at all?

In fact, exposure to the concept of an afterlife plays a crucial role in enriching and elaborating this natural cognitive stance; it's sort of like an architectural scaffolding process, whereby culture develops and decorates the innate psychological building blocks of religious belief. The end product can be as ornate or austere as you like, from the headache-inducing reincarnation beliefs of Theravada Buddhists to the man on the street's "I believe there's *something*" brand of philosophy—but it's made of the same brick and mortar just the same.

In support of the idea that culture influences our natural tendency to deny the death of the mind, Harvard University psychologist Paul Harris and researcher Marta Giménez of the National University of Distance Education in Spain showed that when the wording in interviews is tweaked to include medical or scientific terms, psychological-continuity reasoning decreases. In this 2005 study published in the *Journal of Cognition and Culture,* seven- to 11-year-old children in Madrid who heard a story about a priest telling a child that his grandmother "is with God" were more likely to attribute ongoing mental states to the decedent than were those who heard the identical story but instead about a doctor saying a grandfather was "dead and buried."

And in a 2005 replication of the Baby Mouse experiment published in the *British Journal of Developmental Psychology,* psychologist David Bjorklund and I teamed with psychologist Carlos Hernández Blasi of Jaume I University in Spain to compare children in a Catholic school with those attending a public secular school in Castellón, Spain. As in the previous study, an overwhelming majority of the youngest children—five- to six-year-olds—from both educational backgrounds said that Baby Mouse's mental states survived. The type of curriculum, secular or religious, made no difference. With increasing age, however, culture becomes a factor—the kids attending Catholic school were more likely to reason in terms of psychological continuity than were those at the secular school. There was even a smattering of young extinctivists in the latter camp.

Free Spirits

The types of cognitive obstacles discussed earlier may be responsible for our innate sense of immortality. But although the simulation-constraint hypothesis helps to explain why so many people believe in something as fantastically illogical as an afterlife, it doesn't tell us why

Why doesn't anyone believe that the immortal spirit stays happily in the body after death?

ROBERT STAHL *Getty Images*

At a very young age, we learn that when a person leaves our field of vision, he or she hasn't ceased to exist. This belief stubbornly persists after someone we know dies.

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> Culture develops and decorates the innate psychological building blocks of religious belief.

people see the soul unbuckling itself from the body and floating off like an invisible helium balloon into the realm of eternity. After all, there's nothing to stop us from having afterlife beliefs that involve the still active mind being entombed in the skull and deliriously happy. Yet almost nobody has such a belief.

Back when you were still in diapers, you learned that people didn't cease to exist simply because you couldn't see them. Developmental psychologists even have a fancy term for this basic concept: "person permanence." Such an offline social awareness leads us to tacitly assume that the people we know are *somewhere* doing *something*. As I'm writing this article in Belfast, for example, my mind's eye conjures up my friend Ginger in New Orleans walking her poodle or playfully bickering with her husband, things that I know she does routinely.

As I've argued in my 2006 *Behavioral and Brain Sciences* article, "The Folk Psychology of Souls," human cognition is not equipped to update the list of players in our complex social rosters by accommodating a particular person's sudden inexistence. We can't simply switch off our person-permanence thinking just because someone has died. This inability is especially the case, of course, for those whom we were closest to and whom we frequently imagined to be actively engaging in various activities when out of sight.

And so person permanence may be the final cognitive hurdle that gets in the way of our effectively realizing the dead as they truly are—infinitely in situ, inanimate carbon residue. Instead it's much more "natural" to imagine them as existing in some vague, unobservable locale, very much living their dead lives. M

(Further Reading)

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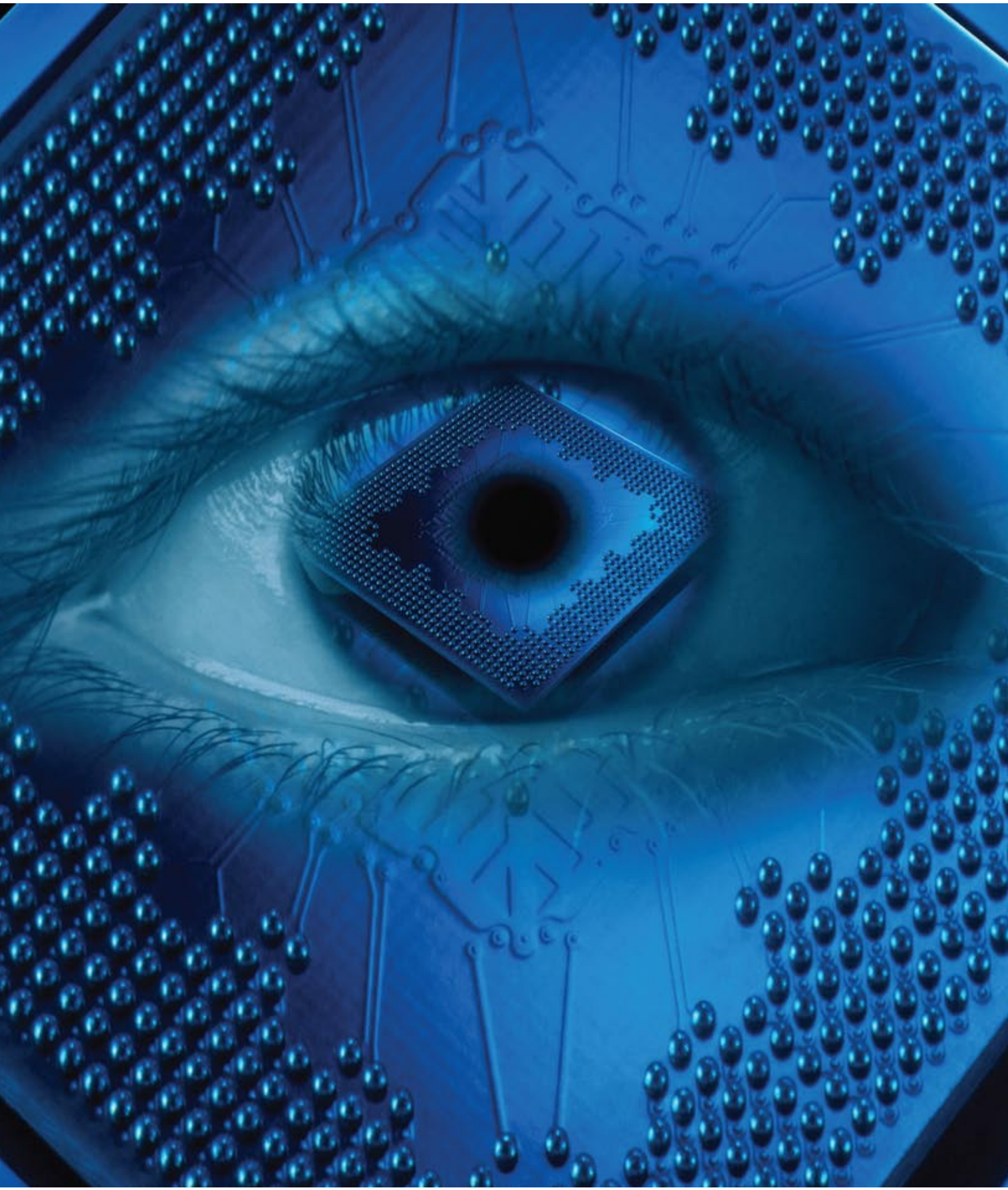

Meet Your iBrain

How the technologies that have become part of our daily lives are changing the way we think

By Gary Small and Gigi Vorgan

You're on a plane packed with other businesspeople, reading your electronic version of the *Wall Street Journal* on your laptop while downloading files to your BlackBerry and organizing your PowerPoint presentation for your first meeting when you reach New York. You relish the perfect symmetry of your schedule, to-do lists and phone book as you notice a woman in the next row entering little written notes into her leather-bound daily planner. You remember having one of those … What? Like a zillion years ago? Hey, lady! Wake up and smell the computer age. You're outside the airport now, waiting impatiently for a cab along with dozens of other people. It's finally your turn, and as you reach for the taxi door a large man pushes in front of you, practically knocking you over. Your briefcase goes flying, and your laptop and BlackBerry splatter into pieces on the pavement. As you frantically gather up the remnants of your once perfectly scheduled life, the woman with the daily planner book gracefully steps into a cab and glides away.

From the forthcoming book *iBrain: Surviving the Technological Alteration of the Modern Mind,* by Gary Small, M.D., and Gigi Vorgan.

JOHN RIZZO Getty Images

The current explosion of digital technology not only is changing the way we live and communicate but also is rapidly and profoundly altering our brains. Daily exposure to high technology—computers, smart phones, video games, search engines such as Google and Yahoo—stimulates brain cell alteration and neurotransmitter release, gradually strengthening new neural pathways in our brains while weakening old ones. Because of the current technological revolution, our brains are *evolving* right now—at a speed like never before.

Besides influencing how we think, digital technology is altering how we feel, how we behave. Seven out of 10 American homes are wired for high-speed Internet. We rely on the Internet and digital technology for entertainment, political discussion, and communication with friends and co-workers. As the brain evolves and shifts its focus toward new technological skills, it drifts away from fundamental social skills, such as reading facial expressions during conversation or grasping the emotional context of a subtle gesture. A 2002 Stanford University study found that for every hour we spend on our computers, traditional face-to-face interaction time with other people drops by nearly 30 minutes.

Digital Natives

Today's young people in their teens and 20s, who have been dubbed "digital natives," have never known a world without computers, 24-hour TV news, Internet and cell phones—with their video, music, cameras and text messaging. Many of these natives rarely enter a library, let alone look something up in a traditional encyclopedia; they use Google, Yahoo and other online search engines. The neural networks in the brains of these digital natives differ dramatically from those of "digital immigrants," people—including most baby boomers—who came to the digital/computer age as adults but whose basic brain wiring was laid down during a time when direct social interaction was the norm.

Now we are exposing our brains to technology for extensive periods every day, even at very young ages. A 2007 University of Texas at Austin study of more than 1,000 children found that on a typical day, 75 percent of children watch TV, whereas 32 percent of them watch videos or DVDs, with a total daily exposure averaging one hour and 20 minutes. Among those children, five- and six-year-olds spend an additional 50 minutes in front of the computer. A 2005 Kaiser Family Foundation study found that young people eight to 18 years of age expose their brains to eight and a half hours of digital and video sensory stimulation a day. The investigators reported that most of the technology exposure is passive, such as watching television and videos (four hours daily) or listening to music (one hour and 45 minutes), whereas other exposure is more active and requires mental participation, such as playing video games (50 minutes daily) or using the computer (one hour).

Daily exposure to high technology, including computers and video games, creates changes in the brain.

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FAST FACTS

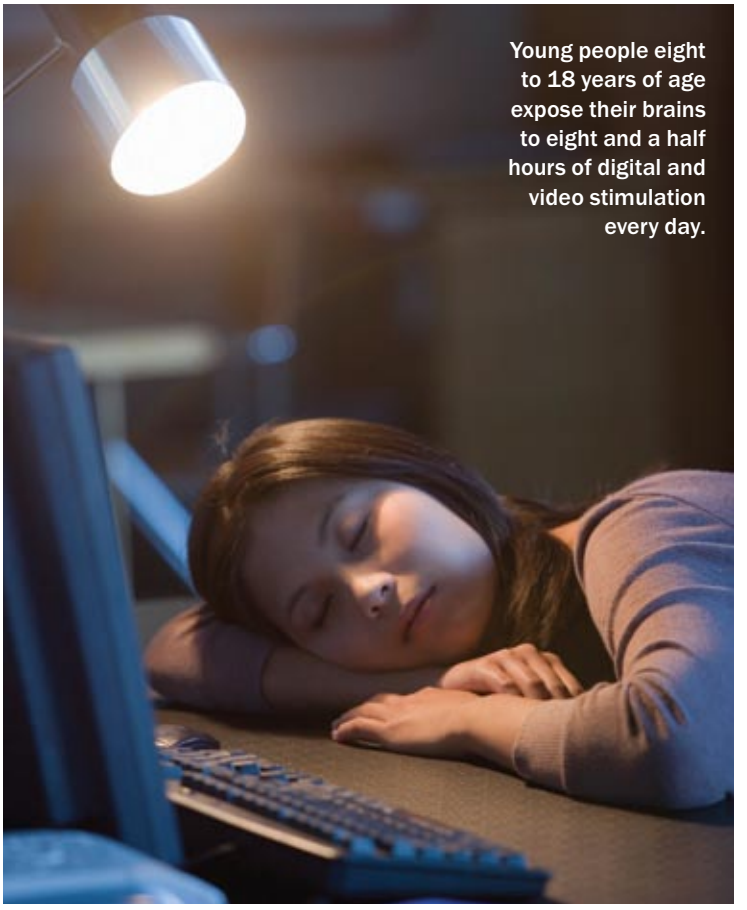
Your Brain on Technology

1» **The brain's plasticity—its ability to change in response to stimuli from the environment—is well known. What has been less appreciated is how the expanding use of technology is shaping neural processing.**

2» **Young people are exposed to digital stimulation for several hours every day, and many older adults are not far behind.**

3» **Even using a computer for Web searches for just an hour a day changes the way the brain processes information. A constant barrage of e-contacts is both stimulating—sharpening certain cognitive skills—and draining, studies show.**

We know that the brain's neural circuitry responds every moment to whatever sensory input it gets and that the many hours people spend in front of the computer—including trolling the Internet, exchanging e-mail, video conferencing, instant messaging and e-shopping—expose their brains to constant digital stimulation. Our research team at the University of California, Los Angeles, wanted to look at how much impact this extended computer time was having on the brain's neural circuitry, how quickly it could build up new pathways, and whether we could observe and measure these changes as they occurred.



Young people eight to 18 years of age expose their brains to eight and a half hours of digital and video stimulation every day.

Google in Your Head

One of us (Small) enlisted the help of Susan Bookheimer and Teena Moody, U.C.L.A. experts in neuropsychology and neuroimaging. We planned to use functional magnetic resonance imaging to measure the brain's activity during a common Internet computer task: searching Google for accurate information. We first needed to find people who were relatively inexperienced and naive to the computer.

Today's young people in their teens and 20s, who have been dubbed "digital natives," have never known a world without computers, 24-hour TV news, Internet and cell phones.

As the brain evolves and shifts its focus toward technology skills, it drifts away from social skills, such as reading facial expressions during a chat.

After initial difficulty finding people who had not yet used PCs, we were able to recruit three volunteers in their mid-50s and 60s who were new to the technology yet willing to give it a try. To compare the brain activity of these three naive volunteers, we also recruited three computer-savvy volunteers of comparable age, gender and socioeconomic background. For our experiment, we chose searching on Google for specific and accurate information on a variety of topics, ranging from the health benefits of eating chocolate to planning a trip to the Galápagos.

Next, we had to figure out a way to perform MRIs on the volunteers while they used the Internet. Because the study subjects had to be inside a long, narrow tube of an MRI machine during the experiment, there would be no space for a computer, keyboard or mouse. To re-create the Google-search experience inside the scanner, we had the volunteers wear a pair of special goggles that presented images of Web site pages. The system allowed the volunteers to navigate the simulated computer screen and make choices to advance their search by pressing one finger on

JUPITERIMAGES (*top*); GETTY IMAGES (*bottom*)

After just five days of practice, the exact same neural circuitry in the front part of the brain became active in Internet-naive subjects as in those who were computer-savvy.

a small keypad, conveniently placed.

To make sure that the fMRI scanner was measuring the neural circuitry that controls Internet searches, we needed to factor out other sources of brain stimulation. To do this, we added a control task in which the study subjects read pages of a book projected through the specialized goggles during the MRI. This task allowed us to subtract from the MRI measurements any nonspecific brain activations that resulted from simply reading text, focusing on a visual image or concentrating.

We wanted to observe and measure only the brain's activity from those mental tasks required for Internet searching, such as scanning for targeted key words, rapidly choosing from among several alternatives, going back to a previous page if a particular search choice was not helpful, and so forth. We alternated this control task—simply reading a simulated page of text—with the Internet-searching task. We also controlled for nonspecific brain stimulations caused by the photographs and drawings that are typically displayed on an Internet page.

Finally, to determine whether we could train the brains of Internet-naive volunteers, after the first scanning session we asked each volunteer to search the Internet for an hour every day for five days. We gave the computer-savvy volunteers the same assignment and repeated the fMRI scans on both groups after the five days of search-engine training.

Hours of unrelenting digital connectivity can create a unique type of brain strain, making people feel fatigued, irritable and distracted.

HANS-ULRICH OSTERWALDER SPL/Photo Researchers, Inc.

Brain Changes

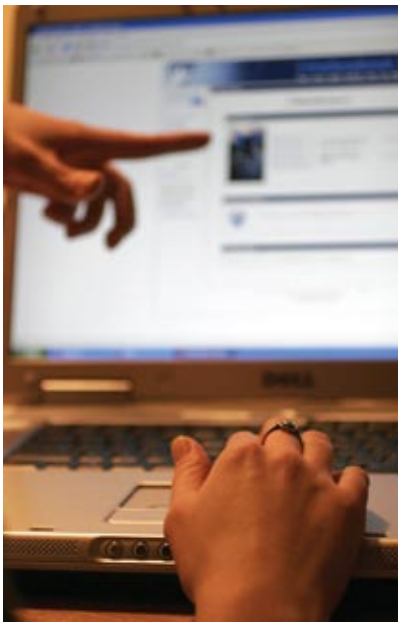
As we had predicted, the brains of computer-savvy and computer-naive subjects did not show any difference when they were reading the simulated book text; both groups had years of experience in this mental task, and their brains were quite familiar with reading books. In contrast, the two groups showed distinctly different patterns of neural activation when searching on Google. During the baseline scanning session, the computer-savvy subjects used a specific network in the left front part of the brain, known as the dorsolateral prefrontal cortex. The Internet-naive subjects showed minimal, if any, activation in this region.

One of our concerns in designing the study was that five days would not be enough time to observe any changes. But after just five days of practice, the exact same neural circuitry in the front part of the brain became active in the Internet-naive subjects. Five hours on the Internet, and these participants had already rewired their brains. The computer-savvy volunteers activated the same frontal brain region at baseline and had a similar level of activation during their second session, suggesting that for a typical computer-savvy individual, the neural circuit training occurs relatively early and then remains stable.

The dorsolateral prefrontal cortex is involved in our ability to make decisions and integrate complex information. It also is thought to control our mental process of integrating sensations and thoughts, as well as working memory, which is our ability to keep information in mind for a very short time—just long enough to manage an Internet-searching task or to dial a phone number after getting it from directory assistance.

In today's digital age, we keep our smart phones at our hip and their earpieces attached to our ears. A laptop is always within reach, and there's no need to fret if we can't find a landline—there's always Wi-Fi (short for wireless fidelity, which supplies a wireless connection to the Internet) to keep us connected.

Our high-tech revolution has plunged us into a state



JACK HOWARD *Star Ledger*/*Corbis* (*left*); GETTY IMAGES (*right*)

of "continuous partial attention," which software executive Linda Stone, who coined the term in 1998, describes as continually staying busy—keeping tabs on everything while never truly focusing on anything. Continuous partial attention differs from multitasking, wherein we have a purpose for each task and we are trying to improve efficiency and productivity. Instead, when our minds partially attend, and do so continuously, we scan for an opportunity for any type of contact at every given moment. We virtually chat as our text messages flow, and we keep tabs on active buddy lists (friends and other screen names in an instant message program); everything, everywhere, is connected through our peripheral attention.

Although having all our pals online from moment to moment seems intimate, we risk losing personal touch with our real-life relationships and may experience an artificial sense of intimacy as compared with when we shut down our devices and devote our attention to one individual at a time.

Techno-Brain Burnout

When paying continuous partial attention, people may place their brain in a heightened state of stress. They no longer have time to reflect, contemplate or make thoughtful decisions. Instead they exist in a sense of constant crisis—on alert for a new contact or bit of exciting news or information at any moment. Once people get used to this state, they tend to thrive on the perpetual connectivity. It feeds their ego and sense of self-worth, and it becomes irresistible.

Neuroimaging studies suggest that this sense of self-worth may protect the size of the hippocampus—the horseshoe-shaped brain region in the medial (inward-facing) temporal lobe, which allows us to learn and remember new information. Psychiatry professor Sonia J. Lupien and her associates at McGill University studied hippocampal size in healthy younger and older adult volunteers. Measures of self-esteem correlated significantly with hippocampal size, regardless of age. They also found that the more people felt in control of their lives, the larger the hippocampus.

Constantly staying busy monitoring buddy lists and instant messages can create a distracted mental state called continuous partial attention.

But at some point, the sense of control and self-worth we feel when we maintain continuous partial attention tends to break down—our brains were not built to sustain such monitoring for extended periods. Eventually the hours of unrelenting digital connectivity can create a unique type of brain strain. Many people who have been working on the Internet for several hours without a break report making frequent errors in their work. On signing off, they notice feeling spaced out, fatigued, irritable and distracted, as if they are in a "digital fog." This new form

(The Authors)

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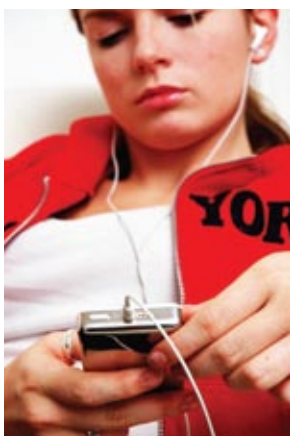


Altering our neural networks and synaptic connections through video games and other technological experiences does sharpen some cognitive abilities. We can learn to react more quickly to visual stimuli and improve many forms of attention, particularly the ability to notice images in our peripheral vision.

of mental stress, what Small terms "techno-brain burnout," is threatening to become an epidemic. Under this kind of stress, our brains instinctively signal the adrenal gland to secrete cortisol and adrenaline. In the short run, these stress hormones boost energy levels and augment memory, but over time they actually impair cognition, lead to depression, and alter the neural circuitry in the hippocampus, amygdala and prefrontal cortex—the brain regions that control mood and thought. Chronic and prolonged techno-brain burnout can even reshape the underlying brain structure.

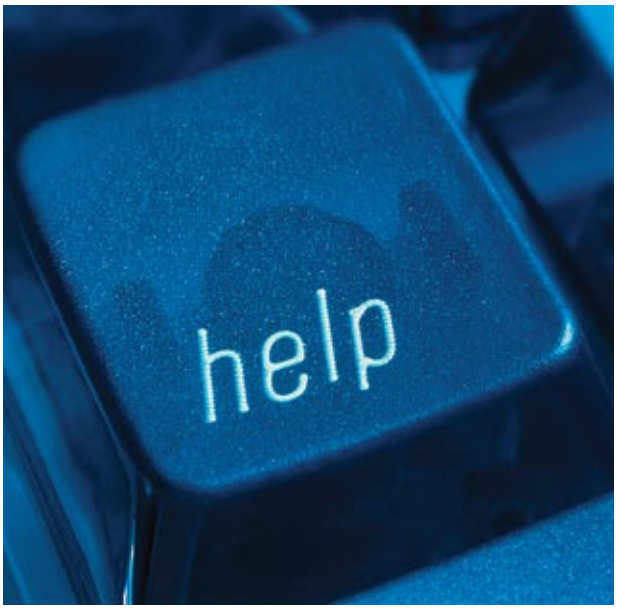
Research psychologist Sara C. Mednick, then at Harvard University, and her colleagues were able to induce a mild form of techno-brain burnout in volunteers experimentally; they then were able to reduce its impact through power naps and by varying mental assignments. Their study subjects performed a visual task: reporting the direction of three lines in the lower left corner of a computer screen. The volunteers' scores worsened over time, but their performance improved if the scientists alternated the visual task between the lower left and lower right corners of the computer screen. This result suggests that brain burnout may be relieved by varying the location of the mental task.

JUPITERIMAGES (*playing video games*); JAMES LANGE *PYMCA/jupiterimages (using iPod)*; GETTY IMAGES (*text messaging*)

The investigators also found that the performance of study subjects improved if they took a 20- to 30-minute nap. The neural networks involved in the task were apparently refreshed during rest; however, optimum refreshment and reinvigoration for the task occurred when naps lasted up to 60 minutes—the amount of time it takes for rapid-eye-movement (REM) sleep to kick in.

The New, Improved Brain?

Whether we're digital natives or immigrants, altering our neural networks and synaptic connections through activities such as e-mail, video games, Googling or other technological experiences does sharpen some cognitive abilities. We can learn to react more quickly to visual stimuli and improve many forms of attention, particularly the ability to notice images in our peripheral vision. We develop a better ability to sift through large amounts of information rapidly and decide what's important and what isn't—our mental filters basically learn how to shift into overdrive. In this way, we are able to cope with the massive amounts of data appearing and disappearing on our mental screens from moment to moment. Initially the daily blitz that bombards us can create a form of attention deficit, but our brains are able to adapt in a way that promotes rapid processing.



STEVEN PUETZER *Getty Images*

All of us, digital natives and immigrants, will master new technologies and take advantage of their efficiencies, but we also need to maintain people skills and our humanity.

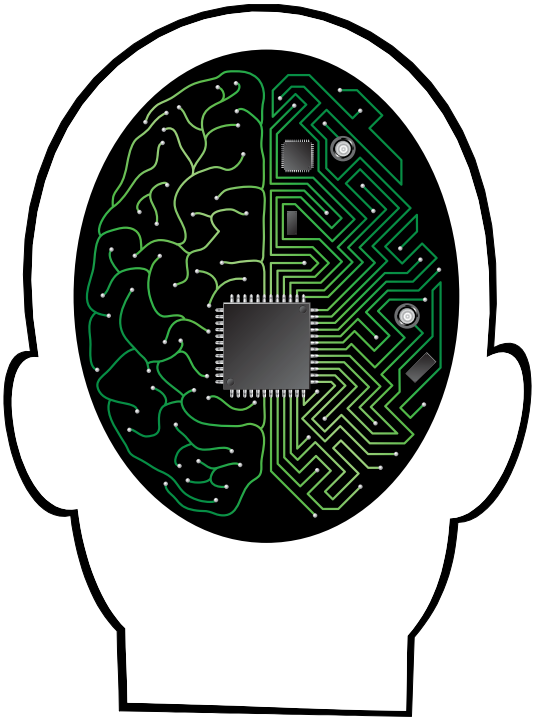
According to cognitive psychologist Pam Briggs of Northumbria University in England, Web surfers looking for facts on health spend two seconds or less on any particular site before moving on to the next one. She found that when study subjects did stop and focus on a particular site, that site contained data relevant to the search, whereas those they skipped over contained almost nothing relevant to the search. This study indicates that our brains learn to swiftly focus attention, analyze information and almost instantaneously decide on a go or no-go action. Rather than simply catching "digital ADD," many of us are developing neural circuitry that is customized for rapid and incisive spurts of directed concentration.

Digital evolution may well be increasing our intelligence in the way we currently measure and define IQ. Average IQ scores have been steadily rising with the advancing digital culture, and the ability to multitask without errors is improving. Neuroscientist Paul Kearney of Unitec in New Zealand reported that some computer games can actually improve cognitive ability and multitasking skills. He found that volunteers who played the games eight hours a week improved multitasking skills by two and a half times. Other research at the University of Rochester has shown that playing video games can improve peripheral vision as well. As the modern brain continues to evolve, some attention skills improve, mental response times sharpen and the performance of many brain tasks becomes more efficient.

While the brains of today's digital natives are wiring up for rapid-fire cyber searches, however, the neural circuits that control the more traditional learning methods are neglected and gradually diminished. The pathways for human interaction and communication weaken as customary one-on-one people skills atrophy. Our U.C.L.A. research team and other scientists have shown that we can intentionally alter brain wiring and reinvigorate some of these dwindling neural pathways, even while the newly evolved technology circuits bring our brains to extraordinary levels of potential.

All of us, digital natives and immigrants, will master new technologies and take advantage of their efficiencies, but we also need to maintain our people skills and our humanity. Whether in relation to a focused Google search or an empathic listening exercise, our synaptic responses can be measured, shaped and optimized to our advantage, and we can survive the technological adaptation of the modern mind. M

Putting **Thoughts** into **Action**



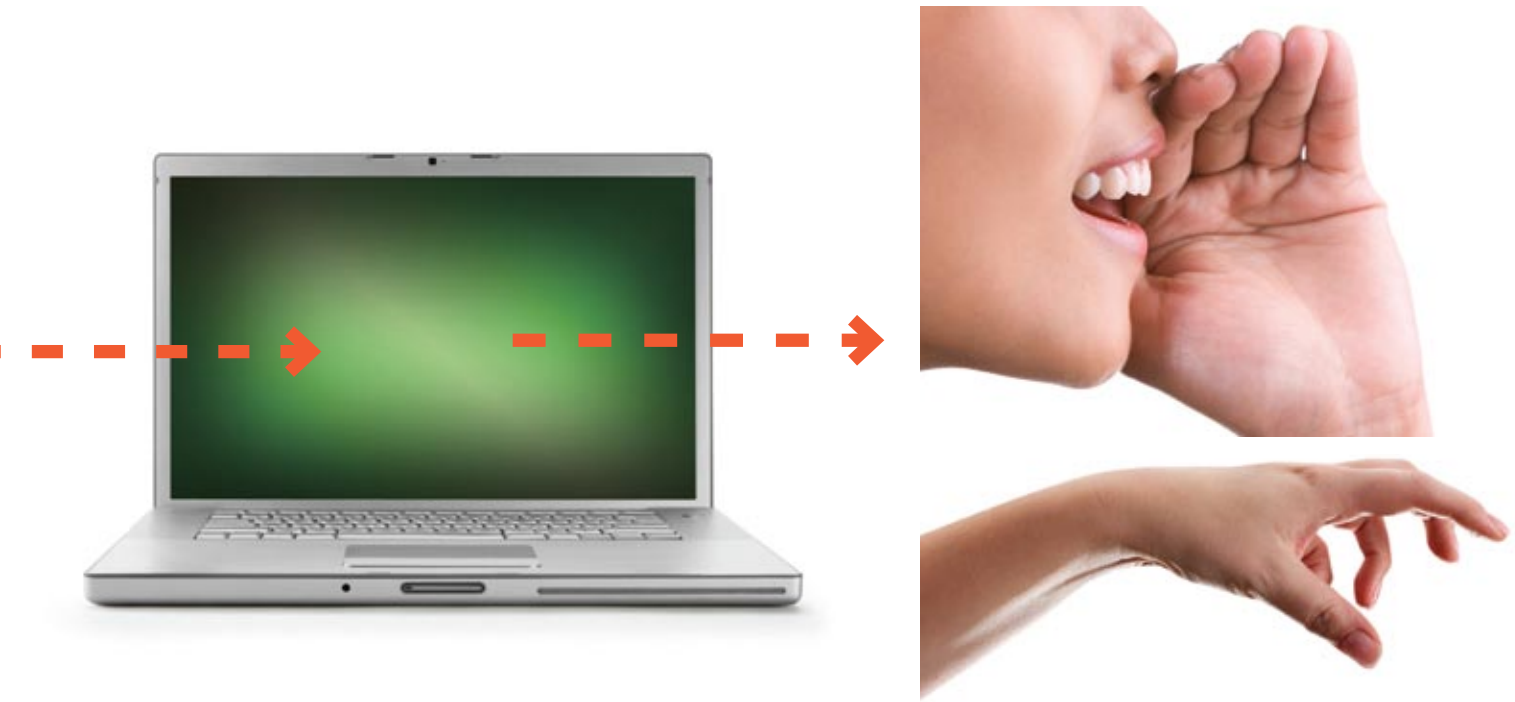
Researchers are decoding the brain to give a voice and a hand to the paralyzed—and to learn how it controls our movements

By Alan S. Brown

Eight years ago, when Erik Ramsey was 16, a car accident triggered a brain stem stroke that left him paralyzed. Though fully conscious, Ramsey was completely paralyzed, essentially "locked in," unable to move or talk. He could communicate only by moving his eyes up or down, thereby answering questions with a yes or a no.

Ramsey's doctors recommended sending him to a nursing facility. Instead his parents brought him home. In 2004 they met neurologist Philip R. Kennedy, chief scientist at Neural Signals in Duluth, Ga. He offered Ramsey the chance to take part in an unusual experiment. Surgeons would implant a high-tech device called a neural

EMANUELE FERRARI *iStockphoto (brain/circuit board)*



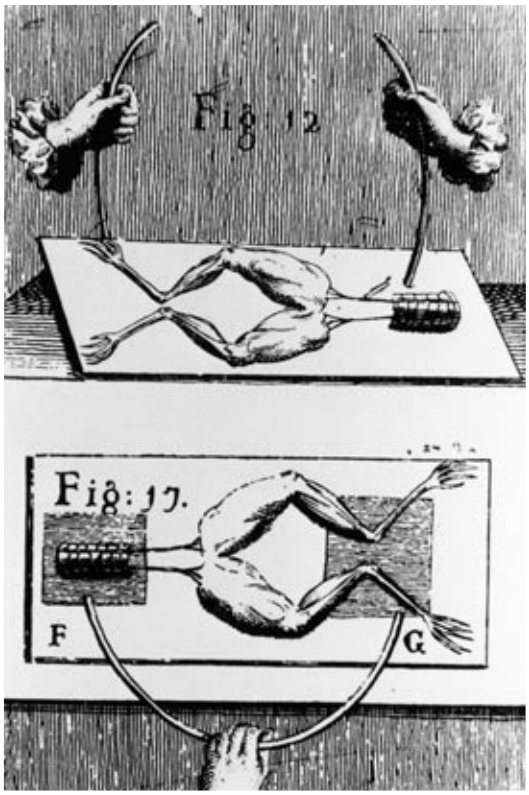
ISTOCKPHOTO (*laptop*); RUDYANTO WIJAYA (*whisper*) AND JANNE AHVO (*hand*) *iStockphoto*

prosthesis into Ramsey's brain, enabling him to communicate his thoughts to a computer that would translate them into spoken words.

Today Ramsey sports a small metal electrode in his brain. Its thin wires penetrate a fraction of an inch into his motor cortex, the part of the brain that controls movement, including the motion of his vocal muscles. When Ramsey thinks of saying a sound, the implant captures the electrical firing of nearby neurons and transmits their impulses to a computer, which decodes them and produces the sounds. So far Ramsey can only say a few simple vowels, but Kennedy believes that he will recover his full range of speech by 2010.

Ramsey's neural prosthesis ranks among the most sophisticated implanted devices that translate thoughts into actions. Such systems listen to the brain's instructions for movement—even when actual movement is no longer possible—and decode the signals for use in operating a computer or moving a robot. The technology needed for such implants, including powerful microprocessors, improved filters and longer-lasting batteries, has advanced rapidly in the past few years. Funding for such projects has also grown. The U.S. Department of Defense, for example, sponsors research in prosthetics for wounded war veterans.

Only nine people, Ramsey included, have received brain-implanted prostheses. In the past, patients have used them to spell words on a computer, pilot a wheelchair or flex a mechanical hand. Monkeys have employed them to perform more complex tasks such as maneuvering mechanical arms to grab food or controlling a walking robot on a treadmill [see "Chips in Your Head," by Frank W. Ohl and Henning Scheich; Scientific American Mind, April/May 2007].



Eighteenth-century Italian physicist Luigi Galvani showed that electricity can power muscle movement. Galvani made frog legs twitch with current created by bringing two metal rods (*top*) or foils (*bottom*) into contact.

SPL/PHOTO RESEARCHERS, INC.

Other experimental brain-computer interfaces read the brain's output noninvasively, through electrodes attached to the human scalp [see "Thinking Out Loud," by Nicola Neumann and Niels Birbaumer; Scientific American Mind, December 2004].

The technology promises to give thousands of victims of stroke, spinal cord injury and paralyzing illnesses the ability to, say, talk with a friend, flip through television channels or transport themselves by driving their own wheelchair. One day implants may enable paralyzed people to move robotic arms or even bypass damaged parts of the nervous system to reanimate unresponsive limbs. In the meantime, the quest to develop implanted neural prostheses is bringing with it revelations about how the brain manages motion and how it can remodel itself so that only a few neurons are needed to direct action through an implant.

FAST FACTS

Speaking Your Mind

1» **Surgeons have implanted a novel neural prosthesis into a paralyzed patient's brain. The high-tech device enables the patient to communicate his thoughts to a computer, which translates them into spoken words.**

2» **Nine people so far have received brain-implanted prostheses. In the past, patients have used these devices to spell words on a computer, pilot a wheelchair or flex a mechanical hand.**

3» **One day implants may enable paralyzed people to move robotic arms or even bypass damaged parts of the nervous system to reanimate unresponsive limbs. In the meantime, the quest to develop implanted neural prostheses is revealing details of how the brain orchestrates movement.**

The brain's motor cortex

Eavesdropping

Scientists have known for more than 220 years that electricity somehow controls muscle movement. In 1783 Italian physician Luigi Galvani, a contemporary of Benjamin Franklin, discovered that electric currents caused a severed pair of frog legs to twitch. By the 1860s German military doctors had discovered that small electric currents applied to the brain could cause certain muscles to contract. Over the following decades, dedicated researchers mapped which regions of the motor cortex control which groups of muscles in the body. But to discover how the brain actually orchestrates movement, scientists had to find a way to eavesdrop on the neural signals in the motor cortex while animals were awake and moving.

This task proved problematic until investigators figured out how to stably affix an electrode, a tiny sliver of conductive wire, to a neuron so they could register its weak, milliseconds-long pulses. When animals move, their brains shift slightly within their skulls, and the motions can rip an electrode from its anchor in the brain. In the late 1950s neurologists found that flooding the space between the skull and the brain with inert wax or neutral oil buffered the brain the way Styrofoam peanuts keep a box from moving inside a larger package. The buffer prevented a brain from shaking off its implant.

Despite this fix, no one could make sense at first of the chatter of individual neurons in the motor cortex. Researchers expected a one-to-one correspondence between the neurons that fired and the muscles that contracted during movements. But when they looked at individual neurons, they found the neurons would fire when a monkey moved its arm forward or backward or even when it kept the arm still.

calculates the trajectory required for a hand to reach a target.

In the late 1970s neurologist Apostolos Georgopoulos, now at the U.S. Department of Veterans Affairs and the University of Minnesota, had a brainstorm. The spinal cord exerts direct control over muscles, Georgopoulos realized. Thus, he supposed that the motor cortex might be directing movement at a somewhat higher level, specifying a trajectory rather than the muscles and joints needed to accomplish a movement.

To test his idea, Georgopoulos developed something called the center-out task, in which monkeys learn to move a joystick toward one of six targets arrayed in a semicircle. "Until then, all the research designs focused on very simple movements—forward, stop, back," he explains. "In our experiment, the monkey was changing the position of its shoulder, elbow and wrist simultaneously."

No one had looked at such complex motions before—or analyzed the data the way Georgopoulos and his colleagues did. Instead of trying to correlate the firing of particular neurons with the contractions of certain muscles, he averaged the responses of small groups of neurons over thousands of experiments. From that average, he saw through the noise that neurons produce when they direct motion, engage in other tasks or just fire spuriously. Although individual neurons fired with every movement, each neuron had a preferred direction: when the monkey moved the joystick that way, its firing frequency peaked. Neighboring neurons with similar preferred directions also became more excited. The closer a monkey's arm moved to a neuron's preferred direction, the more rapidly it fired; the farther away the arm moved, the more slowly it fired.

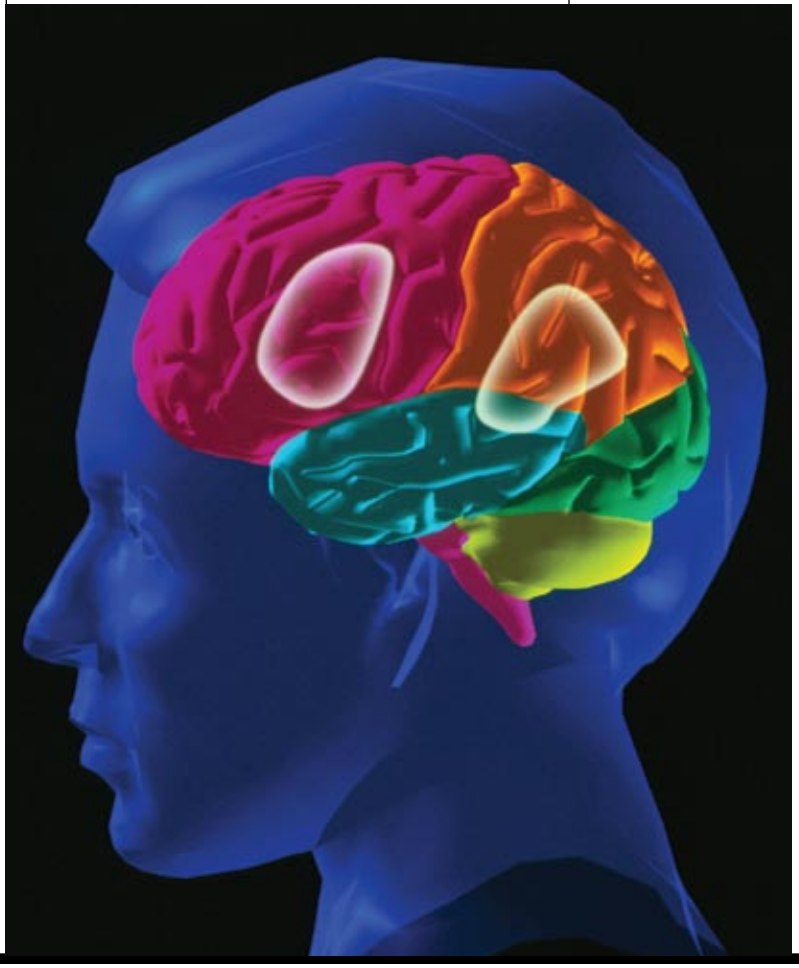
"It's a sort of democracy," Georgopoulos explains. "A given cell will keep voting on the direction of the movement, whether it's in the majority or the minority, but the majority always rules. And the majority vote is an excellent predictor of direction." In this way, the motor cortex sets a strategy for a movement. It calculates the direction (and, as Georgopoulos and others later found, the acceleration) needed for the hand to reach a target. It then sends the information to the spinal cord, which implements that strategy by operating muscles. Those more general commands from the brain, researchers believed, might indeed be useful for controlling external devices.

Making a Move

But progress on developing a neural prosthesis that could translate thoughts into action was slow. At first the electrodes were unreliable, and the electrical connections were sometimes finicky. The neurons themselves would also act unpredictably.

"Brain cells don't behave the same way every time. Perhaps the cells are changing, or maybe the patient is tense or tired," says Brown University neuroscientist John Donoghue, the second scientist after Kennedy to develop a neural prosthesis for human implantation.

Researchers also despaired at the problem of gleaning useful information from a relatively small number of neurons. "Usually the brain uses millions of neurons to perform a motor task. Now we're asking people with prostheses attached to maybe 50 neurons to do the same thing," Donoghue says. Yet those few neurons proved surprisingly capable.



ALFRED PASIEKA *SPL/Photo Researchers, Inc.*

In the brain's language areas (*white circles*), neurons decode or compose written and spoken messages. One language center sits in the frontal lobe (*red*), and the other resides largely in the parietal lobe (*orange*). The brain's speech-production regions occupy an area between the two language centers.

Implant pioneer Eberhard Fetz, a biophysicist at the University of Washington, recalls experiments conducted in the late 1970s and early 1980s in which a monkey learned to use an implant to move the dial on an electrical meter to receive a drop of applesauce. Fetz and his team did not train the monkey, but it quickly learned to control the needle by trial and error, just by thinking. "He learned that there was something he could do to drive the meter to the right and trigger the feeder," Fetz recalls. "Once he got the hang of it, he could do it every time."

Neuroscientists believe that once the monkey chanced on a successful pattern of neural impulses, continued successes triggered the rewiring of its brain to create a faster and more efficient mechanism for repeating that pattern. This process also underpins other types of motor learning, such as that required to manipulate a fork or chopsticks. That is, the monkey learned to work the dial as if it were an extension of the monkey's own body—which, in many ways, it was.

The ability of the brain to rewire itself on the fly is called plasticity. Investigators see examples of it all the time. In 2002 neurobiologist Andrew Schwartz of the University of Pittsburgh and his colleagues reported brain plasticity in a monkey that was trained to hit a target in a 3-D virtual-reality game using a ball that it controlled with its thoughts. Once the monkey learned to hit the target every time, Schwartz altered the settings so that the ball veered a few degrees to the right. Within about five minutes the monkey had adapted to the adjustment and began hitting the target again. "The only way the monkey could correct the error was by changing the firing of the neurons that we were recording," Schwartz explains.

This past June, Schwartz's team reported teaching a monkey to manipulate a gripper on a hinged double-jointed robotic arm to lift food off a hook. Ordinarily the brain uses millions of neurons to control such a multipart, intricate movement. The monkey learned to retrieve the food, at least some of the time, with an implant that read the signals from only a few dozen neurons.

Connecting with People

With time, researchers parlayed their monkey studies into pilot trials with paralyzed people. Early implants generally enabled patients to translate their thoughts into simple actions, such as moving a computer cursor in one or two dimensions rather than using the complex, three-dimensional actions of a robotic arm.

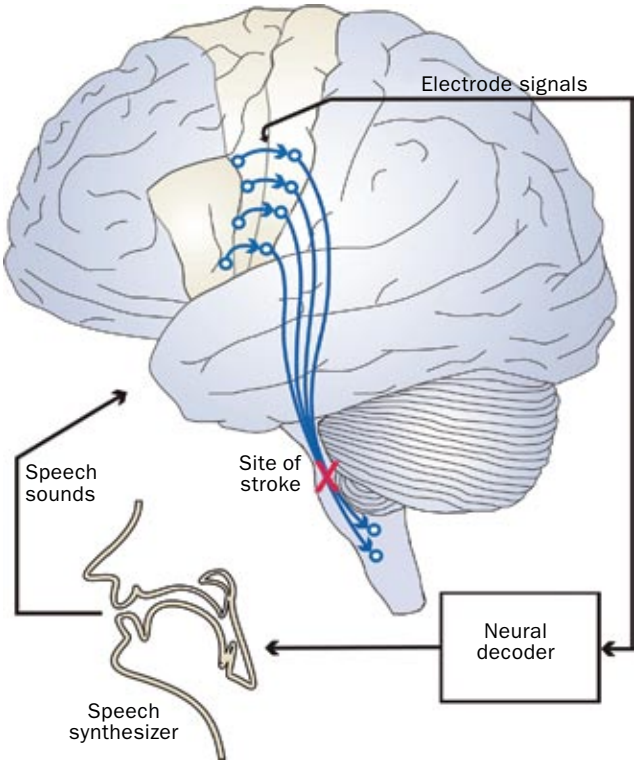
The monkey learned to move a dial on a meter as if it were an

MOTORLAB, UNIVERSITY OF PITTSBURGH SCHOOL OF MEDICINE

In this time-lapse image, a monkey with an implanted neuronal prosthesis uses thought alone to direct a motorized prosthetic arm to pick up food and deliver the food to its mouth.

In 1996, for example, a group of surgeons working under Kennedy inserted the first neural prosthesis into the brain of a paralyzed former teacher and artist in the terminal stages of amyotrophic lateral sclerosis, a progressive paralysis also known as Lou Gehrig's disease. In the two months after the surgery, the woman learned to use it to turn on and off lights on a computer screen. A few years later a second patient, a locked-in 53-year-old former drywall contractor named Johnny Ray, learned to use the implant to move a cursor to pick out computer icons, spell words and generate musical tones.

Since then, seven more patients have received implants. With each one, the technology became more versatile and reliable. The surgical procedures, too, have come a long way since experimenters had to stabilize electrodes with wax. Kennedy, for example, has developed a cone-shaped electrode that contains chemicals to encourage neuron growth. Surgeons make a small hole in the skull above the ear and over the motor cortex and secure the electrode to the bone. When nearby neurons grow into the cone, they



In the first neural prosthesis for speech, an electrode (*below*) captures signals from the speech motor cortex (*gray area*) and transmits them to a receiver under the scalb (*not shown*). From there the signals travel wirelessly to a recorder and amplifier (*not shown*) and then to a computer. A decoder translates the signals into sound data for a speech synthesizer. Blue lines are motor output pathways for speech, which were damaged by a stroke.

COURTESY OF FRANK H. GUENTHER *Boston University (brain diagram)*; COURTESY OF PHILIP R. KENNEDY *Neural Signals, Inc. (electrode implant)*

extension of its own body.

begin transmitting electrical signals to the electrode, which transmits them to a wireless receiver attached to the top of the head.

Researchers have also tried to improve the fidelity of the signals they receive by tapping more neurons. Donoghue and his colleagues developed an electrode array capable of receiving signals from 96 individual neurons. In 2004 neurosurgeons implanted it into the brain of 24-year-old Matthew Nagle of Weymouth, Mass., who was paralyzed when he intervened in a fight and was knifed through the spinal cord. Within only minutes of calibrating the prosthesis, Nagle could move a cursor on a computer. Over the next three years, before he died from an unrelated infection, he learned to control a television, check e-mail, and open and close an artificial hand. He made some rudimentary attempts to draw, which requires fine-motor control. His first attempt to sketch a circle wandered all over the screen, his second try led to more pronounced curves and his third produced an oval.

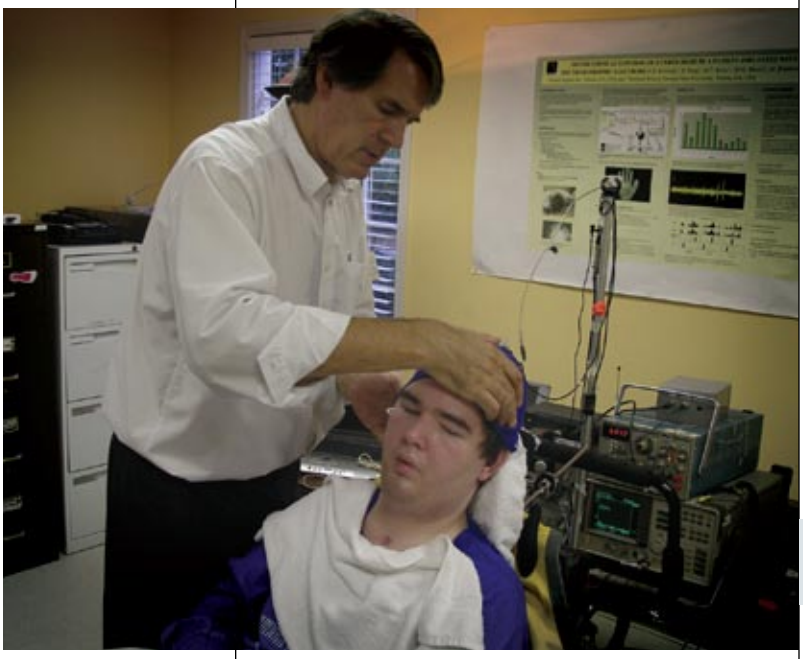
As investigators accumulate experience with human prostheses, they have raised their sights. Donoghue, for example, is teaming up with biomedical engineer Hunter Peckham of Case Western Reserve University, who has developed an electrical device that stimulates nerves or muscles to enable some movement after a partial or lower-level spinal cord injury. But Peckham's system alone allows only simple, preprogrammed motions, such as boosting a person from a wheelchair to a walker. By linking a neural prosthesis to the device, however, Donoghue and Peckham hope to create a system that gives users greater flexibility. "Our goal is that within five years we will have a brain-controlled system that lets a tetraplegic take a glass of water, lift it and bring it to the mouth," Donoghue says.

Fetz hopes to eventually connect a brain prosthesis directly to the spinal cord to flexibly reanimate nerves and muscles after spinal cord injuries. Such a device would tap the cord's natural ability to coordinate groups of muscles.

Neurologist Richard A. Andersen of the California Institute of Technology is taking a different tack. Instead of decoding the motor cortex, he wants to capture the brain's intentions before they become motor commands. Andersen be-

(The Author)

ALAN S. BROWN is a freelance journalist living in Dayton, N.J. He writes mostly about science and engineering and about their importance in business, society and education.



Neurologist Philip R. Kennedy prepares Erik Ramsey, who became paralyzed after a stroke, for a test of his brain implant, which enables him to utter sounds and will eventually allow him to speak.

lieves those commands originate in the posterior parietal cortex (PPC), an area near the top of the back of the head that transforms sensory stimuli into a movement blueprint. Unlike the motor cortex, which estimates the trajectory an arm must take to reach a target, neurons in the PPC produce "goal" signals that specify the target itself. Recently Andersen and his colleagues at the Massachusetts Institute of Technology and McGill University showed that the PPC also predicts and adjusts for changes in a target's motion.

The PPC's focus on the goal makes tapping it potentially more efficient than reading a brain area that plots trajectories, Andersen says. A prosthesis implanted in the PPC might enable a patient to rapidly pick out letters on a screen to spell out words—just as fast-touch typists do on a keyboard. Because of its flexibility, such a prosthesis might let a user operate a wider range of devices than a motor cortex implant designed to control specific movements would. Andersen is hoping to embed the appropriate electronics into a person's parietal cortex within a year or two.

Researchers hope to link a neural prosthesis to a device (*right*) that stimulates nerves or muscles to enable movement. Such a combination might enable a patient to use brain signals to control his or her limbs.

Finding a Voice

Kennedy's speech prosthesis arguably poses the greatest challenge yet because he had almost no experimental data on which to base its operation. After all, monkeys do not speak, and Ramsey is the first person to receive an implant to produce speech. This means that Kennedy must find a way to separate speech signals from neural noise without animal research to guide him.

Ramsey's implant connects with about 50 neurons in the part of his motor cortex that translates how he thinks a syllable should sound into the muscle commands to make the syllable. The implant captures the signals that control the coordinated motion of his mouth, lips and tongue to form sounds.

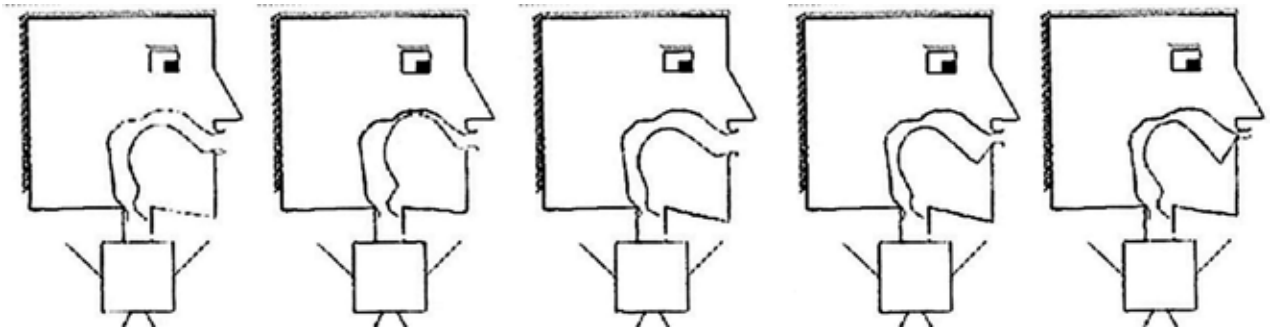
The link between Ramsey's neural implant and speech is a sophisticated computer program called Directions into Velocities of Articulators (DIVA), developed by Frank H. Guenther, a cognitive neuroscientist at Boston University. DIVA is a mathematical description of how the brain controls speech, parsing the process into eight parts that represent different speech functions in the brain. Mathematical formulas define neural firing rates in each area and neuronal connections among areas. DIVA made it possible to build a neural decoder that can decipher the speech signals amid the neural noise coming out of Ramsey's implant. The decoder translates the speech signals into sound data that it sends to a speech synthesizer, which generates human sounds [*see illustration on preceding page*].

Guenther built DIVA by scouring the research literature on the brain's speech centers. His group continually refines the program through additional experiments. "If we want to investigate how the brain corrects speech, we'll perturb a volunteer's speech. They may say 'bet,' but they hear 'bit.' Our model might predict that four parts of the brain should light up when they hear the perturbed sound, and we'll see how that compares with what happens on a [brain] image. If the image lights up in five places, then we update the model to reflect this new information."

DIVA learns to speak from experience. Initially DIVA babbles like a human infant. As it

One paralyzed patient

COURTESY OF EDDIE RAMSEY (*Erik Ramsey*); COURTESY OF THE CLEVELAND FES CENTER (*stimulation device*)



A computer program called Directions into Velocities of Articulators (DIVA) explains how neural speech signals generated in the brain's speech motor cortex can control virtual articulators that produce synthetic speech. Above, a cartoon depiction of this imaginary tongue, jaws, lips and larynx is uttering, from left to right, the vowel sounds "eh," "ee," "ah," "uh" and "oo."

improved his synthetic speech by adjusting his brain signals.

"listens" to the resulting sounds and "senses" the position of its virtual muscles, it uses the feedback to modify its mathematical relationships to speak more clearly. "Then comes the imitation stage," Guenther says. "We have a human say something, and the model tries to reproduce it. It will be wrong at first, but DIVA will use feedback to keep getting it closer. It usually takes about five or six attempts to get it right."

Similarly, the neural decoder based on DIVA does not accurately translate Ramsey's initial attempts to speak, in part because the computer program receives input from just a tiny fraction of the millions of neurons that are involved in speech. The program and Ramsey, however, get better with practice. Guenther starts this learning process by playing a sequence of vowel sounds on a computer—vowels are easier to pronounce than consonants—and Ramsey sings along in his mind. Ramsey and the decoder botched their first five attempts at each of the first three vowels. But then Ramsey adjusted his brain signals based on the feedback from the synthetic sounds the computer produced, and on the next five, he got three or more right.

"Ramsey was able to quickly improve his performance by adjusting the brain signals that were sent to the synthesis system," Guenther recalls. "Most of this learning is subconscious motor learning, like learning to shoot baskets or whistle or ride a bike, rather than requiring a conscious attempt to change the way one communicates." It is slow, arduous work. Ramsey has only enough energy for two or three weekly sessions that usually last no more than an hour or two.

Eventually Kennedy hopes to implant more electrodes in different parts of the brain's speech motor region to provide richer neural input for the speech program. "We'd like to have several electrodes spread out over areas that control the tongue, mouth, jaw and facial muscles. If we had more implants, that would give us even better resolution."

From such endeavors, the neurologist hopes to change the lives of tens of thousands of people. Those who are now entombed within their own bodies will once again be able to communicate and connect with friends, caretakers and family. People who cannot move from room to room or change a television on their own will find a new freedom. Wounded warriors returning from battle may receive artificial limbs that respond to their unspoken commands.

Erik Ramsey is just the beginning. M

(Further Reading)

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- **Cortical Interactions Underlying the Production of Speech Sounds.** Frank H. Guenther in *Journal of Communication Disorders,* Vol. 39, No. 5, pages 350–365; September/October 2006.
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- Cognitive and Neural Systems Speech Lab at Boston University: **http://speechlab.bu.edu/prosthetics.php**
- Web site of Andrew Schwartz of the University of Pittsburgh: **http://motorlab.neurobio.pitt.edu**

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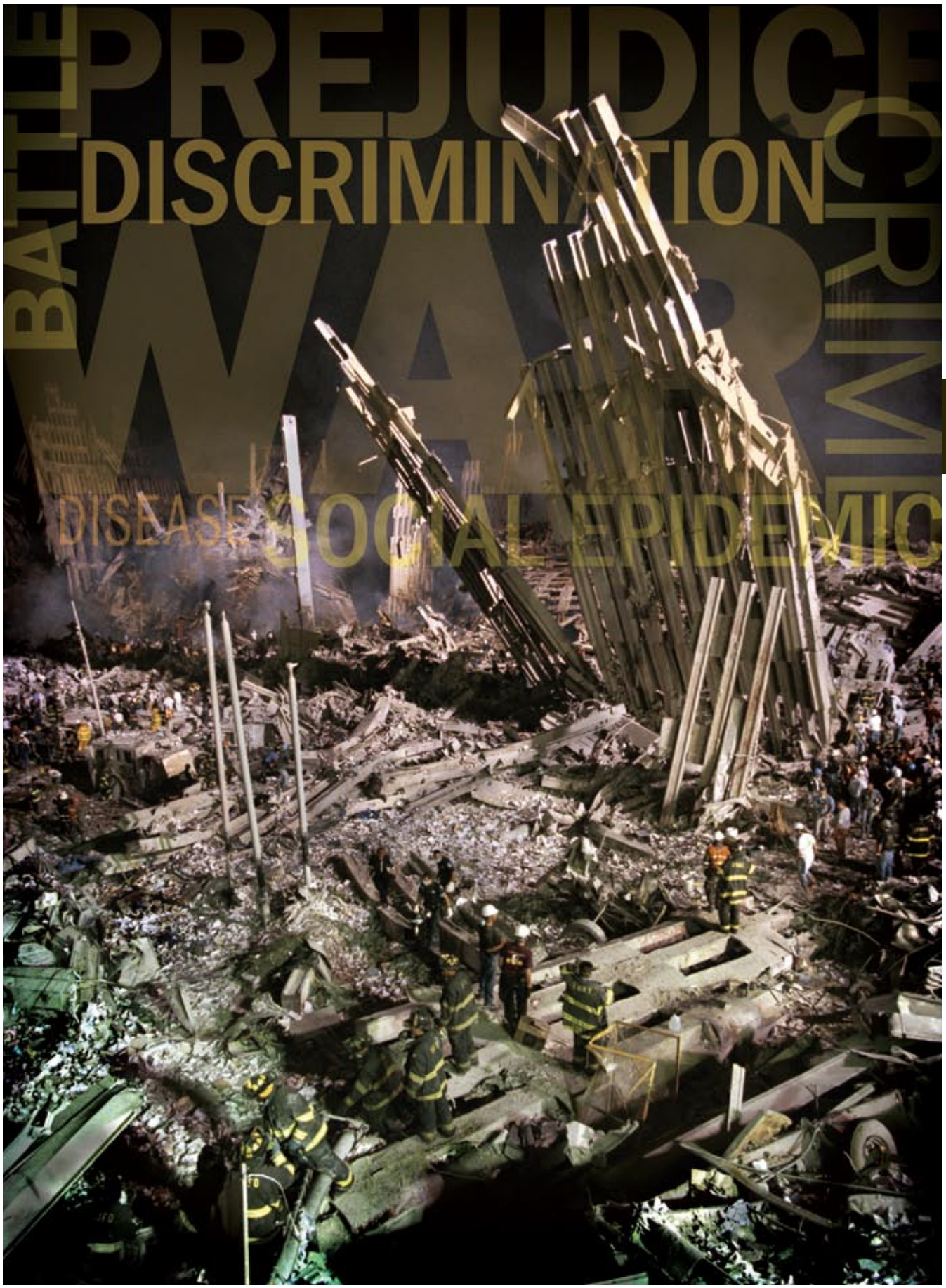


Talking about Terrorism

HOW WE CHARACTERIZE AN ISSUE AFFECTS HOW WE THINK ABOUT IT. REPLACING THE "WAR ON TERROR" METAPHOR WITH OTHER WAYS OF FRAMING COUNTERTERRORISM MIGHT HELP US CURTAIL THE VIOLENCE MORE EFFECTIVELY

BY ARIE W. KRUGLANSKI, MARTHA CRENSHAW, JERROLD M. POST AND JEFF VICTOROFF

On the eve of our national election, we realize that one challenging issue facing the next president is how to address terrorism and the options for counterterrorism. As psychological research has made clear, what he and his administration say about these issues will influence how the public thinks about them—and will affect our national and international policy. [For more on the power of words, see "When Words Decide," by Barry Schwartz; Scientific American Mind, August/September 2007.]

Since the attacks on the World Trade Center and the Pentagon in 2001, the Bush administration has used a battle metaphor: the "global war on terrorism" and the "war on terror." Such descriptive terms simplify complex realities, making them more mentally manageable. But they do not adequately represent the complexities of the problem, resulting in selective perception of the facts, and they may reflect the views of only a few key policy makers. Nevertheless, they can guide national decision making. The wars that began in Afghanistan in 2001 and Iraq in 2003 clearly demonstrate that the concept of a war to combat a method of violence used by nonstate agents is more than rhetoric.

Although the war metaphor has some advantages, the next president should consider other terms that lead to thinking that is more nuanced—and ultimately more effective. Viewing counterterrorism through the lens of law enforcement, for example, may yield more tightly focused tactics that are less likely to provoke resentment and backlash and are also less costly than war. Two other metaphors—relating counterterrorism to disease containment or

RICHARD FALCO *Vision Project/Redux Pictures*

prejudice reduction—home in on many of the deeply rooted psychological underpinnings of terrorism and, in doing so, suggest strategies that may chip away at the motivations of terrorists and thus may be the most successful at squelching the scourge in the long run [see "Inside the Terrorist Mind," by Annette Schaefer; SCIENTIFIC AMERICAN MIND, December 2007/January 2008].

Declaring War

The Bush administration's framing of terrorism as an act of war is a departure from past administrations' ways of thinking. Presidents Richard M. Nixon and Ronald Reagan, for example, preferred a disease metaphor. President Bill Clinton's general themes were the pursuit of justice, law enforcement and international cooperation. Clinton wanted to deny "victory" to terrorists, but he and other previous presidents stopped short of the word "war."

President George W. Bush adopted the war construct immediately. On the morning of September 12, 2001, after a meeting of the National Security Council, the president told reporters: "The deliberate and deadly attacks which were carried out yesterday against our country were more than acts of terror. They were acts of war."

The war metaphor helps to define the American perception of the threat of terrorism. If terrorism is war, then the national security, indeed the existence, of each side is threatened. The conflict is zero-sum; the outcome will be victory for one side or the other. Being in a state of war also requires national unity, and dissent is easily interpreted as unpatriotic. The solution has to be military. Thus, the Department of Defense must play a lead role in shaping policy, and the president's duties as commander in chief must take precedence over his other tasks. An expansion of executive power accompanies the war metaphor: measures that would not be acceptable in peacetime, such as restrictions on civil liberties and brutal interrogation practices, are now considered essential.

But in several ways, the struggle against terrorism differs significantly from conventional war. First, the entity that attacked the U.S. in 2001 was not a state. It was an organization, al Qaeda, with a territorial base within a weak "failed state," Afghanistan, whose ruling Taliban regime was not internationally recognized. Since 2001 the entity that the U.S. is fighting has become even more amorphous and less like a state. It has progressed from the so-called terrorist organizations to an ideology that aspires to world domination. David Brooks, writing in the *New York Times* on September 21, 2006 , called it "chaos theory in human form—an ever-shifting array of state and nonstate actors who cooperate, coagulate, divide, feud and feed on one another without end."

Victory in a war on terrorism is similarly difficult to define. A typical war ends in the capitulation of the enemy, but al Qaeda is unlikely to surrender formally. In 2006 the revised (2002) U.S. National Security Strategy, articulated in a White House "wartime" document, set a goal "to defeat global terrorism." It will be difficult to tell when this objective, which involves eradicating a method of violence and a way of thinking, has been met. As a result, the war drags on, breeding disappointment with the results and a public outcry to bring the troops home.

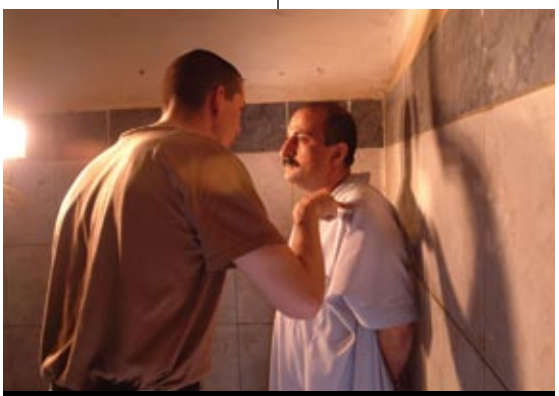
The psychological rationale of war is to bring the enemy

President George W. Bush raises an American flag at the site of the World Trade Center on September 14, 2001. Two days earlier he had described the deadly attacks as "acts of war."

DOUG MILLS *AP Photo*

the motivation to engage in violence—and may even boost it.

to its knees and to convince it and its support base that terrorism is counterproductive. And yet experience in Chechnya, Afghanistan, Iraq, Ireland, and the West Bank and Gaza Strip suggests that the use of military force does little to "prove" the inefficacy of terrorism. Military strikes against terrorist targets may temporarily interfere with terrorists' ability to launch their operations, but they do not generally lessen the motivation to engage in violence—and may even boost it as a result of the enmity that foreign occupation typically engenders and of the injustice and excesses of war.



A U.S. captain interrogates an Iraqi suspected of taking part in a roadside attack on Americans.

The war concept also deafens ears to the underlying troubles of the terrorists—the frustrations and grievances that may have fostered terrorism, as well as the belief systems that lent it ideological sustenance. Meanwhile the metaphor encourages stereotyping and discrimination against members of the broad social categories to which terrorists may belong, such as Muslims, Saudi Arabians or Middle Easterners.

Finally, framing counterterrorism as war has considerable costs. It threatens to corrupt society's values, disrupt its orderly functioning and reshuffle its priorities. War calls for the disproportionate investment of a nation's resources, with correspondingly less left for other concerns, including the economy, health care and education. "Collateral damage," ethnic profiling, harsh interrogation tactics and unlimited internment of suspects may all be condoned in the name of security and excused by the uniqueness of circumstances the war concept implies. These costs are especially steep in a war that has no definite end.

Fighting Crime

Whereas war is a reaction to a massive confrontation, law enforcement generally follows more restricted challenges—akin in many ways to those typically presented by terrorism. For instance, extensive police work, a trial and convictions followed the 1993 truck bombing in the World Trade Center parking garage that resulted in six deaths, hundreds of injuries and property damage just under half a billion dollars. In contrast, war was the response to the 3,000 deaths and tens of billions of dollars in damage from the 9/11 attacks.

In support of the law-enforcement approach, Senator John Kerry of Massachusetts stated in a presidential candidates' debate in South Carolina in 2004 that although counterterrorism will be "occasionally military," it should be "primarily an intelligence and law-enforcement operation that requires cooperation around the world." The United Nations has never been able to agree on a definition of terrorism but has developed articles prohibiting acts such as airline hijacking and violence against diplomatic persons, consistent with a law-enforcement metaphor. After all, terrorists often engage in crime as conventionally defined, and suspected terrorists in the U.S. are typically prosecuted for criminal offenses rather than terrorism—commonly racketeering, possession of firearms and conspiracy.

FAST FACTS

Mind Your Metaphor

1» Since the attacks on September 11, 2001, the Bush administration has used a war metaphor to define counterterrorism strategy. Such a description may simplify a complex reality, making it more mentally manageable, but it may also oversimplify and distort reality.

2» Metaphors can guide national decision making. The wars that began in Afghanistan in 2001 and Iraq in 2003 clearly demonstrate that the concept of a war to combat a method of violence used by nonstate agents is more than rhetoric.

3» Viewing counterterrorism through the lens of law enforcement may yield more tightly focused tactics that are less costly than war and less likely to provoke resentment and backlash.

4» Relating counterterrorism to disease containment or prejudice reduction shifts the focus to the psychological underpinnings of terrorism and, in doing so, may suggest successful long-term strategies that chip away at the motivations of terrorists.

RITA LEISTNER *Redux Pictures*

The law-enforcement metaphor focuses on the specific perpetrators of

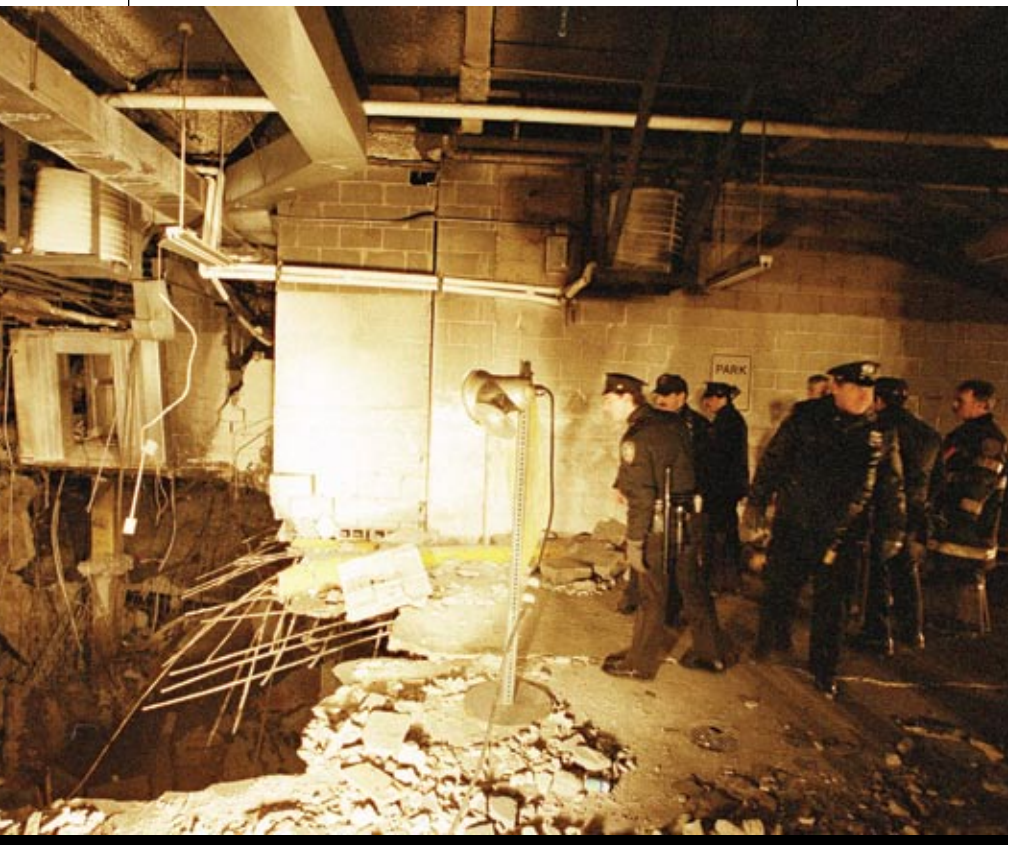
One advantage of the law-enforcement metaphor over the war concept is its focus on the particular perpetrators in violation of the legal code rather than on an actor vaguely defined as the "enemy." Such an emphasis is less likely to incite discrimination against entire groups of people. And as an ongoing concern, law enforcement does not suggest the need for an overwhelming financial commitment but rather must compete for resources with education, jobs, housing and welfare.

The law-enforcement idea also limits the costs of mistakes. Civilian casualties, nearly unavoidable in bombing raids of terrorist targets under the war metaphor, are unlikely with law-enforcement policies, which are thus less apt to fuel anger toward the West and thereby boost support for terrorist organizations. What is more, the experience of the Israelis and the British suggests that successful counterterrorism often resembles painstaking police work more than it does war. That is, effective police work requires understanding a local culture and geography, developing local relationships and cultivating local sources of information—efforts for which an army is ill prepared.

International cooperation in counterterrorism is also more possible under the law-enforcement approach. Whereas the international community is basically in favor of law and order, the war metaphor is often too demanding for many states to embrace. For example, although France strongly opposed the Iraq War, American and French law enforcement have cooperated very effectively since 9/11.

And yet terrorism, unlike most crimes, is ideologically inspired. In contrast to typical criminals, who tend to have selfish, personal motivations, terrorists are often trying to change the world and frequently believe they are serving a cause that will achieve a greater good. Because of such grand ideas, terrorists often inspire admiration and respect in their communities. During much of the second Intifada, which began in September 2000 and ended this past June, public opinion polls conducted among Palestinians revealed that about 80 percent supported suicide attacks against Israelis. In such situations, law-enforcement officials may have difficulty convincing the public to help them fight crimes related to terrorism.

Finally, because law-enforcement tactics do not generally dampen the motivation to engage in terrorism, their success in thwarting attacks is often short-lived. Terrorists are a determined and inventive bunch, and sooner or later they are likely to find other means of carrying out their plans, for instance, resorting to suicide missions if necessary.



Extensive police work—not war—followed the 1993 truck bombing in the World Trade Center parking garage. The bombing left six dead and hundreds injured.

RICHARD DREW *AP Photo*

Containing an Epidemic

The social epidemic metaphor for counterterrorism likens the spread of terrorist ideas to the transmission of infectious disease: an external agent such as a pathogen or violent way of thinking infects a susceptible host—a nonimmune or psychologically vulnerable population—in an environment that brings them together. In that environment a vector—such as the malaria-carrying *Anopheles* mosquito or the Internet—facilitates the transmission of a pathogen or ideas.

The disease metaphor of terrorism guides intelligible questions as to the origins of an outbreak, its boundaries, social contours and method of

an illegal deed rather than on an actor vaguely defined as the "enemy."

Officials destroy thousands of confiscated firearms in Brazil. In the U.S., suspected terrorists are commonly prosecuted for illegal possession of firearms.

RENZO GOSTOLI *AP Photo*

transmission, along with who is most at risk of "infection." It casts terrorism, like disease, as an outgrowth of a complex interaction among people, pathogens and the environment. It thus suggests that rolling back terrorism requires a multipronged effort to tackle each of these elements just as controlling malaria requires preventive methods that target its environmental contributors, such as spraying the ponds in which the mosquitoes breed and supplying people with protective clothing and mosquito nets.

This metaphor offers a lens through which to more closely examine the underlying psychological forces behind terrorism. The agent or pathogen in this case is a terrorism-justifying ideology that includes a collective grievance, such as humiliation of one's nation or religious group, a culprit or party responsible for the grievance, and a belief that terrorism is a morally justifiable and effective tool for redressing the grievance. A hate-mongering leader typically helps to promote a potent "us versus them" social psychology, setting in motion powerful group dynamics centered on the ideology.

A terrorist philosophy may be propagated by any of several vectors or vehicles, one of the most prominent being the mosque, where young Muslims are inculcated with an unquestioning reverence for Allah. The Middle Eastern prisoners whom a team of psychologists led by one of us (Post) interviewed in 2002 consistently cited the mosque as the place where most members were initially introduced to the Palestinian cause.

The Internet may also facilitate spread of the ideological pathogen. In 2007 Army Brigadier General John Custer, head of intelligence at central command, responsible for Iraq and Afghanistan, stated on *CBS News:* "Without doubt, the Internet is the single most important venue for the radicalization of Islamic youth." Experts estimate that 5,000 jihad sites are currently in operation. In one recruitment drive, potential converts are bombarded with religious decrees and anti-American propaganda, provided with manuals on how to be a terrorist and—as they are led through a maze of secret chat rooms—given instructions on how to make the journey to Iraq to fight U.S. and coalition forces there.

The Internet is thus one obvious target for counterterrorism. In the Saudi Al-Sakinah ("Tranquility") campaign, Muslim legal scholars and propagators of Islam—assisted by psychologists and sociologists—enter extremist Web sites and forums and converse with the participants to bring them to renounce their extremist ideas. The campaign's organizers believe these efforts have been successful in many cases (although that claim needs to be more rigorously examined).

In addition to these vehicles, the propagation of terrorism requires a receptive population. Such susceptibility can arise from early socialization to a terrorism-justifying

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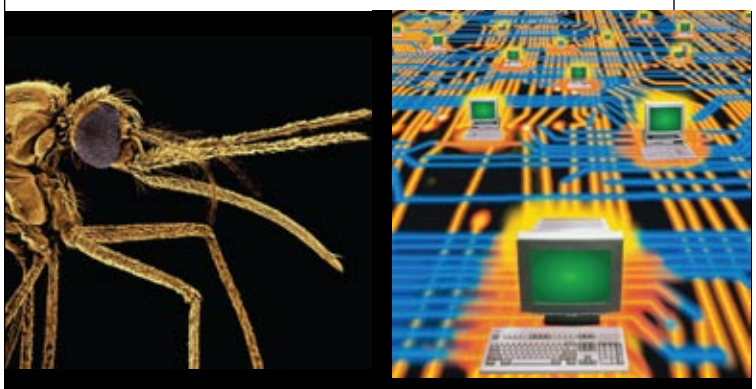
The metaphor of prejudice reduction casts terrorism as one

ideology and personal circumstances that render the ideology appealing. Inculcation at an early age can build hatred into a child. In one campaign, the Hezbollah Shiite youth movement "Imam al-Mahdi Scouts," tens of thousands of children aged eight to 16 are indoctrinated with the ideology of radical Iranian Islam, whereas kindergarteners are a target audience for the educational efforts of Hamas.

Personal suffering and frustrations can add to the vulnerability. For people growing up or currently living in repressed or limited socioeconomic conditions, academic or economic achievement may seem remote. Thus, many people seek success instead as fighters for a terrorist cause. Traumatic experiences such as having a relative or friend killed by the enemy may increase the desire to embrace collectivistic causes. Creating alternative paths to success might immunize a susceptible population by enabling bright, educated individuals to thrive within their culture rather than striking out in despair.



Just as the *Anopheles* mosquito transmits the malaria pathogen, the Internet can facilitate the spread of terrorist ideology.

TIM FLACH (*Anopheles mosquito*) AND BARRY BLACKMAN (*circuit board*) *Getty Images*

Stemming Prejudice

Rather than approaching terrorism as a problem perpetuated by the terrorists alone, as the other three metaphors do, the metaphor of prejudice reduction shifts the focus from a unilateral to a bilateral concern and casts terrorism as one expression of tense and deteriorating intergroup relations. A poignant example of such incendiary associations involves Muslim immigrants in Europe and the ethnically native European populations. Three of the terrorist pilots in the September 11 attacks—Mohamed Atta, Marwan al-Shehhi and Ziad Jarrah—were young Muslims who spent extended periods living in Europe. Since then, a series of attacks, interrupted attacks and plots has been linked to other young Muslims with European background. Most recently, eight Muslim doctors or doctors in training working in British hospitals were arrested in connection with two attempts to explode car bombs in downtown London on June 29, 2007, and an attempt the next day to ram a flaming Jeep into the main entrance of the Glasgow airport.

According to a 2006 report by the Pew Global Attitudes Project, 58 to 70 percent of both Muslims and non-Muslims in Great Britain, France and Germany say that intergroup relations are bad. Cultural differences may explain part of the problem. For instance, many non-Muslim Europeans tend to hold that Muslims are fanatical, violent and disrespectful of women, and most are very or somewhat concerned about the rise of Islamic extremism in their country. As a result of such attitudes, Muslims may be discriminated against in housing, employment and services. Muslim and non-Muslim Europeans also tend not to visit the same stores or entertainment and sporting venues, extending the separation of the two cultures to everyday life.

Although such tensions may not constitute sufficient conditions for terrorism, they may instill the readiness to buy into a terrorism-justifying ideology and are potential harbingers of violent intergroup conflict. For example, 24 percent of British Muslims and 35 percent of French Muslims endorse the statement that violence against civilian targets is sometimes or rarely justified in the service of Islam, according to the Pew report.

Multiple initiatives are under way to enhance integration and reduce friction between Muslims and non-Muslims in Europe. Some of them involve efforts to document discriminatory behavior or civil-rights violations; others strive to promote dialogue or involve legislation to punish discriminatory behaviors in employment, housing and banking.

Despite such efforts, social scientists have done little to evaluate what works to enhance social integration and eliminate tensions. And yet prejudice and discrimination have been among the most intensively studied social psychological phenomena. In particular, a wealth of experimental research has shown that creating opportunities for two groups to meet and interact with each other under agreeable circumstances can go a long way toward reducing prejudice. In the so-called contact hypothesis described by Harvard University psychologist Gordon Allport in his

More Science
See the *Psychological Science in the Public Interest* article, "What Should This Fight Be Called? Metaphors of Counterterrorism and Their Implications," on which this story is based at the Association for Psychological Science's Web site: **www.psychologicalscience.org**

expression of tense and deteriorating intergroup relations.

1954 text *The Nature of Prejudice,* the key is interaction or contact between equal-status members of each group in the pursuit of common goals.

In 2006 psychologists Thomas F. Pettigrew of the University of California, Santa Cruz, and Linda R. Tropp of Boston College reported in a meta-analysis of 515 studies, which included 713 population samples and 1,383 tests, that rates of prejudice fall significantly with contact. Some types of interventions appear to work better than others do: although incidental contact or travel excursions seem to yield little benefit, residential interaction does help; educational and work-based contact is even more valuable, and the best effects were seen in recreational contexts. And, as Allport had argued, when authorities sanction the meetings, that fact predicts success better than any other factor.

Media or community portrayals of aggressive, humiliating or discriminatory activities perpetrated by one group against the other, however, may undermine contact in isolated settings. Efforts at prejudice reduction should include media campaigns and enforcement of antidiscrimination policies as well as immigration laws, educational programs and foreign policy initiatives designed to augment the good will generated by contact programs. And because prejudice is strongly related to real economic disparities and is augmented by a sense of injustice, psychological efforts may work best if combined with credible policies aimed at the elimination of objective inequalities.

Alliances

Prejudicial attitudes are by no means the only explanation for aggression that may translate to terrorism. What is more, the contact prescription that accompanies the idea of prejudice reduction emphasizes cooperative secular activities, thereby failing to address the radical religious notions that fuel terrorism. More generally, the concept of prejudice reduction, like the epidemic metaphor, neglects the short-term challenges posed by terrorism, including the need to counter specific terrorist schemes and protect societies from the immediate threats these entail.

Thus, no single metaphor can fully encapsulate counterterrorism. Each beams a searchlight on specific psychological pieces of the puzzle, illuminating some of its aspects while leaving others in darkness. Jointly, however, these four descriptions manage to convey the considerable complexity behind the violent acts that counterterrorism policies are designed to thwart.

To achieve this broader perspective, we recommend a comprehensive approach involving collaboration between military and law-enforcement experts, along with social scientists who can highlight the likely psychological, political or sociological ramifications of various counterterrorism initiatives. Admittedly, setting up such an alliance may not be easy, and long-term considerations may seem at odds with, or tangential to, current security needs.

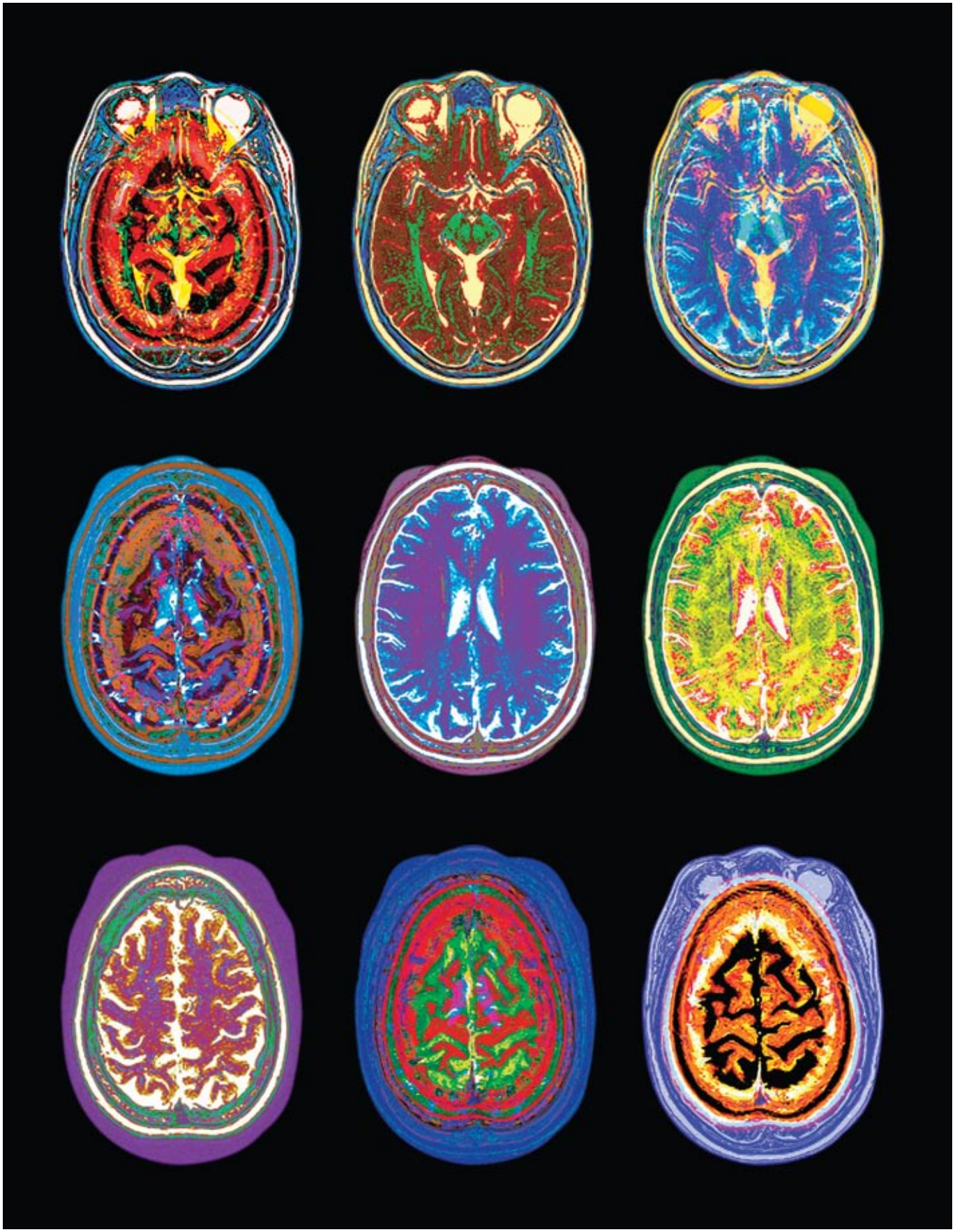
As one sign of strained—and potentially incendiary—relations, Muslim and non-Muslim Europeans tend to visit separate stores. This Beurger King Muslim caters to Islamic clientele.

Nevertheless, academics are finding their way into the relevant security circles. The Homeland Security Act of 2002 established the University Programs initiative, which has led to centers of excellence at U.S. universities that study the social and behavioral (among other) aspects of terrorism. This law has provided a conduit between academic research in the behavioral and social sciences and a government national security agency. In the future, we hope that new cadres of security experts who have been educated in the group and psychological facets of terrorism will lead the U.S. toward more sophisticated and highly effective counterterrorism strategies. M

(Further Reading)

- **The Mind of the Terrorist: A Review and Critique of Psychological Approaches.** J. Victoroff in *Journal of Conflict Resolution,* Vol. 49, No. 1, pages 3–42; February 2005.
- **When Hatred Is Bred in the Bone: Psycho-Cultural Foundations of Contemporary Terrorism.** J. M. Post in *Political Psychology,* Vol. 26, No. 4, pages 615–636; August 2005.
- **The Psychology of Terrorism: "Syndrome" versus "Tool" Perspectives.** A. W. Kruglanski and S. Fishman in *Terrorism and Political Violence,* Vol. 18, No. 2, pages 193–215; 2006.
- **Explaining Suicide Terrorism: A Review Essay.** M. Crenshaw in *Security Studies,* Vol. 16, No. 1, pages 133–162; January 2007.
- **War versus Justice in Response to Terrorist Attacks: Competing Frames and Their Implications.** C. McCauley in *Psychology of Terrorism.* Edited by B. Bongar, L. M. Brown, L. E. Beutler, J. N. Breckenridge and P. G. Zimbardo. Oxford University Press, 2007.

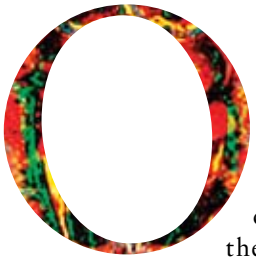
JACKY NAEGELEN *Reuters/Landov*



Why You Should Be Skeptical of Brain Scans

Colorful scans have lulled us into an oversimplified conception of the brain as a modular machine

By Michael Shermer



Over the past few hundred years, as scientists have grappled with understanding the source of the amazing processing power in our skulls, they have employed a number of metaphors based on familiar technologies of their given era. The brain has been thought of as a hydraulic machine (18th century), a mechanical calculator (19th century) and an electronic computer (20th century).

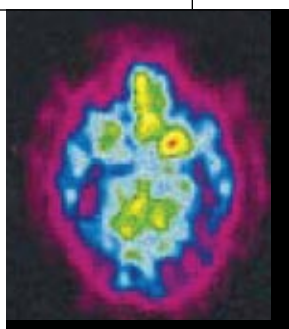
Today, early in the 21st century, we have another metaphor driven by the capabilities of the current technology—this time colorful images from modern brain scans. Evolutionary psychologists, for example, have conceptualized the brain as a Swiss Army knife, with a collection of specialized modules that have evolved to solve specific problems in our evolutionary history, such as language for communication, facial recognition to separate friends from foes, cheating detection to prevent free riders, risk taking to raise the odds of individual or group success, and even God to explain the world and to find individual happiness in thoughts of an afterlife. Many neuroscientists have employed the module metaphor to describe specific regions of the brain "for X," with X being whatever happens to be the task given to subjects while a machine scans their brains. Such tasks might include selecting brand logos they prefer (say, Coke or Pepsi) or political candidates they would vote for (conservatives or liberals).

Scientists often use metaphors such as these as aids in understanding and explaining complex processes, but this practice necessarily oversimplifies the intricate and subtle realities of the physical world. As it turns out, the role of those blobs of color that we see in brain images is not as clear-cut as we have been led to believe. "There are no modules that are encapsulated and just send information into a central processor," declares philosopher of the mind Patricia S. Churchland of the University of California, San Diego. "There are areas of specialization, yes, and networks maybe—but these are not always dedicated to a particular task."

Technologies such as functional magnetic resonance imaging have helped science gain new insights, but overreliance on their use has also presented an oversimplified and sometimes misleading picture of brain operation. Even this magazine, with its focus on explaining brain and behavior, often counts on these simplified metaphors [see "Fact or Phrenology?" by David Dobbs; Scientific American Mind, V. 16, N. 1, 2005].

So let me explain what such images actually can and *cannot* show, by giving you a closer look at the capabilities and operation of fMRI, perhaps the most commonly trumpeted imaging technique. After you have read this article, you will be able to apply a skeptic's careful eye to better appraise any brain studies that you come across in future media headlines. Here are five flaws of brain scans:

GETTY IMAGES (*opposite page*); COURTESY OF MICHAEL SHERMER (*Shermer in scanner, page 69*); GUILBERT GATES (*neuron diagram, page 70*)



Craving

Pictures of brains splotched with sharply defined colored regions suggest well-defined processing blocks (the module metaphor), when in fact the neural activity may be distributed in more of a loosely defined network.

1 Unnatural environment for cognition.

I visited neuroscientist Russell Poldrack's laboratory at the University of California, Los Angeles, and arranged to get my brain scanned inside its MRI machine. Scanners typically weigh around 12 tons and cost about $2.5 million (not including installation, training and maintenance, which can drive the typical bill up by another $1 million). Right off the bat I realized how unnatural an environment it is inside that coffinesque tube. In fact, I had to bail out of the experiment before it even started. I had suddenly developed claustrophobia, a problem I had never experienced earlier. I'm not alone. Poldrack says that as many as 20 percent of subjects are similarly affected. Because not everyone can remain relatively relaxed while squeezed inside the tube, fMRI studies are afflicted with a selection bias; the subject sample cannot be completely random, so it cannot be said to represent all brains fairly.

A person jammed into the narrow tube also has his or her head locked firmly in place with foam wedges inside the head coil—nicknamed "the cage"—to reduce head motion (which can blur the images) before the experiment begins. The MRI scanner snaps a picture of the brain every two seconds while the subject watches images or makes choices (by pushing buttons on a keypad) presented through goggles featuring tiny screens.

So when you read popular accounts of subjects who had their brains scanned while they were shopping, for example, remember that they were not walking around a Wal-Mart with headgear on. Far from it.

2 Scans are indirect measurements of brain activity.

One often reads popular accounts of fMRI research describing how the brain "lights up" when thinking about money or sex or God or whatever. Here is what the MRI machine is really doing when you think. The scanner is a large electromagnetic cylinder constructed from superconducting wire cooled by helium that generates powerful magnetic fields. The levels of these fields are 25,000 to 80,000 times the strength of the earth's magnetic field. They are so powerful that subjects must remove all metal items before entering the shielded area. (Flying metal objects pulled by an MRI machine have killed people.) Patients with pacemakers or metal implants cannot even go into the room, which itself is heavily fortified with steel and uses soundproofing technologies to muffle the bone-shaking noise produced when the magnets work their magic.

When a person is inside the tube, some of the atoms in his or her tissues align to the magnetic field. Only about one in a million atoms so align, but that number is sufficient because the body has about seven octillion (a thousand quadrillion, or a thousand thousand trillion) atoms; the total works out to about six million billion atoms in a two-by-two-by-five-millimeter cube of tissue—plenty for the scanner to read. The protons in the nuclei of these atoms are spinning, and like a spinning top they also precess (or wobble, whereby the axis of rotation sweeps out a cone). The frequency at which a proton precesses—the time it takes for the axis to sweep out a cone

FAST FACTS

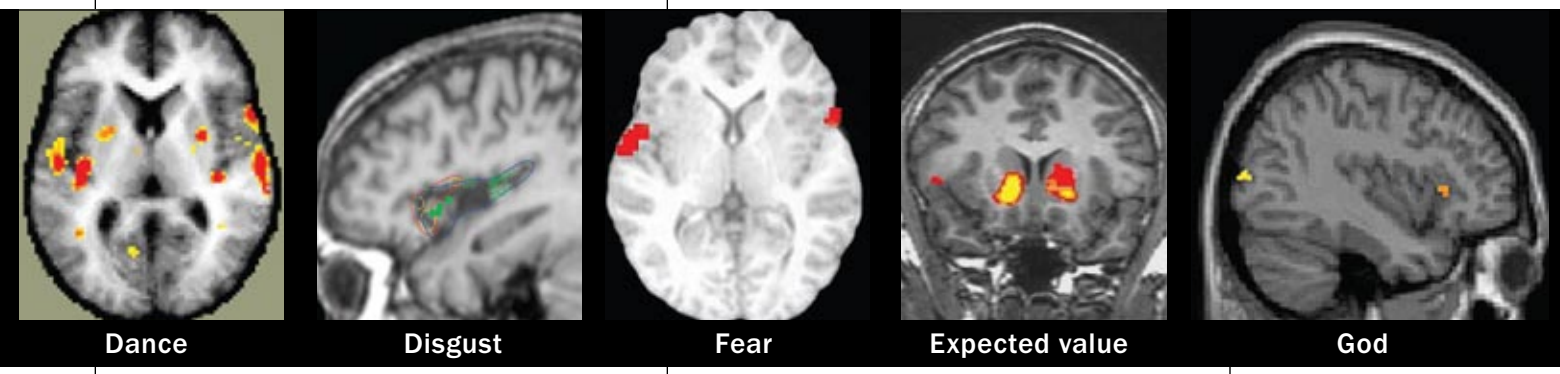
Misleading Brain Scans

1» Metaphors are often used in science to understand difficult and counterintuitive phenomena.

2» The metaphor of the mind as a Swiss Army knife, a collection of specialized modules designed to solve specific problems, has been enhanced by brain-scanning technologies such as functional magnetic resonance imaging.

3» Such brain scans, however, are misleading on a number of levels and have led some neuroscientists and the media to overemphasize the localization of brain function.

COURTESY OF ANNA ROSE CHILDRESS (*craving*); "THE NEURAL BASIS OF HUMAN DANCE," S. BROWN ET AL., IN *CEREBRAL CORTEX*, V. 16, N. 8; 2006. BY PERMISSION OXFORD UNIVERSITY PRESS (*dance*); "A UNIFYING VIEW OF THE BASIS OF SOCIAL COGNITION," V. GALLESE ET AL., IN *TRENDS IN COGNITIVE SCIENCES*, V. 8, N. 9; SEPT. 2004. © 2004, BY PERMISSION ELSEVIER (*disgust*); "DISTRIBUTED NEURAL REPRESENTATION OF EXPECTED VALUE," B. KNUTSON ET AL., IN *JOURNAL OF NEUROSCIENCE*, V. 25, N. 19; MAY 11, 2005 (*expected value*)



once, called the resonant frequency—depends on the strength of the magnetic field, which varies along the length of the tube. This "gradient" is slightly higher at the head end, causing the protons there to precess at a slightly different frequency. To make an image, the machine transmits a certain radio-wave frequency, which excites the protons to match that resonant frequency caused by the magnetic field. This excitement, in effect, tips the direction of their alignment to the side. Over time (milliseconds), these protons come back into alignment with the main magnetic field, and in the process they shed some energy. It is this energy that the machine measures to create the image.

3 Colors exaggerate the effects in the brain.

Pictures of brains splotched with sharply defined colored regions are highly misleading because they suggest well-defined processing blocks (the module metaphor), when in fact the neural activity may be distributed in more of a loosely defined network. Here is how fMRI produces data that can lead to this artificial modularity. As a basic principle, scientists agree that changes in blood flow and oxygenation levels in particular areas of the brain signal greater neural activity. When neurons are active, they consume more oxygen, which is pulled out of the hemoglobin in red blood cells from nearby capillaries; the brain responds to this increased need for oxygen by sending more—and for reasons that are not yet fully understood, it actually sends a greater amount than is needed. There is a delay of about five seconds between neural activity and blood-flow change, which leads to differences in the relative concentration of oxygenated hemoglobin in those active brain areas. Because the iron in hemoglobin is magnetically sensitive, there are measurable magnetic differences between blood cells with and without oxygen, and the MRI scanner measures these differences.

The coloring is artificial, and the process of coloring the regions is even more misleading, as Churchland says: "The difference in activity levels is tiny. You can make these differences look huge by coloring them red and by subtracting everything else out, so it gives an impression that is exaggerated." The choice of what to emphasize is also misleading. "Take the cingulate nucleus, an area dealing with conflict," Churchland adds. "You can get it to respond by showing subjects a picture of, say, Hillary Clinton. But the cingulate nucleus does 57 other things as well."

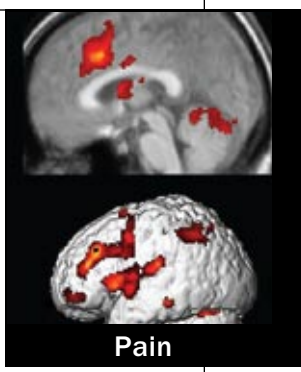
Finally, Churchland exclaims in partial exasperation when I ask her about exposing subjects to various stimuli inside the scanner: "The thing of it is that most of the activity of the brain is not stimulus-driven but is spontaneous, and we don't know why there is so much activity and what it is doing." In other words, many areas of the

Many subjects, such as the author himself (*below*), cannot long tolerate the claustrophobic environment in an MRI machine—making it impossible for studies to represent all brains fairly.

(The Author)

MICHAEL SHERMER is publisher of *Skeptic* magazine (www.skeptic.com) and a monthly columnist for *Scientific American* (www.SciAm.com). His latest book is *The Mind of the Market: Compassionate Apes, Competitive Humans, and Other Tales from Evolutionary Economics* (Henry Holt/Times Books, 2007). This is his second feature for *Scientific American Mind*.

In a brain scan, the image itself does not represent any one person's brain. It is instead a statistical computation of the entire subject pool adjusted for head motion and different head sizes.



brain are continually active during different processing tasks, and separating them out properly is a challenge that requires careful experimental design.

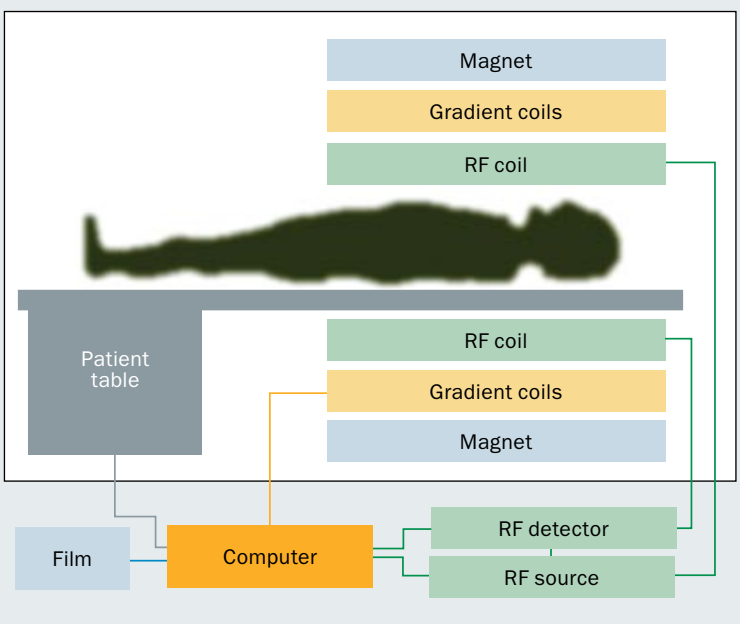
4 Brain images are statistical compilations.

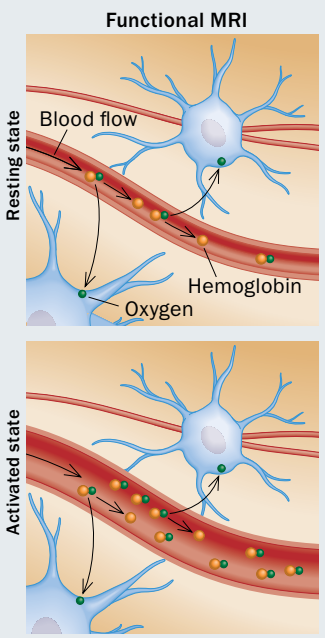
During a given experiment, the scanner snaps pictures of the rapid-fire brain activity only every two seconds, resulting in hundreds to thousands of images per scanning period (which can last anywhere from 15 minutes to two hours). After the experiment concludes, researchers make corrections for head motion and for small differences in brain size and the location of structures within different brains. The scientists line up all the individual images with one another and then combine the data and take averages for the subjects in the experiment. They employ additional statistical software to convert raw data into images as well as to correct for other possible intervening variables, such as cognitive tasks that produce neural activity changes in the brain faster than the blood-flow changes that are actually being measured by the MRI.

Keep all this background in mind the next time you see one of those colorful brain scans with an arrow pointing to some spot that says,

What the MRI "Sees"

Series of magnets and a radio-frequency (RF) generator and detector in an MRI machine create images. Functional MRI detects changes in oxygen levels, which rise in the nearby blood vessels because active neurons consume more oxygen than when they are at rest (*right*).





"CEREBRAL ACTIVATION DURING HYPNOTICALLY INDUCED AND IMAGINED PAIN," S.W.G. DERBYSHIRE ET AL., IN *NEUROIMAGE*, V. 23, N. 1; SEPT. 2004. © 2004, BY PERMISSION ELSEVIER (*pain*); "NUCLEUS ACCUMBENS ACTIVATION MEDIATES THE INFLUENCE OF REWARD CUES ON FINANCIAL RISK TAKING," B. KNUTSON ET AL., IN *NEUROREPORT*, V. 19, N. 5; MARCH 26, 2008 (*risk*); "NEURAL CORRELATES OF CONSCIOUS SELF-REGULATION OF EMOTION," M. BEAUREGARD ET AL., IN *JOURNAL OF NEUROSCIENCE*, V. 21, N. 18; SEPT. 15, 2001 (*sexual arousal*)

"This is your brain on X." The image usually does not represent any one person's brain. It is a statistical computation of the entire subject pool rendered with artificial colors to highlight the places where there is a consistent response to a given task or experimental condition.

5 Brain areas activate for various reasons.

Interpreting fMRI scans is as much an art as a science, Poldrack admits. "It is tempting to look at one of those spots and say, 'This is where X happens in your brain,' when in fact that area could be lighting up when involved in all sorts of tasks," he explains. "Take the right prefrontal cortex that lights up when you do almost any difficult task. One way to think about it is in terms of networks, not modules. When you are engaged in thinking about money, there is a network of several different areas involved in communicating with one another in a particular way. Thus, the prefrontal cortex may be involved in many different tasks. But in communication with other brain networks, it becomes active when engaged in one particular task, such as thinking about money." Teasing these differences apart requires making relative comparisons across a spectrum of tasks. Certain experiments work especially well with fMRI because decisions provide contrasts between tasks, giving the neuroscientist something to compare.

What about research showing differences in rational versus emotional parts of the brain, as in the "emotional low road" in the deeper and more ancient parts of the brain and the "rational high road" in the cortical regions of the brain? "There *are* rational and emotional ways of thinking," Poldrack says. But "it turns out that they interact with one another a lot." The amygdala, an area typically associated with processing the fear response, also is activated by arousal and positive emotions: "If I put you into a state of fear, your amygdala lights up. But that doesn't mean that every time your amygdala lights up, you are experiencing fear. Every brain area lights up under lots of different states. We just don't have the data to tell us how selectively active an area is."

Networks, Not Modules

A number of interconnected neural networks may in some cases be localized and bundled into modulelike units, but in most ways they are better described as being splayed out over, under or through the brain's crevasses. The metaphor of "distributed intelligence"—sometimes used to describe the World Wide Web's power—more closely matches the network distribution of tasks in the brain than the module metaphor does.

Of course, there are areas that specialize in certain types of processing, such as the visual cortex at the back of the brain and Broca's area for language in the left frontal lobe. And roughly speaking, reason and rationality happen in the cortical areas, whereas emotion and irrationality are experienced in the limbic system.

Nevertheless, as many neuroscientists now believe, the metaphor of "neural networks" is superior to that of mental modules. The latter forces us to think of the brain as a kludge of encapsulated organs specialized for one function and no other, whereas the former more accurately reflects what modern neuroscience tells us is actually happening during cognition. Brain-scanning technologies such as fMRI will continue to generate copious data for our metaphorical theories—and as long as our skeptical networks are active, we should be able to better map neural networks and their accompanying functions onto the landscape of our behaviors. M

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TEMPERING TAN

Emotional outbursts afflict virtually all toddlers. Some children, however, are prone to more violent fits that could—if left unchecked—pave a path toward persistent aggression

By Stefanie Reinberger

Three-year-old Merle throws a tantrum in the supermarket whenever her mother refuses to buy something she wants. Little Anna screams wildly when her mother interrupts her playing to put on a jacket so the family can go out. Ben, an adorable towhead, barely two, bites into furniture and toys as soon as anyone drops the word "no."

Merle, Anna and Ben are in the tantrum phase—sometimes referred to as "the terrible twos"—and they dispense frustration and anger to everyone around them. (All of the names of the children mentioned in this article have been changed to protect their privacy.) Reasoning is useless; threats and punishment fail to stem the bawling, agitation and aggression. And then, just as suddenly as it begins, it is over: the child is cuddling up to Mommy or Daddy for comfort. Small wonder that so many parents feel powerless to control these mini crises.

Virtually all small children throw temper tantrums, typically starting around age 15 to 18 months and sometimes earlier. In most cases, these fits are not worrisome but simply reflect a stage of development in which increasing independence and willfulness collides with emotional and verbal immaturity. "Temper tantrums are a normal part of infant development," says psychiatrist and family therapist Manfred Cierpka of the University of Heidelberg in Germany.

But a minority of children display more excessive tantrums. The little rebels regularly flip out—in some cases more than five times a day—and are extremely hard to calm. They may become destructive to objects or aggressive toward adults and children and even injure themselves occasionally by, for example, scratching themselves until their skin bleeds or banging their head against the wall.

Frequent rage attacks, together with violent or self-destructive behavior, may signal a more serious problem and warrant professional attention. Not only are such extreme outbreaks emotionally exhausting for the parents and children, but they also may be a harbinger of psychiatric and behavior issues, including depression and a propensity toward violence.

Genetic factors contribute to overly aggressive behavior in toddlers, as do language delays, smoking during pregnancy, socioeconomic factors and certain parenting styles. Studies show, for example, that parents who are more authoritarian and less democratic in their parenting beliefs and actions tend to foster aggression in their children.

Many psychologists recommend that doctors and teachers, along with parents, try to identify young children who display particularly belligerent personalities. Contrary to the conventional wisdom that violence is learned during adolescence, a wealth of recent research has shown that aggressive behavior even before age two can signal persistent problems. Thus, experts are stressing the importance of trying to curtail physically hurtful actions in kids during the first few years of life.

PATRIK GIARDINO *Corbis*

When little children exhibit negative feelings such as anger, parents should respond with understanding so the child knows he or she is loved even when the child is angry.

JUPITERIMAGES

Anger Management

Although toddler tantrums are frustrating and unpleasant, they are usually not a cause for concern. These outbursts are a normal expression of emotions that emerge from an immature brain. Two-and-a-half-year-old Sarah's parents were concerned because their daughter screamed at day care when her teacher intervened in fights over toys. "And at home," her mother says, "Sarah falls apart more and more often, and we can't seem to reach her or calm her down."

When Sarah's parents came to see Cierpka at the Institute for Psychosomatic Cooperative Research and Family Therapy, however, Cierpka saw little cause for alarm. After entertaining herself without incident for more than an hour, Sarah started playing with her mother's pocketbook. Her mother yanked the purse out of Sarah's hands. Sarah simply looked puzzled and sought out the purse again. Her mother took it away a second time, saying, "Come on, Sarah, do we really have to do this right now?" Only then did the toddler begin to howl.

This behavior is quite typical, Cierpka says. "Children in the tantrum phase are making a giant developmental leap," he explains. Not only are their motor skills improving rapidly, enabling them to act independently to explore their surroundings, but also, at about age two and a half, kids start to perceive themselves as individuals; for instance, they suddenly recognize themselves in a mirror. This perception enables a child to have independent desires and realize that her actions elicit responses from others, Cierpka says.

The boost in experimentation, combined with awareness of other people's reactions, is a recipe for frequent distress, as a toddler's explorations and wishes very often elicit "no's" from parents and caretakers. Parents typically will not allow a child to eat a cookie before dinner, for example, to grab a shiny knife blade, or to play with Mommy's purse and wallet. The toddler, for her part, not only can and wants to do these activities but also understands what and who is foiling her—without understanding why.

The result is disappointment and rage—negative feelings that are completely new to the child. Sarah, for example, feels angry about the

FAST FACTS

Tackling Aggression

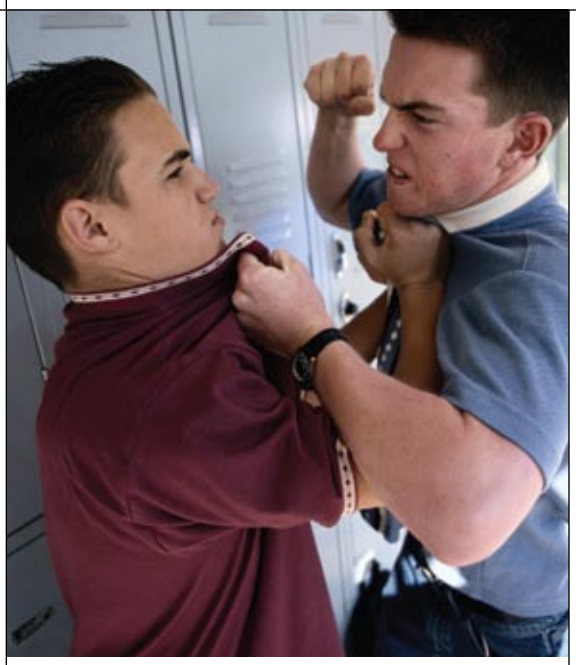
1» **Occasional tantrums are normal for children during the first three years of life, as increasing independence collides with emotional and verbal immaturity.**

2» **Frequent rage attacks, together with unusually aggressive or self-destructive behavior, however, may augur more serious behavior issues, including a propensity toward violence.**

3» **Genetic factors play a role in overly aggressive behavior in toddlers as do language delays, smoking during pregnancy, socioeconomic factors and certain parenting styles. Countering such contributors may help curtail the number of youths who become chronically violent.**

purse being snatched away, helpless because she cannot do anything about it, and rejected by her mother. "These are all extremely strong emotions that are hard for babies to assimilate," Cierpka says. Unable to express their feelings with words, toddlers discharge them instead with irrational screaming and a physical frenzy—a temper tantrum.

Cierpka's advice to parents: acknowledge your child's feelings. For instance, Sarah's mother could have calmly said to her daughter, "I know you are angry about the purse, but my purse is not a plaything." Then she could distract Sarah—say by pulling out a toy from her pocketbook. Or if Daddy wants Sarah to interrupt her play to put on a jacket, he could sweeten the deal by offering to play with her after the shopping trip. Such strategies enable a child such as Sarah to know that her parents are there for her even when she is angry, which will eventually enable her to respond more rationally to her distress.



In about 4 percent of boys, highly physical behavior persists from an early age, and those males are the most likely to be violent as teenagers.

Unable to express their feelings with words, toddlers discharge them with screaming and a physical frenzy.

Escalating Actions

Even if anger and aggression are developmentally appropriate, some children display these traits more than others do. Tantrums may become more seated in willful children, who tend to act and think more independently than their peers do. During a consultation with Cierpka, two-and-a-half-year-old Ben cries and screams without provocation, shakes the leg of a table and then bites into it—a markedly wilder performance than Sarah's.

Rather than a passing phenomenon, unusually aggressive behavior during the toddler years may be a sign of a persistent problem, psychologists now say. A 1995 review of the literature by University of Pittsburgh psychologist Susan B. Campbell suggests that children with behavior problems at age three or four have about a 50 percent chance of having similar problems in early adolescence.

In these cases, physical aggression is the chief concern. For most boys—boys are far more prone than girls are—hitting, kicking, biting and the like seem to peak in kindergarten and then decline between the ages of six and 15. But in about 4 percent of boys, highly physical behavior persists from an early age, and those males are the most likely to be violent at age 17.

Extreme tantrums might in some cases be a sign of attention-deficit hyperactivity disorder (ADHD). In a 2007 study psychologist Manfred Laucht of the Central Institute of Mental Health in Mannheim, Germany, along with psychologist Günter Esser of the University of Potsdam in Germany, compared developmental and behavioral profiles at age two of 26 elementary school children who had ADHD-like disorders with those of 241 healthy grade school kids. They found that potential harbingers of ADHD included fidgetiness, irritability and difficulty understanding language. The last two traits may also contribute to acting out, and many (though not all) hyperactive kids are also aggressive. Thus, toddlers who have very wild tantrums may be at risk for both types of behavior problems, although no one has proved a direct link between toddler fits and ADHD.

Both genetics and the environment contribute to a toddler's temperament. In particular, genetic factors account for more than half of the variation among toddlers in how often they use physical

(The Author)

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GETTY IMAGES

aggression. Psychologist Ginette Dionne of Laval University in Quebec and her colleagues assessed levels of aggression in 562 19-month-old twins. In 2003 the researchers reported that identical twins, whose DNA is almost indistinguishable, shared the trait nearly 60 percent of the time, whereas only 28 percent of fraternal twins, who have about half their genes in common, were similar in levels of belligerence.

Language delays can exacerbate a genetic predisposition toward disruptive and aggressive behavior. Epidemiological studies show that as many as 60 to 80 percent of preschool and school-age children whose speech developed slowly exhibit such behaviors, compared with 20 percent in the general population. Dionne and her colleagues, who assessed the language skills of the twins in their study, did not find a strong association between language and aggression at 19 months. In many cases, aggression appears before any problems with language, suggesting that a language delay does not cause aggression but may increase it: kids may become frustrated by an inability to communicate or use fists when they cannot produce the appropriate words.

Language delays can exacerbate a genetic predisposition toward **disruptive and aggressive** behavior.

Behavior can be shaped in the womb. Heavy smoking by a mother during pregnancy is associated with aggression in kids. Genetic factors also play a big role in how often a toddler exhibits aggressive behavior.

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Meet the Parents

Parenting behavior, starting in the womb, can have a significant effect on a child's temperament. In a study published this year, psychologist Richard Tremblay of the University of Montreal and his colleagues reported that heavy smoking (10 or more cigarettes a day) by the mother during pregnancy was associated with aggression in 1,745 Quebec-born children between the ages of 17 and 42 months. Scientists believe that smoking perturbs the development of the fetal brain.

Psychologists are also convinced that certain parenting styles influence a child's aggressiveness and emotional stability. When a child is distressed, parents who either leave the child to his own devices or respond in an authoritarian manner are looking for trouble. Kids react to neglect or draconian rules with agitation and rebellion and may start to behave aggressively toward other adults or peers, Cierpka says.

A 2008 study of 1,508 elementary school kids by clinical psychologist Mireille Joussemet of the University of Montreal, along with Tremblay and their colleagues, supports a link between aggression and having a "controlling parent"—that is, one who likes to exert power over a child, values obedience and does not encourage a child to express his own opinions. The study found the usual risk factors for aggressive behavior (judged, in this case, by the kids' teachers): being male, having a reactive temperament, and family problems such as separated parents. But beyond these contributors, the investigators discovered that having a controlling mother further boosted the odds of belligerence in grade school.

Other parenting strategies tend to lower the risk for unruliness. In a 1996 study of 69 families rearing firstborn sons, psychologist Jay Belsky, now at Birkbeck, University of London, and his colleagues observed that the parents who had more trouble managing their son's behavior at ages 15 and 21 months tended to give their sons simple directives without embellishment rather than combining such instructions with an explanation, as in: "Don't touch that knife. It could hurt you." Parents who promote guidelines and democracy in a household are more likely to have well-adjusted children than are those who utter simple commands, the psychologists suggest.

In addition, however, kids often suffer from socioeconomic and family factors that are more difficult to change. In the 2008 smoking study,

for instance, the effects of smoking on aggressiveness were enhanced if the family had a low income or the mother had a history of antisocial behavior. The personality of the father can also play an important role in how well a family manages a toddler's behavior. In Belsky's 1996 study more troubled families had fathers who tended to be less friendly and social and more negative than those in households that were coping well. A hostile personality may, after all, equip a person poorly for dealing with temper tantrums.

In addition, marital conflicts added to the mix insofar as they related to parenting. In particular, trouble seemed to flourish when one parent expressed negative emotion while undermining a spouse's parenting—such as interrupting the other parent or giving the child conflicting instructions. Marital quality, in general, however, did not show up as an important factor in this study.

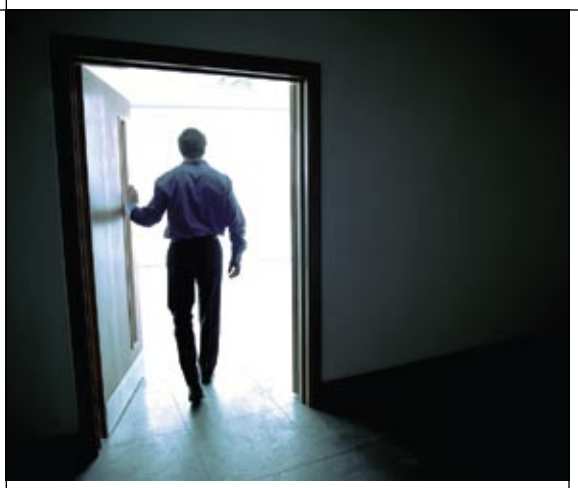
In Ben's case, Cierpka speculates that marital issues may partly underlie Ben's extreme tantrums. Ben's father, he discovered, is an inconsistent presence. Dad leaves home without notice for long periods and does not tell his wife where he is or what he is doing, making her feel hurt and anxious. Ben's mother may then inadvertently transmit her own anger and insecurity to her son, whose tantrums may be a cry for the attention he needs as a salve for his own insecurity.

Cierpka also notices a more superficial problem: as soon as Ben breaks down, his mother pulls him to her to console him. This action tends to reinforce the connection between hostile agitation and love. Cierpka advises Ben's mother to comfort her son only after he has started to calm down, rewarding him for regaining his composure instead.

Expressing Themselves

Anger rears its head within the first six months of life, and as kids such as Ben illustrate, this emotion may lead to aggression within a few years. Because early aggressiveness can portend later violence, programs that quell anger and prevent hostile actions at an early age may help curtail the number of youths who become violent.

Although no preschool program has been proved to prevent chronic physical aggression, studies of childhood aggression and experimental prevention programs hint at what might work. Mental empowerment may be one antidote. An intervention called the Perry preschool experiment that focused on boosting the cognitive development of three- and four-year-olds significantly reduced criminal behavior in males.



PHIL BOORMAN Getty Images

A father's personality—and his presence or absence—can influence a family's ability to cope with a toddler's volatile behavior. Toddlers tend to suffer if a father is antisocial, negative, or absent much or all of the time.

Another promising approach might be to exploit the link between language delay and aggression, targeting children who exhibit a delay and working with them to overcome it, perhaps through intensive verbal stimulation. In addition, social workers might teach aggressive children social competencies such as being helpful, comforting others, sharing, and finding alternative ways of dealing with anger. In cases where authoritarian parenting may play a role, targeted psychotherapy may help break the cycle of aggressive-oppositional behavior in the child and punishment from the parents.

At least one gene has been shown to influence aggression in humans. Males who were badly treated as children were more likely to be convicted of a violent crime before age 27 if they had a shorter form of the gene for an enzyme called monoamine oxidase A. [For more on genetics and character traits, see "The Character Code," by Turhan Canli; Scientific American Mind, February/March 2008.] In the future, as researchers develop more genetic insights into aggressive behavior, these molecular findings may lead to medications that might be combined with behavioral tactics to combat the emergence of violent tendencies in young people. M

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Why Do We Panic?

A better understanding of the path from stress to anxiety to full-blown panic disorder offers soothing news for sufferers

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

"I WAS DRIVING home after work," David reported. "Things had been very stressful there lately. I was tense but looking forward to getting home and relaxing. And then, all of a sudden—boom! My heart started racing, and I felt like I couldn't breathe. I was sweating and shaking. My thoughts were racing, and I was afraid that I was going crazy or having a heart attack. I pulled over and called my wife to take me to the emergency room."

David's fears turned out to be unjustified. An emergency room doctor told David, a composite of several therapy patients seen by one of us (Arkowitz), that he was suffering from a panic attack.

The current edition of the *Diagnostic and Statistical Manual* (*DSM*) defines a panic attack as an abrupt and discrete experience of intense fear or acute discomfort, accompanied by symptoms such as heart palpitations, shortness of breath, sweating, trembling, and worries about going crazy, losing control or dying. Most attacks occur without obvious provocation, making them even more terrifying. Some 8 to 10 percent of the population experiences an occasional attack, but only 5 percent develops panic disorder. Contrary to common misconception, these episodes aren't merely rushes of anxiety that most of us experience from time to time. Instead patients who have had a panic attack typically describe it as the most frightening event they have ever undergone.

Research has provided important leads to explain what causes a person's first panic attack—clues that can help ward off an attack in the first place. When stress builds up to a critical level, a very small additional amount of stress can trigger panic. As a result, the person may experience the event as coming out of the blue.

Some people may have a genetic predisposition toward panic, as psychologist Regina A. Shih, then at Johns Hopkins University, and her colleagues described in a review article. The disorder runs in families, and if one identical twin has panic disorder, the chance that the other one also has it is two to three times higher than for fraternal twins, who are genetically less similar. Although these findings do not rule out environmental

COURTESY OF HAL ARKOWITZ (*top*); COURTESY OF SCOTT O. LILIENFELD (*bottom*); MARCOS WELSH *age fotostock* (*man on phone*)

When stress builds up to a **critical level**, a very small amount of additional stress can trigger a panic attack.

factors, they do strongly suggest a genetic component.

Panic disorder imposes serious restrictions on patients' quality of life. They may be plagued by a persistent concern about the possibility of more attacks and may avoid situations associated with them. To receive a diagnosis of panic disorder, patients must also worry that they might have another attack where it would be embarrassing (say, in a public setting such as a classroom), difficult to escape (such as when one is stuck in traffic), or difficult to find help (for example, in an area with no medical facilities nearby). Panic disorder accompanied by extensive avoidance of these situations results in a diagnosis of panic disorder with agoraphobia; in extreme cases, sufferers may even become housebound.

From Normal Anxiety to Crippling Fear

What are the roots of such incapacitating attacks? Psychologist David H. Barlow of Boston University, who has conducted pioneering research on understanding and treating panic disorder and related disorders, and others believe that panic attacks result when our normal "fight or flight" response to imminent threats—including increased heart rate and rapid breathing—is triggered by "false alarms," situations in which real danger is absent. (In contrast, the same response in the face of a real danger is a "true alarm.")

When we experience true or false alarms, we tend to associate the biological and psychological reactions they elicit with cues that were present at the time. These associations become "learned alarms" that can evoke further panic attacks.

Both external situations and internal bodily cues of arousal (such as increased breathing rate) can elicit a learned alarm. For example, some people experience panic attacks when they exercise because the physiological arousal leads to bodily sensations similar to those of a panic attack.

Why do some people experience only isolated attacks, whereas others develop full-blown panic disorder? Barlow has synthesized his research and that of others to develop an integrated theory of anxiety disorders, which states that certain predispositions are necessary to develop panic disorder:

- *A generalized biological vulnerability* toward anxiety, leading us to overreact to the events of daily life.
- *A generalized psychological vulnerability* to develop anxiety caused by early childhood learning (such as overprotection from our parents) that the world is a dangerous place and that stress is overwhelming and cannot be controlled.
- *A specific psychological vulnerability* in which we learn in childhood that some situations or objects are dangerous even if they are not.

Panic disorder develops when a person with these vulnerabilities experiences prolonged stress and a panic attack. The first attack activates the psychological vulnerabilities, creating a hypersensitivity to external and internal cues associated with the attack. As a result, even medication containing a mild stimulant can provoke an attack.

Still, there is good news. Two findings in particular can provide reassurance for those with panic disorder. The first is that all panic attacks are triggered by known events, even though the sufferer may be unaware of them. This knowledge can reduce the anxiety associated with the sense of unpredictability. Second, it can be reassuring to learn that a panic attack is a misfiring of the fight-or-flight response in the absence of danger.

Basic research not only has helped us understand panic disorder but also has led to effective treatments. In particular, Barlow and his associates developed panic-control treatment, described in their 2006 book *Mastery of Your Anxiety and Panic*. It involves education about panic disorder and somewhat gradual exposure to the internal and external cues that trigger panic attacks, along with changing the catastrophic interpretations of bodily cues so that they no longer trigger the attacks. This treatment has in most instances surpassed drug therapies for the disorder over the long term. M

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

Send suggestions for column topics to editors@SciAmMind.com

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- For a referral to a therapist in your area who uses panic-control treatment or similar treatments, contact the Center for Anxiety and Related Disorders at **www.bu.edu/card** or the Association for Behavioral and Cognitive Therapies at **www.aabt.org**

A Sense of Irony

Language has many layers of meaning. When and how do we grasp them?

BY WRAY HERBERT

"Well, that's just great." Scientists have probed how early children can grasp the wry tone in that sentence.

MATT MENDELSOHN (*Herbert*); CLAIRE BOCK *jupiterimages* (*birthday party*)

"WELL, that's just great." Quick, what does that sentence mean? Is the speaker acknowledging some good news, celebrating a joyful event that just took place? Do we take the statement at face value? Or could the person who said it mean something quite different, maybe even the opposite? Perhaps his pleasure is not genuine.

The fact is we do not know. The words are ambiguous. The comment could be kind and authentic: imagine his daughter has just announced that she made the school honor roll for the first time. But he could just as well be stuck in rush-hour traffic, late for an important meeting. His comment in that case is probably not genuine at all but sarcastic.

How can we tell which is which? How as listeners do we recognize and comprehend irony? And what makes us use sarcasm and irony in the first place, when we could just as easily be literal and unambiguous? Communication is tricky enough without deliberately muddling things with hidden layers of meaning. What social purpose could such vagueness serve?

Language of Failed Expectations?

Psychologists are very interested in both how we use ironic language and how we see it for what it is. And there are lots of ideas. Some argue that ironic language is the language of failed expectations; it is a fact of the human condition that things do not always

> What makes us use sarcasm and irony in the first place when we could **just as easily** be unambiguous?

Ironic sensibility appears to be **hardwired into neurons**, although using irony also requires social intelligence.

turn out as planned, and language needs to capture and highlight that ironic sense of life. But when and how does that sense of life emerge, and when do we develop the social competence to recognize it?

One way to approach these questions is to look at language comprehension in children. Youngsters have few life experiences to speak of, so it would seem that they should be innocent of its ironies. They should take every sentence they hear literally, unless they are given some reason not to do so. So, to stick with the same example: if someone says, "Well, that's just great," kids should simply believe it. They should not be expected to probe for deeper meaning. If they do probe, it should be as an afterthought.

But is that the case? Psychologist Penny M. Pexman of the University of Calgary in Alberta decided to explore this problem in the laboratory, to see how quick and efficient kids are at processing irony and sarcasm. She wanted to see how early in life this cognitive skill emerges. She also wanted to find out if indeed kids go through a two-step process every time they are confronted with irony—taking the literal meaning first, then perceiving the hidden meaning as an afterthought.

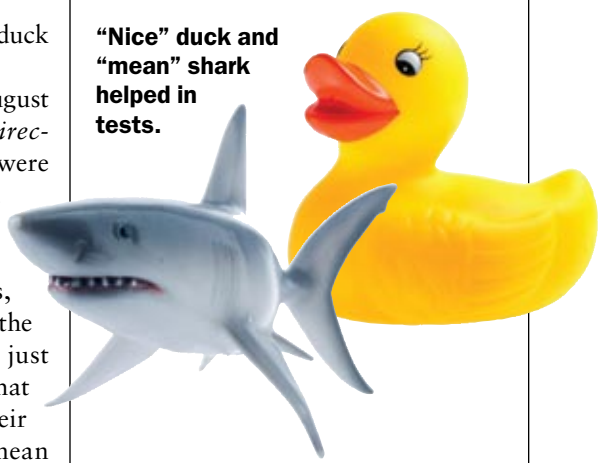
It is hard to study children's minds, especially the five- to 10-year-old minds in Pexman's studies. She could not entirely rely on them to report on their own thinking, so she had to devise special methods to probe their perceptions. Here is an example of what she did. In one experiment, she trained kids to associate niceness with a smiling yellow duck and meanness with a snarling gray shark. Then they watched puppet shows, in which the puppets made both sarcastic and literal remarks. Rather than asking the kids to interpret the remarks, she tracked their eye gaze, to see whether they shifted their attention ever so slightly toward the shark or the duck after a particular remark.

The results, reported in the August issue of the journal *Current Directions in Psychological Science,* were intriguing. If kids were indeed processing every sentence as literally true to begin with, then their eyes would reveal that. That is, they would look automatically at the duck on hearing "Well, that's just great." But they did not. When that sentence was used ironically, their eyes went immediately to the mean shark. The irony required no laborious cognitive crunching. They processed the insincerity as rapidly as they processed the basic meaning of the words.

Hints of Irony

So ironic sensibility appears to be hardwired into the neurons, although using and understanding irony also require social intelligence. Both children and adults need hints that a comment is ironic as opposed to literal. These hints come in the form of facial expression, tone of voice, knowledge of the speaker's personality, and so forth. But all these social cues are processed instantaneously and integrated into a reliable sense of another person's beliefs and intentions. Children with autism have difficulty doing this processing—that is, "theorizing" about what others are thinking and feeling. Interestingly, some autistic children also have difficulty appreciating irony and sarcasm, suggesting that the same brain abnormality may be linked to both deficits.

Pexman's puppet experiments have revealed a fascinating subtlety about children's emerging ironic sensibilities.



"Nice" duck and "mean" shark helped in tests.

She found that although even those as young as six years understand ironic criticism, they do not seem to "get" ironic praise. For example, if a young child misses a soccer goal, he has no trouble knowing that "Hey, nice shot" is insincere and mean-spirited. But if he scores a difficult shot and a teammate yells, "Hey, lousy shot, man," that is a lot harder to process. It does not compute automatically. In other words, children appreciate hurtful irony but not cheerful irony.

Why would that be? Pexman believes it is because most people have a general expectation that others will be nice to them, not mean; ironic language calls attention to the unexpected meanness. Which seems to suggest that kids develop a sardonic sense of life's travails very early on. Well, that's just great. M

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

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

(Further Reading)

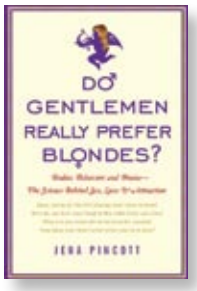
- **How Do Typically Developing Children Grasp the Meaning of Irony?** Penny M. Pexman and Melanie Glenwright in *Journal of Neurolinguistics,* Vol. 20, No. 2, pages 178–196; March 2007.
- **It's Fascinating Research: The Cognition of Verbal Irony.** Penny M. Pexman in *Current Directions in Psychological Science,* Vol. 17, No. 4; August 2008.

ISTOCKPHOTO

ON DATING AND MATING

Do Gentlemen Really Prefer Blondes? Bodies, Behavior, and Brains—The Science behind Sex, Love and Attraction

by Jena Pincott. Bantam Dell, 2008 ($20)



There are two types of romantics: those who enjoy love and simply go along for the ride, and those who analyze and obsess about the whole process before it even begins. If you're the latter, get excited: there's fun reading in store from science writer Jena Pincott.

Geared toward female readers, Pincott's book tackles 95 burning questions about sex, love and attraction. Among the most interesting are the hidden agendas behind men's terrible pickup lines, the reasons men rarely give women useful gifts and why regular physical contact with semen makes women happier. Although some of Pincott's explanations are based on neuroscience—such as functional MRI studies and chemical analyses—most come from the controversial field of evolutionary biology, which attempts to explain human behaviors based on the reasons evolution might have made them common over millions of years. For example, evolutionary biologists believe that women have orgasms because the contractions "suck up" more sperm, increasing the chance of conception.

Evolutionary biology is plagued by more theories than evidence, so take Pincott's answers with a grain of salt—but to her credit, she points out most of the scientific uncertainties herself. Her explanations, based on studies and peppered with personal anecdotes, are never boring. Perhaps Pincott's biggest failure is that her writing is at times corny, trite or pedantic, as if she can't quite decide whether she wants *Gentlemen* to be a science book or a self-help guide. Luckily, the topic is so fascinating, you will keep turning the pages no matter how many times you've rolled your eyes. —*Melinda Wenner*

Mind Reviews

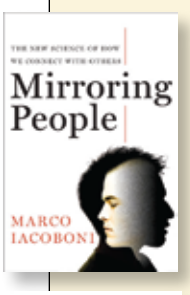
The Social Brain

Mirroring People: The New Science of How We Connect with Others

by Marco Iacoboni. Farrar, Straus and Giroux, 2008 ($25)

Loneliness: Human Nature and the Need for Social Connection

by John T. Cacioppo and William Patrick. W. W. Norton, 2008 ($25.95)



It is no fluke that solitary confinement is one of the worst punishments we have devised. Our brains are so exquisitely calibrated to read those around us that we can hardly survive alone. Two recent books, one by a neuroscientist and the other by a psychologist, make the case that we are all wired for social living. Both argue that we can ignore this fact at our own risk.

Marco Iacoboni, a neurologist and neuroscientist at the University of California, Los Angeles, is one of a growing number of researchers who believe that we owe much of our ability to interpret the minds of others to a class of cells called mirror neurons.

Mirror neurons were discovered in Parma, Italy, in the early 1990s, when a lab assistant noticed that a single cell in a macaque's brain fired both when it reached for an object and when it saw others grasp that object. The monkey's brain seemed to be simulating every action it saw, pointing to a shockingly simple mechanism for the complex behavior of imitation. Ethics will not permit scientists to tap into single neurons in people, but neuroscientists are making the best inferences they can from brain scans such as functional MRIs.

Iacoboni's attempts to measure neural responses to Super Bowl ads and presidential candidates have rightly been labeled "neuropunditry" by skeptical observers, and his argument that mirror neurons explain language seems forced. But he does make a powerful and charming case that mimicry is an essential part of human empathy. It is not always clear how mirror neurons are involved, but the behavioral studies are suggestive. When people are asked to grip a pencil between their teeth, they are slower to detect emotion in other people's faces, because they cannot mimic those expressions.

TODD DAVIDSON *Getty Images (social connection illustration)*

If mirror neurons allow us to feel what others are feeling, as Iacoboni claims, we should expect to see a breakdown in empathy when they are on the fritz. And indeed, Iacoboni cites a recent finding (by his wife, Mirella Dapretto, also at U.C.L.A.) that mirror neurons are defective in autistic children. Broken mirror neurons do not necessarily cause autism, however; as Iacoboni observes, the cells may be weakened as a result of autism.

GOOD DRAMA, BAD THERAPY

In Treatment

DVD available at http://store.hbo.com

Laura, an attractive and deeply disturbed young woman, tells her therapist she's in love with him. After several sessions, they begin to explore the idea of starting a romantic relationship. Good drama? Yes. Good psychotherapy? No.

So it goes with HBO's engrossing television series *In Treatment,* which follows the therapy sessions of three patients and a distressed couple with psychologist Paul Weston, played by Gabriel Byrne. The acting is excellent, and the show succeeds in providing insights into the hidden motivations of the patients and a sense of the process of psychotherapy over time—a rarity in Hollywood.

In many instances, Weston provides good therapy. Unlike most real-life therapists, however, he often lacks empathy and confronts his patients with challenging interpretations of their behavior based on little clinical data. Research has confirmed that a confrontational style leads to patient resistance and sometimes to the worsening of symptoms, whereas a more supportive style sets the stage for positive therapeutic change. Patients need to be able to safely explore their thoughts, feelings and behaviors in order to move toward change. Weston frequently fails to provide these essentials of good therapy.

Weston wrestles with many of his own demons, including significant marital difficulties and problems with anger, depression and burnout. One night a week we see him visit his own therapist-cum-friend, but he is often as resistant to insight and change as his patients are. All too often his personal problems spill over into his therapeutic work in ways that hurt the people he is trying to help. I watched the show with two friends, Ted Reid and Diane Reid, who are experienced psychotherapists like myself—and at many points we found ourselves simultaneously groaning aloud at Weston's mishandling of delicate situations, such as his relationship with Laura (played by Melissa George).

Though riveting to watch, the therapist-patient conflict in almost every session seriously misrepresents real-life psychotherapy in the U.S.—therapy is usually slow, hard work. But *In Treatment* is translated from a popular TV series shown in Israel (*Be Tipul,* created by filmmaker Hagai Levi), where therapy may work somewhat differently. In her book *Tin Soldiers on Jerusalem Beach* (Pantheon Books, 1978), Amia Lieblich describes the Israeli "ego ideal" as characterized by strength and action orientation, with tendencies to associate introversion and introspection with weakness. It could be that confrontation by both therapist and patient is more the norm and less destructive in Israel than it is in the U.S. But no matter what the cultural context may be, Weston's therapy style is perfect for one thing—captivating, irresistible entertainment. —*Hal Arkowitz*

But Iacoboni may have stumbled on a promising treatment. When therapists imitate the rigid and repetitive gestures of autistic children, then invite the kids to imitate healthy actions, the youngsters seem to get better.

University of Chicago social psychologist John T. Cacioppo (with *Journal of Life Sciences* editor William Patrick) tackles a more widespread form of social alienation: loneliness. Cacioppo has discovered that lonely people tend to be more sensitive to cues sent by others but have a harder time reading them accurately. Even as they crave human contact, they are demanding and withdrawn, leading to a spiral of isolation that can cause high blood pressure, poor sleep and premature aging. Chronic loneliness is a hunger that refuses to be fed.

Although he dutifully rehashes the literature on sociability, Cacioppo is at his best when he gets out of the lab—in one case, to a Chicago lakefront to show passersby photographs from space, where he finds that the lonely are more likely to attribute human intentions to clouds of interstellar gas. Another experiment suggests that lonely people will accept unfair treatment that others will not.

After learning that 60 million Americans are suffering from this hidden epidemic and hearing Cacioppo argue that it should not be lumped in with depression, one might expect him to propose that psychiatrists make room for loneliness in their catalogue of mental disorders. But, strangely, Cacioppo backtracks when he admits that persistent loneliness is not its own disorder but a normal risk of being human.

Cacioppo seems comfortable with the idea that chronic and painful isolation will always be with us, quoting allegorist C. S. Lewis, who once wrote that "as soon as we are fully conscious we discover loneliness." Iacoboni appears to disagree. "We have evolved to connect deeply with other human beings," he argues in a final chapter. "Our awareness of this fact can and should bring us even closer to one another."

They may both be right. Our species has a natural gift for mimicry that allows us to enter into one another's minds effortlessly. We also have a craving for contact that makes us vulnerable not only to one another but to our own solitude. The instinct to connect comes with an addiction to company. For better or worse, we are born with both. —*Jascha Hoffman*

Many Connections

Three other recent books also delve into the complexities of our social existence.

>> In ***Experiments in Ethics*** (Harvard University Press, 2008), philosopher Kwame Anthony Appiah explores how our treatment of others is rarely as simple as choosing right from wrong.

>> Get a glimpse of a social structure that depends on sibling support rather than marriage or monogamy for child-rearing and community stability in ***A Society without Fathers or Husbands: The Na of China*** (Zone Books, 2008), by Cai Hua.

>> Beyond the one-on-one communication that we engage in every day, our vast social networks contain a "crowd intelligence" that influences us in ways we do not realize. Computational sociologist Alex Pentland explains how to recognize and use this wisdom in ***Honest Signals*** (MIT Press, 2008).

● *Compiled by Victoria Stern.*

Head Games

Match wits with the Mensa puzzlers

1 OVALESE

Fill in the blanks with spelled-out numbers to make the statement true. (Hint: uppercase and lowercase letters count as the same letter.)

This oval contains _____ Ns, _____ Ts, and _____ vowels.

2 DEGREES O'CLOCK

At 4:20 A.M., through how many degrees has an analog clock's hour hand moved since midnight?

3 MAN IN THE MIDDLE

Fill in the blanks so that each column spells out a common five-letter word and the two blank rows spell out the first and last name of a famous physicist.

B	U	D	E	G	A
R	D	E	R	I	O
H	R	L	Y	F	N

4 SAFECRACKER

The entry code for a bank safe is a five-digit odd number that has no repeated digits and that does not start with zero. What is the maximum number of combinations a thief might have to try?

5 A COUPLE OF TRIPLES

Insert two different trios of letters into the blanks in each row to get two common English words.

a)	**DOMI _ _ _ E**	**DOMI _ _ _ E**
b)	**AR _ _ _ IC**	**AR _ _ _ IC**
c)	**BULL _ _ _ N**	**BULL _ _ _ N**
d)	**D _ _ _ TEE**	**D_ _ _ TEE**

6 AVIANAGRAM

Change one letter in each word to uncover a hidden five-letter bird. For example, change the N in DIAGNOSED to an O to get GOOSE.

a) SNORKEL
b) SUBTRAHEND
c) AQUAPLANE
d) COLLEAGUE
e) TOMAHAWK

7 THREE'S COMPANY

Replace the missing vowels (including "Y") to find famous trios.

a)	**BCN**	**LTTC**	**TMT**
b)	**HK**	**LN**	**SNKR**
c)	**FTH**	**HP**	**CHRT**
d)	**SHK**	**RTTL**	**RLL**
e)	**THS**	**PRTHS**	**RMS**

8 BORDERLINE

Each word below is made of the first two letters of one country and the first two letters of one of its bordering countries. For example, ARCH is a combination of Argentina and Chile.

PAIN TAKE COPE SLIT SUER

9 MISSING PIECES

Fill in the blanks according to the clues.

a)	**R E F _ _**	**Pertain**
b)	**_ R E F _ _**	**Choose**
c)	**R E F _ _ _ _ _ _**	**Get a new loan**
d)	**_ R _ E F**	**Quick**
e)	**_ _ R E F _ _**	**Luminescent insect**
f)	**R _ E F _ _**	**Rife with regrets**
g)	**_ _ _ R E F _ _ _ _**	**A Main Street sight**
h)	**_ R _ _ E F _ _**	**Appreciative**
i)	**R _ _ _ E F**	**Unburdening**
j)	**_ R E _ _ F _ _ _ _ _**	**Devastated**

Answers

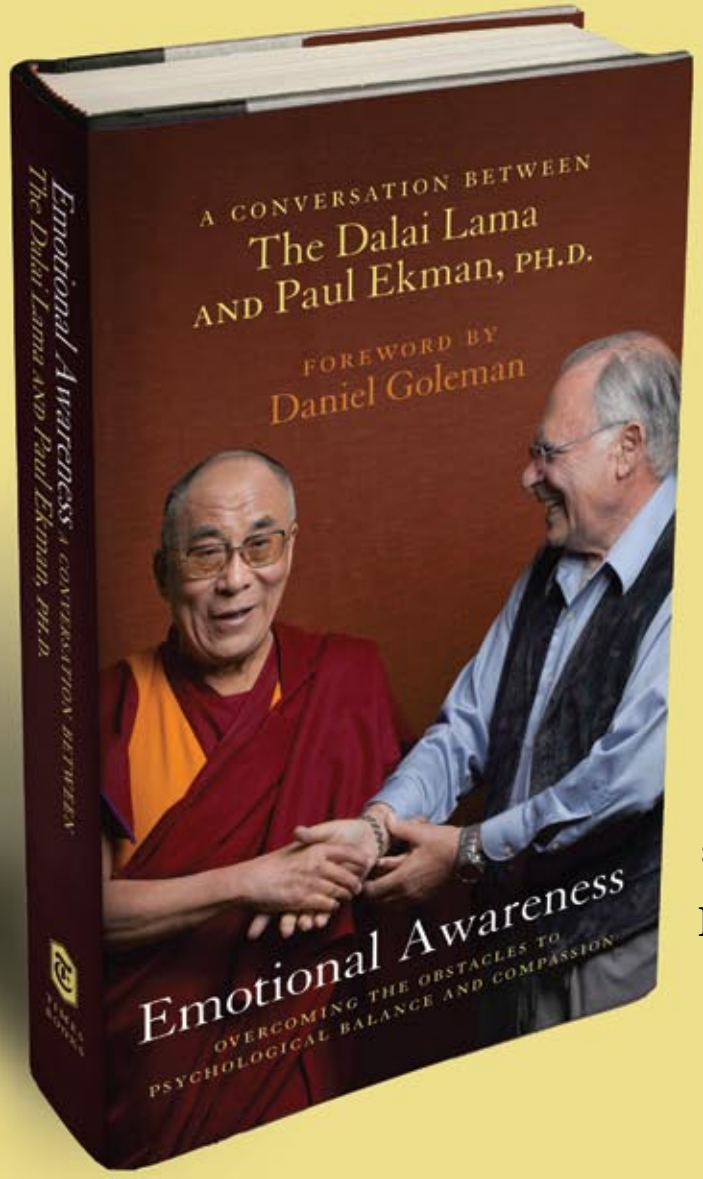
1. Five, four, sixteen.
2. 130 degrees.
3.

B	U	D	E	G	A
E	**D**	**W**	**A**	**R**	**D**
R	D	E	R	I	O
T	**E**	**L**	**L**	**E**	**R**
H	R	L	Y	F	N

4. 13,440. There are five choices for the last digit: 1, 3, 5, 7, 9. Once one of these is chosen, there are eight choices left for the first digit (which cannot be the first chosen number or zero). Once both of these are selected, eight choices remain for the second digit, seven for the third and six for the fourth. The number of possible combinations is $5 \times 8 \times 8 \times 7 \times 6 = 13{,}440$.
5. a) Domicile, dominate. b) Archaic, arsenic. c) Bulletin, bullhorn. d) Devotee, draftee.
6. a) Stork. d) Eagle. b) Raven. e) Macaw. c) Quail.
7. a) Bacon, lettuce and tomato. b) Hook, line and sinker. c) Faith, hope and charity. d) Shake, rattle and roll. e) Athos, Porthos and Aramis.
8. Pakistan/India, Tanzania/Kenya, Colombia/Peru, Slovenia/Italy, Sudan/Eritrea.
9. a) REFER b) PREFER c) REFINANCE d) BRIEF e) FIREFLY f) RUEFUL g) STOREFRONT h) GRATEFUL i) RELIEF j) CREST–FALLEN

"A rich feast for the mind . . . This is a singular meeting of two intellectual traditions—and two remarkable minds and hearts grappling with some of humanity's most critical challenges."

—Daniel Goleman



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askthe**Brains**

Does napping after a meal affect memory formation?

—Yadhu Kumar, Konstanz, Germany

Neuroendocrinologists **Manfred Hallschmid** and **Susanne Diekelmann** of the University of Lübeck in Germany reply:

THE PAST two decades have yielded considerable evidence for sleep's pivotal role in memory consolidation. The lion's share of research has focused on the relevance of longer periods of nocturnal rest. For that reason, the duration that is actually needed for sleep's effects on memory to become behaviorally relevant has not yet been exhaustively investigated. We have reason to assume, however, that even short periods of rest can indeed improve memory formation.

There are only a handful of studies investigating the effect of a short nap on the consolidation of declarative memories, which involve facts and events. Most of these studies have reported better memory performance after sleep as compared with wakefulness, revealing improvements of 4 to 46 percent in word-pair memory after a nap and a 3 percent loss to a 28 percent improvement after wakefulness. Even an ultrashort catnap of about six minutes resulted in better memory retention than staying awake did, but a longer doze of 35 minutes was clearly superior. Interestingly, a number of experiments have indicated that sleep improves memory regardless of whether it occurs during the night or the day, which further highlights the cognitive potential of a postprandial nap.

Research on procedural memory, which comprises perceptual and motor skills (such as learning to play an instrument), has found that a short siesta of 60 to 90 minutes improves visual perception only if the nap includes both slow-wave and rapid-eye-movement sleep, the two phases that the brain cycles through while we doze. In studies focusing on motor skills, such as those in which subjects were asked to repetitively type certain keyboard sequences, a posttraining nap of 60 to 90 minutes likewise improved finger-tapping performance. Even so, the study participants did not show as much improvement after the nap as they did after the following full night of sleep.

In sum, these observations suggest that napping may indeed help you remember what you have just learned but that you need longer periods of shuteye to tap the full potential of sleep.

Why do we find it funny when someone falls down?

—William B. Keith, Houston

William F. Fry, a psychiatrist and laughter researcher at Stanford University, explains:

EVERY HUMAN develops a sense of humor, and everyone's taste is slightly different. But certain fundamental aspects of humor help explain why a misstep may elicit laughter.

The first requirement is the "play frame," which puts a real-life event in a nonserious context and allows for an atypical psychological reaction. Play frames explain why most people will not find it comical if someone falls from a 10-story building and dies: in this instance, the falling person's distress hinders the establishment of the nonserious context. But if a woman casually walking down the street trips and flails hopelessly as she stumbles to the ground, the play frame may be established, and an observer may find the event amusing.

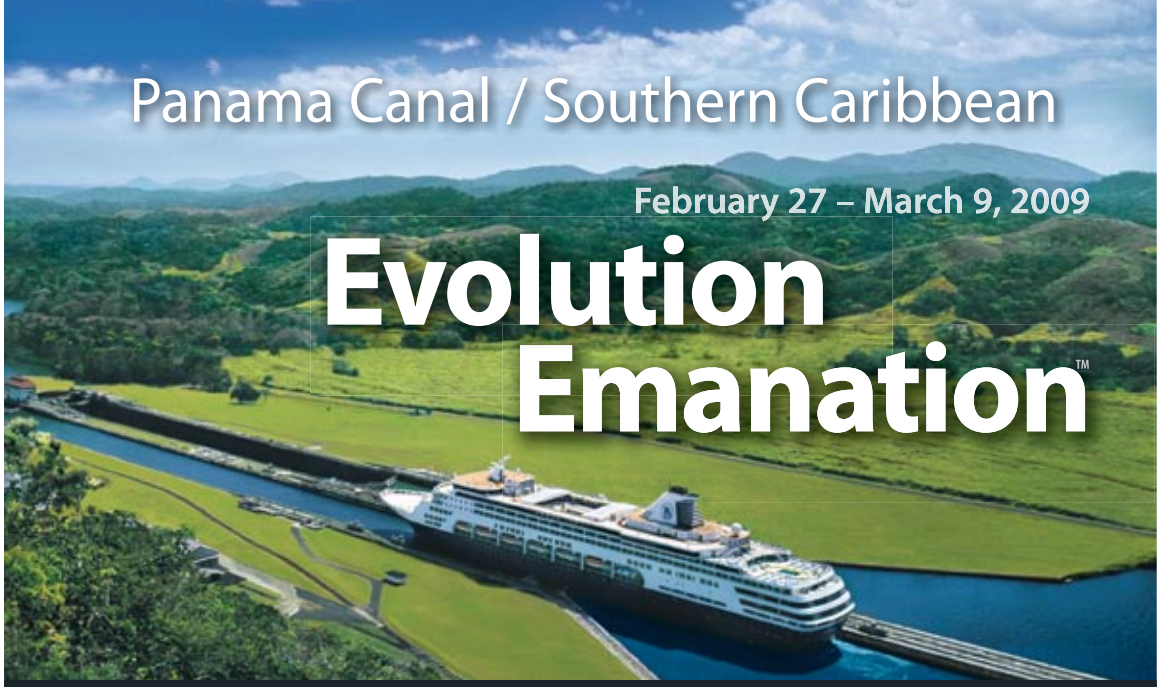
Another crucial characteristic is incongruity, which can be seen in the improbable or inconsistent relation between the "punch line" and the "body" of a joke or experience. Falls are incongruent in the normal course of life in that they are unexpected. So despite our innate empathetic reaction—you poor fellow!—our incongruity instinct may be more powerful. Provided that the fall event establishes a play frame, mirth will likely ensue.

If a woman walking down the street trips and flails hopelessly as she stumbles to the ground, a "play frame" may be established, and an observer may find the event amusing.

Play frames and incongruity are psychological concepts; only recently has neurobiology caught up with them. In the early 1990s the discovery of mirror neurons led to a new way to understand the incongruity aspect of humor. When we fall down, we thrash about as we reach out to catch ourselves. Neurons in our brain control these movements. But when we observe another person stumbling, some of our own neurons fire as if we were the person doing the flailing—these mirror neurons are duplicating the patterns of activity in the falling person's brain. My hypothesis regarding the relevance of this mechanism for humor behavior is that the observer's brain is "tickled" by that neurological "ghost." The observer experiences an unconscious stimulation from that ghost, reinforcing the incongruity perception. M

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

COURTESY OF MANFRED HALLSCHMID, SUSANNE DIEKELMANN AND WILLIAM F. FRY



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The Evolution of the Genetic Code
Speaker: **Stephen J. Freeland, Ph.D.**

Why should all life use two utterly different chemical languages with which to construct itself? Why did it arrive at a single set of encoding rules for translating between them? How can the precise choice of coding rules influence life's struggle to stay one step ahead of extinction? You'll get the bottom line (as it stands now) on the origin and subsequent evolution of the genetic code from Dr. Freeland, including:

- the central dogma that unifies life
- the non-random "design" of genetic code words
- emergence from an RNA world
- the great unknowns

1859: The Impact of a Dangerous Idea
Speaker: **Jerry Coyne, Ph.D.**

In this session we'll trace the origin of Darwin's "dangerous idea" (actually several ideas) beginning with his famous voyage on the HMS Beagle. We will learn what Darwin really proposed, what impact the ideas of evolution and natural selection had on the Victorian world, and why Darwinism was — and still is — considered a dangerous idea.

Unconscious Design: Natural Selection
Speaker: **Jerry Coyne, Ph.D.**

While the idea of evolution was immediately accepted by 19th-century biologists, the concept of natural selection — the purposeless driving force of evolution and adaptation — has been much more controversial. This talk will describe what natural selection really is and see examples of how it works in nature. We will also examine the complementary theory of sexual selection, which explains the remarkable difference in appearance and behaviour between males and females in many species.

For details contact:
Neil Bauman • 650-787-5665
or neil@InSightCruises.com

On the Origin of Species, Really
Speaker: **Mohamed Noor, Ph.D.**

Although Darwin's book title suggested that he provided us with insights on the origin of species, in fact, he only focused on the process of divergence within species and assumed the same processes "eventually" led to something that could be called a new species. In this session, we'll talk about how species are identified (in practice and in principle), and then how modern evolutionary biologists use this type of information to get a handle on how species are formed.

From Magic to Muons: Why People Believe in Strange Things
Speaker: **Tania Lombrozo, Ph.D.**

Much of our knowledge is about things that we cannot see or touch. By studying human reasoning we can begin to understand both how people make scientific discoveries and how these processes can lead to some surprising errors in understanding our world. We'll consider the debate over evolution and intelligent design as a case study in people's understanding of and preference for different kinds of explanations for the world around us.

The Mathematics of Mind: Exploring the Formal Foundations of Human Thought
Speaker: **Thomas Griffiths, Ph.D.**

Over the last two millennia, scientists and philosophers have used approaches such as logic, artificial neural networks, and probability theory to develop scientific and mathematical models of thought. Dr. Griffiths will talk about current status of work to understand the formal principles that underlie human thought and our ability to solve the computational problems we face in everyday life.

Evolution of Individuality and Complexity Through Cooperation and Conflict
Speaker: **Richard Michod, Ph.D.**

Our understanding of life is being transformed by the realization that evolution occurs not only among individuals within populations, but also through the integration of groups of cooperating individuals into new higher-level individuals — that is, through evolutionary transitions in individuality (ETIs). The major landmarks in the diversification of life and the hierarchical organization of the living world are consequences of a series of ETIs: from genes to gene networks to the first cell; from prokaryotic to eukaryotic cells; from cells to multicellular organisms; from asexually reproducing individuals to sexually reproducing pairs; and from solitary individuals to societies. How do groups become new individuals? Cooperation and conflict play a major role in these evolutionary transitions. Join Dr. Michod and come away with a new perspective on the process of evolution and what it means to be an individual.

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GETTY IMAGES (*left*); CORBIS (*right*)

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