A HIDDEN PLAGUE REVEALED: "MILD" BRAIN TRAUMA *page 50*

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COVER IMAGE BY AARON GOODMAN

Charge Forward

Oof. It was yet another "gotcha" moment for me working here at *Scientific American Mind*. Walking home from the train a few days ago, I was running through my mental to-do list. I realized that, yet again, I somehow had not gotten around to the simple task of making appointments for routine dental and physical checkups. Fact is I still haven't done so even as I type these words.

Why do I do that, when it's so obviously smarter to get a quick screening now rather than risking the bother and expense of treating a possible cavity later? Thanks to the feature article "I'll Do It Tomorrow," by Trisha Gura, I now know why—and you will, too, if you turn to page 26. Almost everyone procrastinates, as Gura explains, especially when we find a task disagreeable. But we can take steps to short-circuit such tendencies.

Interrupting—or correcting—circuits is also the key to an intriguing therapy called deep-brain stimulation. "The brain is an electrical organ, so there is little that goes wrong with it that could not, hypothetically, benefit from finely calibrated pulses of electricity," write neuroscientists Morten L. Kringelbach and Tipu Z. Aziz in "Sparking Recovery with Brain 'Pacemakers.'" A battery implanted in a person's chest can, like a pacemaker, provide pulses of electricity to targeted areas of the brain to treat ailments such as Parkinson's, chronic pain and depression. The article begins on page 36.

At the lead of another kind of treatment front are scientists who are trying to better understand "mild" traumatic brain injuries such as those sustained by hundreds of combat veterans in Iraq. In "Impact on the Brain," starting on page 50, neuropsychologist Richard J. Roberts explains how a nearby blast that may knock out a soldier only briefly can nonetheless bruise brain tissue, resulting in later emotional trauma and post-traumatic stress disorder. Sports and accidents cause hundreds of thousands of similar injuries every year in the U.S. as well. A growing appreciation of the problem of mild brain trauma is spawning research into welcome treatments for this hidden plague.

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FEATURES

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TO SLEEP, TO DREAM

Where does dreaming fit into the information provided in "Quiet! Sleeping Brain at Work," by Robert Stickgold and Jeffrey M. Ellenbogen? Does dreaming interfere, improve or have no effect on sleep's enhancement of memory?

"old curmudgeon"
adapted from a comment
at www.SciAmMind.com

ELLENBOGEN REPLIES: *One proposed mechanism for how sleep leads to memory enhancement is that while we are asleep, the brain is busy replaying previously learned information—kind of like an actor rehearsing his lines. Is that a type of dream? Seen from this perspective, dreams do not influence the memory-enhancing effects of sleep, they are the memory-enhancing effect. But some researchers disagree. This debate will continue until we are able to experimentally manipulate the content of dreams and reliably (that is, objectively) record them during sleep. Stay tuned! For a great summary discussion of this topic, see the fourth edition of* Principles and Practice of Sleep Medicine, *edited by Meir H. Kryger, Thomas Roth and William C. Dement (Elsevier, 2008).*

SKIPPING GRADES

Christian Fischer's statement in "Coaching the Gifted Child," favoring placement of highly gifted children with age peers, ignores a large body of research supporting acceleration. The Johns Hopkins Center for Talented Youth, in more than 30 years of research, has found that "acceleration has been shown to be an appropriate practice for meeting the needs of academically talented students; as a way to keep these students motivated and appropriately challenged. There is no evidence to support the notion of negative social and emotional consequences of acceleration for talented students as a whole."

Fischer also perpetuates the negative stereotype of highly gifted children as social misfits and indirectly condones the bullying of gifted children by using the example of a boy who is bullied because he bragged about being smart. In fact, highly gifted children are frequent targets of bullying simply *because* they are so smart. Recent research at Purdue University found that "by eighth grade, more than two thirds of gifted students have been victims" of bullying.

Social difficulties are not individual "shortcomings," as Fischer implies; they are a result of developmental asynchrony common to highly gifted children. These children need help to find friends who understand them and share common interests and who are not threatened by their intellect; these friends are not easy to find among age peers. The highly gifted child will typically have no intellectual peers and endure both boredom and bullying when kept at grade level. Highly gifted children who find older intellectual peers (or other highly gifted age peers) can experience increased self-esteem, not feeling "inferior in every other realm," as the article states.

"Miss Prism"
adapted from a comment
at www.SciAmMind.com

REAL STORIES

In "The Secrets of Storytelling," Jeremy Hsu speaks of "the human predilection for storytelling." Although he mentions nonfiction, the weight of his article is on fiction. Hsu links the idea of story

with "the safe, imaginary world," "fantasy," "folktales" and "narrative traditions"—these are descriptions of fiction. But the father who, putting his children to bed at the end of day, says to them, "Let me tell you the story of how I met your mother," is engaging in storytelling and captivating his listeners just as much—and maybe even more so—as is the father who says to his kids, "Once upon a time there was a prince who lived in a land of dragons." If we are going to study the fascinating world of stories, we must include in our discussion all acts of storytelling: fiction but also gossip, rumor, anecdotes, teaching stories, slice-of-life stories, personal histories, and so on. We must, uppermost, keep in mind that "story" refers to a certain mode of expression, not to a type of narrative.

David H. Morgan
Richmond, Va.

HSU REPLIES: *I agree with Morgan's point. Storytelling clearly encompasses more than the formal works of fiction that we consume in books and on television. Studying the personal stories told among friends and family is also important for understanding storytelling. Nonfiction and fiction can both prove compelling, as I mentioned in my article.*

I emphasized fictional stories because they present perhaps the most intriguing puzzle for scholars of the mind. Why should people care at all about a prince in a land of dragons or the mythical exploits of Greek warriors and gods of thousands of years ago? The process of answering that question is bringing together researchers across the humanities, social sciences and natural sciences.

Hsu's article is strongly oriented toward socialization and romance. As such, it neglects the "cautionary tale" as an important reason—both practical and Darwinian—for storytelling. Throughout my career in the fire service I was exposed to (and told a few of my own) stories about "how I survived to tell the tale." These were meant, and accepted, as lessons on how to be effective at the job while living long enough to be a silverback. Similar conversations broke out every year near the start of hunting season. Old soldiers' tales and a myriad of other survival stories may represent an important reason for storytelling, beyond socialization.

"fire1fl"
adapted from a comment
at www.SciAmMind.com

The comment by "fire1fl" raises a very good point. Stories have many purposes, and these recur cross-culturally at different levels of abstraction. My work has focused on recurring narrative structures in the most enduring stories, which commonly involve thematic concerns that bear on fairly broad issues of ethics or politics (for example, the value of loyalty). Yet the more directly prudential concerns of cautionary tales (relating to, say, hunting) may be more context-bound, more limited in their target audience and, therefore, more ephemeral—less likely to be written down, anthologized or translated. As a result, they would less likely turn up in research on cross-cultural patterns. This situation results in a certain kind of bias in the data.

Perhaps surprisingly, this issue of data bias bears on another issue in the article—literary Darwinism. My problem with certain aspects of the literary Darwinist approach is that writers in this school tend (in my view) to draw biological conclusions far too quickly from what is at best scanty evidence. Consider, for example, two very plausible preliminary hypotheses. First, stories commonly have political functions. Second, dominant groups have disproportionate control over the production and preservation of widely circulated stories. Given these hypotheses, one would expect, for instance, that the representation of men and women would develop in pretty much the ways literary Darwinists report. Thus, the data alone do not decide between social constructionist and biological views of gender.

These are all reasons it is important to be bold in researching possible patterns across cultures but also to be cautious in drawing conclusions about just what those patterns mean. For instance, recurring patterns in heroic plots may tell us something about human biology. But they may also tell us something about more malleable aspects of group dynamics and the ideologies needed to maintain group stratification.

Patrick Hogan
University of Connecticut
adapted from a comment
at www.SciAmMind.com

ERRATUM In "Why Dogs Don't Enjoy Music," by Sandy Fritz [Head Lines, October/November 2008], we misspelled the name of Itzhak Fried of the University of California, Los Angeles.

HARRY GIGLIO *jupiterimages*

MEHAU KULYK SPL/Photo Researchers, Inc.

>> EVOLUTION

Schizophrenia's Roots

The massive human brain enables language—and psychosis

Brains today are expensive—metabolically speaking, that is. Pound for pound, the human brain demands a huge amount of energy to support its recently evolved language and social skills. Now a study offers some of the first strong evidence that the rapid development of our metabolically costly brain may have led to an unfortunate by-product: when energy problems arise, the result may be schizophrenia.

No one knows exactly what causes schizophrenia, a debilitating disorder characterized by psychosis and severe cognitive impairments. One theory, which suggests it is a consequence of our brain's high metabolism, has been around for years—but until now scientists had not developed a way to test it.

In the new study—a rare combination of evolutionary genetics and medicine—researchers in China, Germany and the U.K. compared gene expression (when and where in the body certain genes are active) and concentrations of metabolites (small molecules crucial for metabolic processes) in the postmortem brains of people without schizophrenia with those in the brains of chimpanzees, rhesus macaques and human schizophrenics. They determined that the genes and metabolites that are altered in schizophrenia appear to have changed rapidly in recent human evolution. More important, they are related to energy metabolism.

Because these changes may have happened recently (on an evolutionary scale), we may not yet have developed ways to cope with energy problems that arise, according to study coauthor Philipp Khaitovich, an evolutionary biologist at the joint Max Planck/Chinese Academy of Sciences Institute for Computational Biology in Shanghai. Khaitovich suggests that the brain could be operating at the limit of its energy-regulating abilities, so it might be easy for something to go wrong, as in the case of schizophrenia.

This study may begin to explain why schizophrenia exists but not necessarily why some people are more predisposed to it than others, says Matthew Keller, an evolutionary behavioral geneticist at the University of Colorado at Boulder, who was not involved with the study.

Khaitovich agrees that the work is just a glimpse into the mechanisms responsible for our uniquely human abilities, but the findings do put metabolism in the spotlight for future research. Once we understand what makes our brains special, we can begin to understand what goes wrong in schizophrenia, he says.

—Rachel Mahan

>> ATTRACTION

A Tough Pill to Swallow

Birth-control pills affect women's taste in men

This year 2.25 million Americans will get married—and a million will get divorced. Could birth control be to blame for some of these breakups? Recent research suggests that the contraceptive pill—which prevents women from ovulating by fooling their body into believing it is pregnant—could affect which types of men women desire. Going on or off the pill during a relationship, therefore, may tempt a woman away from her man.

It's all about scent. Hidden in a man's smell are clues about his major histocompatibility complex (MHC) genes, which play an important role in immune system surveillance. Studies suggest that females prefer the scent of males whose MHC genes differ from their own, a preference that has probably evolved because it helps offspring survive: couples with different MHC genes are less likely to be related to each other than couples with similar genes are, and their children are born with more varied MHC profiles and thus more robust immune systems.

A study published in August in the *Proceedings of the Royal Society B*, however, suggests that women on the pill undergo a shift in preference toward men who share similar MHC genes. The female subjects were more likely to rate these genetically similar men's scents (via a T-shirt the men had worn for two nights) as pleasant and desirable after they went on the pill as compared with before. Although no one knows why the pill affects attraction, some scientists believe that pregnancy—or in this case, the hormonal changes that mimic pregnancy—draws women toward nurturing relatives.

Women who start or stop taking the pill, then, may be in for some relationship problems. A study published last year in *Psychological Science* found that women paired with MHC-similar men are less sexually satisfied and more likely to cheat on their partners than women paired with MHC-dissimilar men. So a woman on the pill, for example, might be more likely to start dating a MHC-similar man, but he could ultimately leave her less sexually satisfied. Then if she goes off the pill during the relationship, the accompanying hormonal changes will draw her even more strongly toward more MHC-dissimilar men. These immune genes may have a "powerful effect in terms of how well relationships are cemented," says University of Liverpool psychologist Craig Roberts, co-author of the August paper.

—Melinda Wenner

>> COGNITION

A Bird in the Mirror

Magpies join the elite group of animals that can recognize their reflection

When you look in the mirror, you know you are seeing yourself. Your dog, on the other hand, thinks its reflection is a fellow canine (if anything). So far scientists thought this lack of self-recognition was ubiquitous in the animal kingdom—with the exception of apes, elephants and dolphins. But a new study presents evidence that self-recognition has also evolved in a bird species.

Helmut Prior of Goethe University in Frankfurt, Germany, and his team tagged magpies with a brightly colored mark below their beaks, where the birds could not see it directly. When the magpies looked in the mirror, some of them tried to reach the mark with their beak or touch it with their foot, which shows that they recognized their own mirror image, the researchers say.

The evolutionary lines of birds and mammals split apart about 300 million years ago from our common ancestors, which were small-brained reptiles. Such a long separation suggests that self-recognition emerged independently at least two times, Prior says. The findings also provide a challenge for scientists trying to identify regions of the brain associated with consciousness and self-recognition by looking at brain structures that are unique to higher mammals, he explains: "Obviously, self-recognition is possible with completely different brains." [For more on animal intelligence, see "One World, Many Minds," on page 72.]

—Nicole Branan

Wisdom of the Gut

What people call intuition is really the brain picking up on subtle signals and learning how to use them, according to research in the journal *Neuron* in August. Over time, volunteers playing a gambling game developed a gut instinct about when to take a risky bet: they improved their winning ratio to slightly above chance, indicating they were actually responding to subliminal images embedded in the game that hinted when a bet would pay off. *—Rachel Mahan*

DICK MAKIN Getty Images (*the pill*); COURTESY OF HELMUT PRIOR (*magpie*); GETTY IMAGES (*gut*)

>> BODY

The Perception of Self

When the mind is fooled into disowning a limb, body functions go awry

Look down. There isn't a doubt in your mind that the body you are looking at is yours. But what if you could be fooled into thinking that one of your hands belonged to someone else? Scientists at the University of Oxford recently incited this false perception through an illusion—and they found that when people felt dissociated from a limb, their brain devoted less processing power toward that limb and even interfered with its temperature regulation. These findings, building on a smattering of other studies in disembodiment, suggest that the conscious mind's control over basic body function is much stronger than scientists once thought.

The science of out-of-body experiences seems to have begun with an impromptu party trick. In 1998 Matthew Botvinick, a psychiatrist at the University of Pittsburgh, attended a gathering where the hostess happened to have a rubber hand as a Halloween prop. Botvinick, who was interested in how we distinguish our body from other objects, immediately thought up an experiment. He asked a fellow guest to hide one of his hands behind an opaque screen, then placed the rubber hand next to the screen where the person could see it. When Botvinick simultaneously tickled the man's hidden hand and the rubber hand with brushes, the person felt as if the rubber hand was his own. Thus, the "rubber hand illusion," as it is now called, was born. [For more, see "The Phantom Hand," by V. S. Ramachandran and Diane Rogers-Ramachandran; SCIENTIFIC AMERICAN MIND, December 2004.]

But how does it work? Seeing the touch delivered on the rubber hand "captures the sense of touch experienced by the subject's real hand," explains Manos Tsakiris, a psychologist at Royal Holloway, University of London. "The

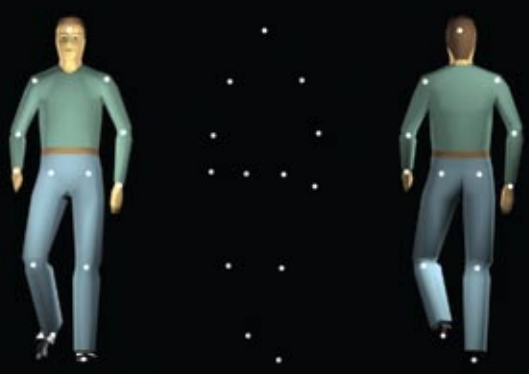
>> GENDER

It's in His Walk

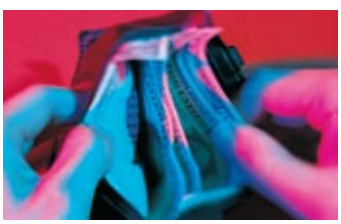
Male walkers seem to approach; females walk away

Men and women have very different gaits—and viewers tend to perceive stereotypically masculine motion as approaching, whereas a feminine saunter seems to move away. As reported in September in the journal *Current Biology*, volunteers were asked to guess the direction of motion of point-map figures, in which the image of a walker's body is reduced to a few dots at his or her major joints (*below*). The figures are the same from the front and back—so they could theoretically be perceived as walking either toward or away from the viewer—but volunteers perceived the swaying hips and protruding elbows of a feminine walk as moving away, and they saw neutral and masculine gaits as coming nearer. The researchers suggest that because men offer more of a threat, our ancestors may have benefited from assuming that a male figure was walking toward them—that way the observer could get ready to flee or fight. But as children, early humans may have been better off assuming that a woman, perhaps their mother, was walking away—then, they would need to follow.

—Rachel Mahan



A point-map figure (*center*) can appear to walk either toward or away from a viewer.



Cut Up Those Cards

Forget about money burning a hole in your pocket: carrying cash rather than credit cards may help you spend less. Business researchers from New York University and the University of Maryland report that study subjects given cash to shop with spent less than those given credit. The team speculates that people are less willing to spend cash because it is the most "transparent" payment—it is easy to see how much you have spent. When the scientists asked study subjects to itemize expenses, however, they were as conservative with their credit cards as they were with their cash. *—Rachel Mahan*

ROBERT BENSON *jupiterimages (hands)*; ANNA BROOKS (*walking experiment*); GETTY IMAGES (*cash*)

rubber hand illusion shows that the integration of different senses is powerful enough to fool the brain into treating a fake hand as a real one," he says.

Last year scientists used a similar tactic to fake an entire out-of-body experience: they gave subjects goggles that played live feeds from two video cameras located eye distance apart two meters behind them. The experimenter stood beside the subject and used two rods to touch the person's actual chest and the "illusory chest," the space that would correspond to the chest of someone whose eyes were located at the two video cameras. After two minutes, subjects began to feel as if they were sitting two meters behind their bodies.

The stronger a person experiences these types of illusions, the stronger the activity in his or her brain's premotor and parietal cortices, which integrate sensory and movement information. The brain's fear circuits are also affected: although subjects know they are experiencing an illusion, they become protective of their new body part. When experimenters threaten the fake hand, brain areas corresponding to threat responses and withdrawal urges become more active.

In the latest study, University of Oxford scientists used the illusion to figure out what happens to the hand that becomes "disowned." Immediately after the brain begins thinking of the rubber hand as its own, the temperature of the disowned hand drops (while the rest of the body's temperature remains the same). When an experimenter touches the disowned hand, the subject's brain responds more slowly than it does when his or her other real hand is touched. These results suggest that when the brain forgets about a limb, the body responds accordingly.

The mind's control over basic body function is much stronger than scientists once thought.

Disease-associated problems in temperature regulation have always been attributed to central nervous system defects, never to thought alone—but these new results offer the tantalizing suggestion that conscious control may be possible, too. These types of illusion-based experiments could help scientists understand what is required for amputees to accept prosthetic limbs as "real" body parts, and they could lead to treatments for people who disown their limbs, such as stroke patients who stop recognizing their paralyzed body parts.

Ultimately, doctors might be able to treat intractable diseases by changing how a person consciously perceives his or her body. "Several spiritual and alternative health groups have been convinced for a long time of the mind-body connection and its two-way-ness. I think this corroborates their conviction," says University of Oxford physiotherapist and study co-author Lorimer Moseley. But, he adds, "we need experiments galore to see if this is anything more than fancy." —*Melinda Wenner*

>> PSYCHOLOGY

Soldiers Who Have Taken a Life Defend Iraq War More

Compared with veterans who have not killed, those who have more strongly begrudge Americans who oppose the war

How do soldiers come to terms with having taken a life in combat? Research has suggested that when people consider themselves to be "good" but are forced to do something "bad" to others, they adopt negative opinions about their victims to rationalize their actions. But according to a new study, this tendency may not apply to soldiers or at least not to those who have served in the Iraq War. American soldiers who have killed in Iraq do not think more poorly of Iraqis than Iraq War soldiers who have not killed—they do, however, think worse of Americans who speak out against the war.

Wayne Klug, a psychologist at Berkshire Community College, asked 68 Iraq War veterans about their experiences, their thoughts on the war and their opinions about Iraqis and Americans. Compared with soldiers who never saw combat and those who witnessed a death but were not involved, veterans who "were directly involved in an Iraqi fatality" were much more likely to consider the war to be beneficial to both countries. The finding is consistent with prior evidence that people tend to value outcomes that require great effort or distress. But although previous research predicts that these soldiers might disparage their victims, investigators were surprised to find that these veterans instead resented Americans whose opinions about the war suggest that their killings may have been unjustified.

MIHAI BARBU *Reuters/Landov*

This change could be a result of the unique circumstances surrounding the Iraq War. "A clue lies in the political and public nature of a controversial war fought by a volunteer army," says Klug, who presented his findings in August at the annual conference of the American Psychological Association in Boston. For example, in the Vietnam War soldiers were drafted, and people who avoided serving were viewed with suspicion, he explains. But today the situation is reversed.

"The veterans are aware of their status as the 'stepchildren' of polite American society, a sense that's enhanced by their abysmal treatment upon returning," he posits. Because America's decision to go to war was the sole reason these soldiers killed, they "now depend on that policy to justify their actions," Klug believes. Those who disagree with the policy, then, become automatic enemies. —*Melinda Wenner*

>> MENTAL HEALTH

Abortion Risk Reviewed

Research shows no credible evidence that a single abortion causes psychological problems in women

About half of all pregnancies in the U.S. are unintended, and 40 percent of these are terminated by abortion. Those ideologically opposed to abortion often argue that the experience is psychologically harmful to women, citing reports of a link between abortion and later mental health problems such as depression. Now, after an exhaustive review of the literature, experts conclude that the best scientific evidence indicates that having a single abortion does not increase a woman's risk of emotional problems.

In 2006 the American Psychological Association (APA) assembled a task force of researchers with wide-ranging expertise to evaluate all peer-reviewed studies published in English since 1989 (when the last such review was conducted) that compared the mental health of women who had an abortion with that of other women. It is clear that after an abortion some women experience sadness and grief and, in some cases, clinically significant disorders such as depression or anxiety. But the task force concluded in August that "among women who have a single, legal, first-trimester abortion of an unplanned pregnancy for nontherapeutic reasons, the relative risks of mental health problems are no greater than the risks among women who deliver an unplanned pregnancy." The evidence for the risk associated with multiple abortions is more equivocal.

In its report the APA highlighted the often severe methodological shortcomings that plagued much of the research. "Very rarely does a study include an appropriate comparison group," laments task force chair Brenda Major, a psychologist at the University of California, Santa Barbara. The only suitable comparison groups include women who carry their unwanted pregnancy to term and either raise the child or give it up for adoption, Major explains, because these are the two main options in addition to abortion that a woman has once she is faced with an unwanted pregnancy.

Many studies did not adequately control for other variables known to be associated with psychological well-being, including poverty, prior exposure to violence, and a history of mental health problems or substance abuse. Failure to parse out the effects of these co-occurring risk factors, the APA explains, can lead to reports of associations between mental health and abortion history that are misleading.

The task force called for more rigorous studies that try to disentangle such confounding factors. "It's not that we need more research," Major warns. "We need better research." Studies should be longitudinal—following women over time—and include larger, more representative samples. Furthermore, authors need to more adequately assess the degree to which a pregnancy is intended or wanted. A woman who terminates a wanted pregnancy because of a fetal abnormality, for example, may suffer more emotionally than someone who aborts because of an unplanned pregnancy.

The reviewers identified several risk factors for women in the U.S. that were predictive of adverse reactions subsequent to abortion, including perceptions of stigma, a need for secrecy, low social support and personality traits such as coping style. The strongest predictor of postabortion mental health is a woman's preexisting mental health.

Major and her colleagues believe future research should focus on understanding the conditions that contribute to negative emotional responses and on bolstering women's resilience. Emphasizing the "diversity and complexity of women and their circumstances," the report cautions that any global statements about the psychological impact of abortion have the potential to be misleading. —*Rachel Dvoskin*

>> POLICY

Mental Benefits

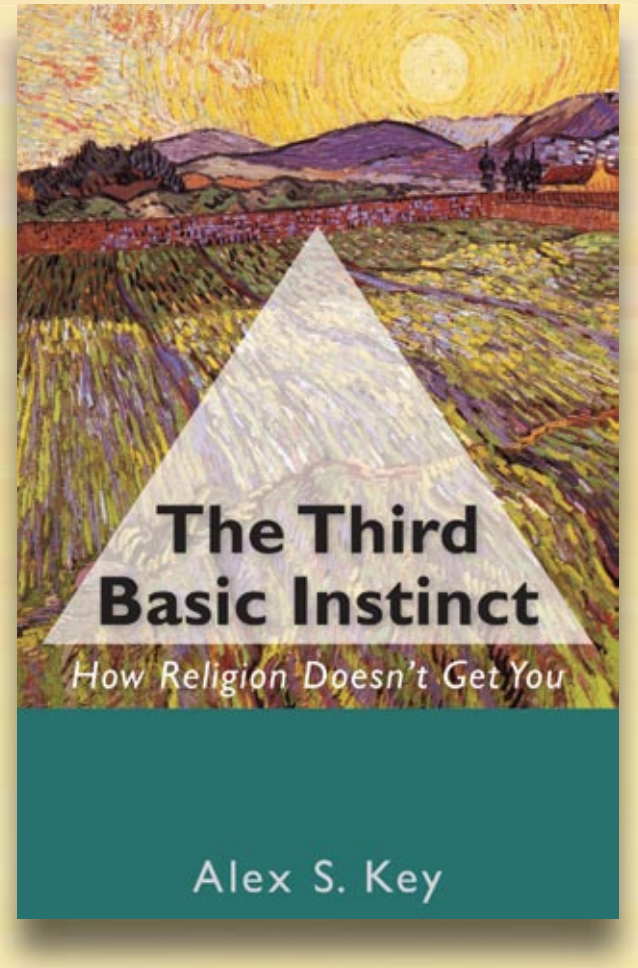
A new law requires better insurance coverage for mental illness

For decades, research has suggested that mental illnesses are just as real—and devastating—as more "physical" ailments such as cancer. Now health care coverage will finally reflect this scientific understanding: in October, Congress passed a bill, 12 years in the making, requiring equal insurance coverage for mental and physical illness. Most insurance companies currently impose higher co-pays and greater restrictions on treatments for addictions, mood disorders, autism, schizophrenia and other mental illnesses. The parity law, which will go into effect for most health plans on January 1, 2010, will improve coverage for 113 million Americans, according to the National Council for Community Behavioral Healthcare. —*Karen Schrock*

GETTY IMAGES (*woman* and *health icon*)

FORGIVE THEM

for they know not WHY they do



The latest understanding of human emotions and motivation finally comes face to face with religion in Alex S. Key's penetrating new book, *The Third Basic Instinct*.

In addition to the basic animal instincts to survive and to reproduce, humans possess a crucial third instinct, which has been a force for scientific discovery, innovation, emotional intelligence…and the bane of organized religion.

Combining news, science, humor, and history, *The Third Basic Instinct* offers a journey into the importance of personal belief systems. Covering such topics as women's rights, addiction, morality, sex, and the origin of gods, Key avoids raging about the dismantling of organized religion, but instead renders science the greatest belief system of all.

The Third Basic Instinct
How Religion Doesn't Get You
Alex S. Key

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>> THE SENSES

The Obesity-Earache Link

Childhood ear infections may damage the nerve for taste, leading to obesity

AGE FOTOSTOCK

Middle-ear infections—the most common illness in young children—afflict three out of every four kids before the age of three. Now research suggests that these bacterial infections cause more than just pain. They may lead to taste impairment, putting children at an increased risk of becoming obese.

Linda Bartoshuk, a University of Florida researcher who studies how taste perception affects health, knew from earlier research that middle-ear infections can damage the chorda tympani, the nerve that carries taste information from the front of the tongue to the brain. She wanted to know whether such damage might have other health effects, so she administered surveys to 6,584 people attending a scientific lecture series.

Bartoshuk was surprised to find that subjects with a history of moderate to severe middle-ear infections were 62 percent more likely than the others to be obese, according to data presented at the American Psychological Association meeting in August. She has since confirmed the link using three large databases maintained by the University of Wisconsin–Madison, the University of Minnesota and the National Center for Health Statistics (NCHS). Bartoshuk also found a link between tonsillectomies, which were a common treatment for ear infections until the late 1980s, and obesity: six- to 11-year-olds who had their tonsils removed were 40 percent more likely to be obese as children than other kids were.

"One could imagine since these children have ear problems or other illnesses more constantly, they'd be smaller," says Howard Hoffman, a researcher at the National Institute on Deafness and Other Communication Disorders, who examined the NCHS data. "Turns out that's not what happens."

Because ear infections precede the weight gain, Bartoshuk believes they cause obesity rather than result from it. Previous research suggests that taste damage limits a person's enjoyment of certain flavors but that it intensifies the ability to experience other kinds of oral sensations, such as texture. Fatty foods have a creamier texture than low-fat foods, so Bartoshuk speculates that people with taste damage consume more high-fat foods to compensate for flavor loss. ***—Melinda Wenner***

>> EMOTIONS

More Than Flattery

Imitating others' emotional expressions may foster empathy

Most of us reflexively grin when we see another beaming face and grimace when we see a comrade in pain. New research suggests that such mimicry helps people—especially women—more quickly grasp others' emotional expressions.

In their recent study Dutch psychologists Mariëlle Stel of Leiden University and Ad van Knippenberg of Radboud University Nijmegen showed 62 research participants a series of photographs of faces, each for less than a tenth of a second. After viewing each face, participants pressed a button to indicate whether the image displayed positive or negative emotion. For half the experimental trials, Stel and van Knippenberg instructed participants to avoid mimicking the faces' emotional expressions and to clench their teeth, which hindered their ability to do so. In a control condition, participants were asked to hold their shoulders still as they responded, a constraint that the researchers believed was about as distracting as having to avoid moving facial muscles. The investigators measured how quickly participants responded to each face and found that when women were free to mimic emotional expressions, they were faster than men were to recognize whether the emotion was positive or negative. When mimicry was constrained, the men were not affected, but the women slowed down to the males' speed.

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The results square with brain-imaging studies that suggest that our brain possesses a shortcut for processing

>> SOCIAL CUES

Loneliness Really Feels Cold

"Cold shoulder" may be more than a saying

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"I feel cold and lonely without you...." It sounds like a line out of a cheesy power ballad, but a new study suggests that social rejection literally makes us feel chilly.

Chen-Bo Zhong and Geoffrey Leonardelli of the University of Toronto had 65 volunteers recall a situation in which they felt either socially welcomed or excluded. Then, under the pretense that the maintenance staff wanted the information, the researchers asked the volunteers to estimate the current room temperature. The volunteers gave answers ranging from 54 to an astonishing 104 degrees Fahrenheit. Even more interesting, those participants who were thinking of social rejection gave lower numbers than did those who remembered being included.

In a second experiment 52 volunteers played a virtual ball game, unaware that the computer was programmed to exclude some players from most of the throws. After they played, participants filled out a supposedly unrelated marketing survey that asked, for example, whether they were in the mood for hot coffee or an icy soda. Those who had been excluded in the ball game, on average, showed a preference for warm foods and drinks.

The results demonstrate that physical experience (such as temperature) and social constructs (such as ostracism) are linked, according to Zhong. That could have implications for such conditions as seasonal affective disorder, which scientists currently associate mainly with sunlight exposure. Winter temperatures might actually influence people's perception of social interactions, Zhong says. —*Nicole Branan*

emotional expressions, the authors say. The findings also hint that women may make more use of this biological shortcut than men do. Social psychologist Dacher Keltner, who studies emotions at the University of California, Berkeley, says the study is important because it corroborates other work showing that, as compared with men, women report greater correspondence between their own emotions and those of others and that they experience higher levels of empathy. Most existing data, Keltner explains, depend on research participants' self-reported perceptions: "This study shows that these gender differences are also observed in very fast, behavioral mimicry."

What remains unknown is how commonly people mimic emotional expressions in natural circumstances or whether mimicry is essential for the "fast route" that women take to emotion recognition, according to psychologist Simon Baron-Cohen of the University of Cambridge. "Certainly there is lots of evidence that females have a stronger drive to empathize, but whether this is mimicry-mediated remains to be firmly established. This new study is at least consistent with that possibility," he says. —*Siri Carpenter*

GETTY IMAGES

>> AGING

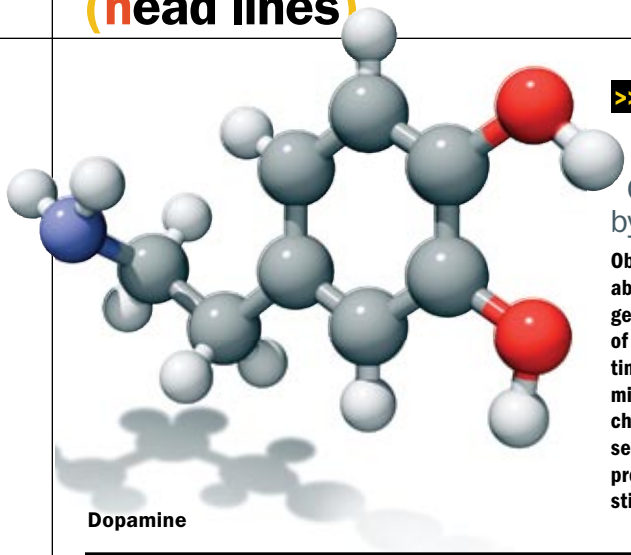
Slow to Ignore

Brains slow down as they become more easily distracted

Older brains do not think as quickly as younger brains do. But does this cognitive impairment arise because processing speeds slacken or because the ability to block out irrelevant information falters? A recent study reconciles these two leading hypotheses: older brains have a harder time ignoring distractions in the initial stages of performing a task, which slows down processing.

Adam Gazzaley of the University of California, San Francisco, and his colleagues asked two groups—one made up of 19- to 33-year-olds and the other of 60- to 72-year-olds—to perform a memory task. The researchers used electroencephalography to record electrical signals from the participants' brains in milliseconds during the task. In contrast to the younger adults, the older group could not suppress distracting stimuli during the first 200 milliseconds after exposure. "At later time points, the ability to ignore does show up," Gazzaley says. "It's not abolished, just delayed." By then, however, the irrelevant information had interfered with the memory task, making the older group less accurate overall than the younger group.

On average, older adults display this cognitive deficit, but "not all older adults are impaired relative to younger adults," Gazzaley notes. Dividing the older group in half according to high and low task performance indicated that only the low scorers had the problem. He adds that exploring the older adults' differences may reveal ways to avoid or correct the deficit. —*Aimee Cunningham*



Dopamine

>> ADDICTION

Food Fix

Overeating may be a self-medication attempt by dopamine-deprived brains

Obesity is frequently framed as an addictive disorder, but scientists understand little about what first prompts the compulsion to eat. Now a study at Tufts University suggests that the impulse could be hardwired. In addicts of any type, the brain's signaling of dopamine—a chemical involved in motivation and reward—becomes abnormal over time. The Tufts study shows, however, that rats prone to obesity are born with low dopamine levels. Eating, then, is akin to self-medication because it helps to restore the chemical to healthy levels; obesity may simply be a side effect that develops from this self-remedy over time. The findings also raise the question of whether animals born prone to obesity could be at a heightened risk for developing addictions to drugs that stimulate dopamine function, such as cocaine and amphetamines. ***–Melinda Wenner***

>> MEDICINE

Psychiatry in Flux

As drugs move in, talk therapy moves out

In the 1960s, the heyday of psychoanalysis, psychiatrists often saw their patients five days a week. But the number of psychiatrists today who focus on talk therapy is dwindling, according to a recent study that analyzed trends in psychiatry offices across the U.S. The study's authors determined that between 1996 and 2005 the percentage of psychiatry office visits involving psychotherapy decreased from about 44.4 percent—already a significant decline from the 1980s—to 28.9 percent.

One of the main causes for this 35 percent reduction in psychotherapy, the study's authors say, is the increasing availability of psychiatric medications with few adverse effects. As patient demand for these medications has increased over the years, they argue, many psychiatrists have had their hands full managing patients' prescriptions, leaving the talk therapy—if it happens at all—to nonmedical therapists, such as psychologists and social workers. The authors suggest that insurance companies may encourage this arrangement by reimbursing less for psychotherapy sessions and more for medication management sessions, which tend to be shorter.

All these changes, the authors point out, have left psychiatrists wondering what their place is in the mental health field. "I think what these data show is a profession in transition," says Mark Olfson, a psychiatrist and public health researcher at Columbia University and co-author of the study. "The role of the psychiatrist is changing, and the impact of that on patient outcomes is really an open question."

Historically, psychiatrists have managed all aspects of patients' care, and many psychiatrists who trained heavily in psychoanalytical techniques contend that such an all-inclusive care model works best for patients. Others favor a split-care model, preferring to handle the medical side of patient care and delegating psychotherapy to nonmedical professionals. "We find there are really two kinds of psychiatrists now," says Ramin Mojtabai, the study's other author and a researcher at Johns Hopkins University's Bloomberg School of Public Health.

GETTY IMAGES (*dopamine* and *psychiatric session*)

It is not yet clear whether one care model benefits patients more than the other does, although some studies indicate, at least for disorders such as depression, that a combination of both psychotherapy and medication works better than either treatment alone. So psychiatrists who want to be involved in their patients' psychotherapy need to make some changes to keep treatment financially feasible for patients, Olfson says. Many psychiatrists have started forming group practices with psychologists, which allows them to play a role in their patients' therapy with fewer reimbursement issues from insurance companies.

Both patients and clinicians stand to gain from an office environment that integrates the biomedical perspective of psychiatrists with the more behavioral perspective of psychologists, says Mojtabai, who holds degrees in both disciplines. "Psychologists and psychiatrists look at problems somewhat differently and can work well together to help the patient," he notes. *—Erica Westly*

How Your Brain Works

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The Truth about Hypocrisy

Charges of hypocrisy can be surprisingly irrelevant and often distract us from more important concerns

BY SCOTT F. AIKIN AND ROBERT B. TALISSE

Al Gore flies in a private jet—but that fact does not negate his admonitions to conserve.

FORMER U.S. VICE PRESIDENT Al Gore urges us all to reduce our carbon footprint, yet he regularly flies in a private jet. Former drug czar William Bennett extols the importance of temperance but is reported to be a habitual gambler. Pastor Ted Haggard preached the virtues of "the clean life" until allegations of methamphetamine use and a taste for male prostitutes arose. Eliot Spitzer prosecuted prostitution rings as attorney general in New York State, but he was later found to be a regular client of one such ring.

These notorious accusations against public figures all involve hypocrisy, in which an individual fails to live according to the precepts he or she seeks to impose on others. Charges of hypocrisy are common in debates because they are highly effective: we feel compelled to reject the views of hypocrites. But although we see hypocrisy as a vice and a symptom of incompetence or insincerity, we should be exceedingly careful about letting our emotions color our judgments of substantive issues.

Allegations of hypocrisy are treacherous because they can function as argumentative diversions, drawing our attention away from the task of assessing the strength of a position and toward the character of the position's advocate. Such accusations trigger emotional reflexes that dominate more rational thought patterns. And it is precisely in the difficult and important cases such as climate change that our reflexes are most often inadequate.

Thus, listeners should temper such knee-jerk reactions toward the messenger and instead independently consider the validity of the message itself. It also pays to examine closely what the duplicitous deeds really mean: from some vantage points, such behavior may actually support a hypocrite's point of view, significantly softening the hypocrisy charge in those cases.

Undermining Authority

One surprising truth about hypocrisy is its irrelevance: the fact that someone is a hypocrite does not mean that his or her position on an issue is false. Environmentalists who litter do not by doing so disprove the claims of environmentalism. Politicians who publicly oppose illegal immigration but privately employ illegal immigrants do not thereby prove that contesting illegal immigration is wrong. Even if every animal-rights activist is exposed as a covert meat eater, it still might be wrong to eat meat.

More generally, just because a person does not have the fortitude to live up

> From some vantage points, hypocritical behavior **may actually support** a hypocrite's point of view.

JUPITERIMAGES

to his or her own standards does not mean that such standards are not laudable and worth trying to meet. It therefore seems that charges of hypocrisy prove nothing about a topic. Why, then, are they so potent?

The answer is that such allegations summon emotional, and often unconscious, reactions to the argument that undermine it. Such indictments usually serve as attacks on the authority of their targets. Once the clout of an advocate is weakened, the stage is set for dismissal of the proponent's position. Consider the following two examples:

Dad: You shouldn't smoke, son. It's bad for your health, and it's addictive.
Son: But, Dad! You smoke a pack a day!

Amy: Have you seen Al Gore's *An Inconvenient Truth*? We need to reduce our carbon footprint right away.
Jim: Al Gore? You know he leaves a huge footprint with all his private jet flights!

In the first example, the son feels that his father is not an appropriate source of information on smoking because Dad is a hypocrite. The accusation of hypocrisy does not so much defeat Dad's position as nullify it, almost as if Dad had never spoken. The same holds in the case of Gore's airplane, although the speaker, Amy, is not the alleged hypocrite but rather Gore, the authority to which she appeals. In both cases, hypocrisy is proffered as evidence of the insincerity or incompetence of a source, providing ammunition for ignoring his or her advice or instruction.

Such ammunition is particularly potent because of the power of such personal portrayals. Once people have characterized someone in a negative light, they tend to ignore evidence to the contrary. In a 2007 study psychologists David N. Rapp of Northwestern University and Panayiota Kendeou of McGill University asked student volunteers to read 24 different stories involving a character who behaves in a way that suggests he is sloppy or lazy. Later in each story, however, the individual acts in a manner that contradicts this judgment. Nevertheless, less than half of the respondents revised their view of the character.

These results suggest that a first impression of someone as lazy or hypocritical actively inhibits the consideration of other information that might be important to understanding that person or the issue at hand. In the smoking and airplane examples, the son and Jim foolishly focus on the father's and Gore's hypocrisy rather than on the perils of smoking or the human contribution to global warming.

A smoker who tells his son not to smoke because the habit is unhealthy may be hypocritical. He may also be right.

Duplicity Understood

In fact, if the son and Jim had focused on the issues, they might have viewed the father's and Gore's behavior radically differently. Consider what Dad's smoking suggests: Dad believes smoking is bad for him, yet he continues to smoke because, of course, he is addicted. So Dad's behavior—his hypocrisy—actually supports his point that smoking is addictive. Gore's behavior also bolsters one of his arguments for change in national energy policy: that certain ingrained aspects of the American lifestyle, such as our penchant for driving SUVs and distaste for riding city buses, lead to environmental irresponsibility—even *Gore* cannot escape it. (To his credit, Gore compensates for his plane trips by buying carbon offsets, which pay for projects that reduce greenhouse gas emissions.)

Of course, hypocrisy does not always support the hypocrite's view. Spitzer's visits to prostitutes do nothing to reinforce his official opposition on prostitution. And in some cases, hypocrisy has precisely the significance that the son and Jim assign to it: it is reason enough to dismiss a source because the person has lost his credibility. For example, when the preacher who presents himself as a moral authority gets caught having an adulterous affair, his followers may rightly call his teachings into question.

Thus, hypocrisy is sometimes sufficient to undermine a person's authority. It *can* warrant the thought, "Why pay attention to what *he* says?" But hypocrisy does not always have this effect, as the Dad and Gore cases show.

Whether hypocrisy is relevant to a person's credibility usually depends on the content of the hypocrite's statements. And yet hypocrisy charges, as they are popularly deployed, tend to short-circuit rational examination of that content. To skirt this danger, people should suppress their instinctual responses to accusations of duplicity so that they can focus on the real issues at hand. Such concentration is essential to our ability to rationally judge our leaders, colleagues and friends as well as to make decisions about important social issues that affect our lives. M

SCOTT F. AIKIN earned a Ph.D. in philosophy at Vanderbilt University in 2006. ROBERT B. TALISSE is associate professor of philosophy and political science at Vanderbilt.

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CORBIS

What Is It Like to Be a Bee?

Bees display a remarkable range of talents—abilities that in a mammal such as a dog we would associate with consciousness BY CHRISTOF KOCH

WE TAKE THE MAGICAL GIFT of consciousness for granted. From the time I awaken until I fall into a deep, dreamless sleep, I am flooded with conscious sensations. And contrary to assertions made by philosophers, novelists and other literati, by and large this stream of consciousness does not relate to quiet self-reflection and introspective thoughts. No, most of it is filled with raw sensations.

Two weeks ago a friend and I climbed a sea cliff above the Pacific surf at Malibu, Calif. When I am on the sharp end of the rope, my inner critic—that voice in my head reminding me of deadlines, worries and my inadequacies—is gone, is silent. My mind is all out there—conscious of the exact orientation, shape and texture of the rock, looking for tiny indentations where I can get purchase for my fingers and toes, always aware of how high I am above the last bolt. One moment I am exquisitely aware of my feet on all too smooth rock, reaching upward with my left hand for a handhold. The next I am airborne, my right hand bloody, my right rib cage aching. After catching my breath and shouting to my anxious belayer that I'm okay, I am filled with adrenaline for having survived yet another fall, can't contain my enthusiasm, and scream.

Today only the bruised rib remains as a testament to how much of the stream of consciousness is pure sensation. Whether you are weaving on a motorbike through flowing traffic, running in the mountains, dancing to fast rock and roll, reading an engaging book, making love or debating with your friend, your eyes, ears, skin and body sensors paint an engrossing picture of the outside, including your own body, onto your mind's canvas.

Animal Consciousness?

I suspect this feeling is not that dissimilar to the way animals consciously experience their world. Except perhaps for the great apes and a few other privileged big-brained animals, most species do not posses the highly developed sense of self, the ability to reflect on oneself, that people have. Most biologists and pet owners are willing to grant consciousness to cats, dogs and other mammals. Yet our intuitions fail us completely when we consider fish and birds, let alone invertebrates such as squid, flies or worms. Do they experience the sights and sounds, the pains and pleasures, of life? Surely they can't be conscious—they look too different from us, too alien.

A honeybee hovers in front of a flower with her antennae pointing forward.

Insects, in particular, were long thought to be simple, reflexive creatures with hardwired instinctual behaviors. No more. Consider the amazing capabilities of the honeybee, *Apis mellifera*.

Martin Giurfa of the University of Toulouse in France and Mandyam Srinivasan and Shaowu Zhang, both at the Australian National University in Canberra, trained free-flying bees, using sugar water as a reward, in a variety of complex learning tasks. The neuroethologists taught the bees to fly in and out of tall cylinders with one entryway and two exit holes. Each bee had to choose one of two exits to leave the cylinder and to continue her flight. (In bee colonies, males are a small minority and do only one thing—and that only during the virginal flight of the colony's queen.)

These cylinders were staggered into mazes with multiple levels of "Y" branch points that the bees encountered before reaching the desired feeder station. In one set of experiments, the scientists trained bees to track a trail of colored marks, as in a scavenger hunt. The bees could then follow—more or less—the same strategy in a completely unfamiliar maze. Amazingly enough, bees can use color in an abstract manner, turning right, for instance, when the branch point is colored blue and left when it is colored green. Individual animals developed quite sophisticated strategies, such as the right-turn rule, that always led to the goal, though not necessarily by the shortest route.

In humans, the short-term storage of symbolic information—as when you enter an acquaintance's phone number into your iPhone's memory—is associated with conscious processing. Can bees remember task-relevant information? The gold standard for evaluating working

FATMA KONUSKAN (*Koch*); JEFF WILSON *Australian National University* (*honeybee*)

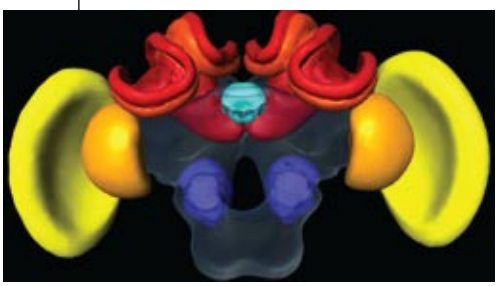
Bees have group **decision-making skills** that rival academic and corporate committees in efficiency.

memory is the delayed matching-to-sample (DMTS) paradigm. The subject looks at a picture for a few seconds. The test image then disappears for five or 10 seconds. Subsequently, two pictures are shown next to each other, and the animal has to choose, by pushing a lever or moving its eyes, which of the two images was the test picture. This test can be carried out correctly only if the animal remembers the image. A more complex version, the delayed nonmatching-to-sample (DNMTS) task, requires one additional processing step: choosing the opposite image from the one previously shown.

Although bees can't be expected to push levers, they can be trained to take either the left or the right exit inside a cylinder modified for the DMTS test. A color disk serves as a cue at the entrance of the maze, so that the bee sees it before entering. Once within the maze, the bee has to choose the arm displaying the color that matches (DMTS) or differs from (DNMTS) the color at the entrance. Bees perform both tasks well. They even generalize to a situation they have never previously encountered. That is, once they've been trained with colors, they "get it" and can now follow a trail of vertical stripes if a disk with vertical gratings is left at the entrance of the maze. These experiments tell us that bees have learned an abstract relation (sameness in DMTS, difference in DNMTS) irrespective of the physical nature of the stimuli. The generalization to novel stimuli can even occur from odors to colors.

Insect Intelligence

Although these experiments do not tell us that bees are conscious, they caution us that we have no principled reason at this point to reject this assertion. Bees are highly adaptive and sophisticated creatures with a bit fewer than one million neurons, which are interconnected in ways that are beyond our current understanding, jammed into less than one cubic millimeter of brain tissue. The neural density in the bee's brain is about 10 times higher than that in a mammalian cerebral cortex, which most of us take to be the pinnacle of evolution on this planet. In humans, widespread loss of cerebral cortex, as in the vegetative patient Terri Schiavo, leads to an irreversible loss of consciousness. That is not to say that a cerebral cortex is necessary for consciousness in creatures with a different evolutionary heritage.



A view of the honeybee brain from the back. The brain, including the prominent lobes that process visual information and that lie just below the compound eyes (*yellow*), is about two millimeters across.

Bees live in highly stratified yet flexible social organizations with group decision-making skills that rival academic, corporate or government committees in efficiency. In spring, when bees swarm, they choose a new hive that needs to satisfy many demands within a couple of days (consider that the next time you go house hunting). They communicate information about the location and quality of food sources using the waggle dance. Bees can fly several kilometers and return to their hive, a remarkable navigational performance. Their brains seem to have incorporated a map of their environment. And a scent blown into the hive can trigger a return to the site where the bee previously encountered this odor. This type of associative memory was famously described by French novelist Marcel Proust in *À la Recherche du Temps Perdu*.

Given all of this ability, why does almost everybody instinctively reject the idea that bees or other insects might be conscious? The trouble is that bees are so different from us and our ilk that our insights fail us. But just because they are small and live in colonies does not mean that they can't have subjective states, that they can't smell the fragrance of the golden nectar or experience the warm rays of the sun or maybe even have a primitive sense of self. I am not a mystic. I am not arguing for pan-psychism, for the notion that anything is conscious. Nor am I assuming that bees can reason or can reflect on their fate as animated cartoon bees.

What this dilemma highlights is that there is no accepted theory of consciousness, no principled theory that would tell us which systems, organic or artificial, are conscious and why. In the absence of such a theory, we must at the very least remain agnostic about consciousness in these creatures. So the next time a bee hovers above your breakfast toast, attracted by the sweet jam, gently shoo her away. For she might be a fellow sentient being, experiencing her brief interlude in the light, shoehorned between this moment and eternity. M

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RANDOLF MENZEL *Free University of Berlin*

I See, But I Don't Know

Patients with unusual visual deficits provide insights into how we normally see

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

UNTIL ABOUT 35 years ago scientists believed there was only a single visual-processing area, called the visual cortex, situated at the back of the brain. We now know more than 30 areas in the brains of primates—including humans—are involved in handling aspects of vision such as the perception of motion, color and depth. Vision, it turns out, is a much more complex and sophisticated affair than anyone had imagined. It makes sense that responsibility for processing is divided into various areas that have different computational objectives.

We take our sight for granted because it usually seems so effortless. It is only when parts of these different visual areas are damaged, causing selective yet often profound disturbances in perception, that we begin to appreciate the range and subtlety of normal human vision. This approach parallels our study of "normal" illusions—by understanding misperceptions, whether for intact or damaged systems, we gain insight into brain processes involved in perception.

Consider the case of a man known as GY. Damage to his visual cortex resulted in complete blindness in one half of the visual field. He could not consciously see anything, not even a spot of light, shown to him in that region. Yet when asked to reach out and touch the spot, he could do so accurately; he could touch a spot he couldn't see! It seems downright spooky, but, as you will soon learn, we can explain—at least partially—his condition, known as blindsight, in terms of the multiple specialized anatomical pathways devoted to vision that we mentioned earlier. [For more on blindsight, see "Subconscious Sight," by Susana Martinez-Conde; SCIENTIFIC AMERICAN MIND, April/May 2008.]

Or consider the strange case of John, elegantly studied in 1987 by M. Jane Riddoch and Glyn W. Humphreys, both now at the University of Birmingham in England. John had served as an air force pilot. Soon after his retirement he suffered a stroke that partially damaged visual regions of both hemispheres of his brain. He could observe things around him; he was not blind in the usual sense. But when he saw his wife—or anyone else for that matter—he could not recognize her. He knew her by her voice; his brain areas for hearing were unaffected, as were his memories. Indeed, he could not visually distinguish among umbrellas, chairs or other common objects, even though he claimed to be able to see them perfectly clearly. "They are out of focus in my mind, doctor," he would say, "not in my eye."

The doctors confirmed this assertion by asking him to copy a drawing of, for example, St. Paul's Cathedral that was hanging on the wall. John could produce a faithful rendering, almost a carbon copy, of the picture but had no idea what it was. He might as well have been copying a meaningless jumble of lines.

John had a condition known as visual agnosia, a phrase coined by Sigmund Freud meaning "lack of visual knowledge." Unlike some of Freud's more outlandish ideas such as "penis envy" or the "Oedipus complex," this one has survived the test of time.

What must it feel like to have such a condition, seeing yet not knowing? You can get an inkling by looking at the famous old woman/young lady illustration (*a*). The first time you look at this illusion, you probably see the girl. But after a while, you can mentally flip the image to see an old face. The young woman's chin becomes the hag's nose, and the young ear becomes the old eye. Now, when you were perceiving the face as a young woman, you were also simultaneously seeing the lines and curves

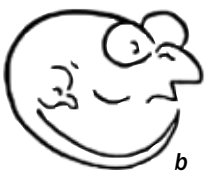
GY could not see it consciously, but when asked to reach out and **touch a spot** he could do so accurately.

SWIM INK 2, LLC/CORBIS

Both pathways are composed of neural circuits, but only one (as far as we can tell) **is conscious**.

constituting the old hag. Yet you were not perceiving (or "knowing") the old woman. In effect, you suffer from a temporary form of agnosia for her. Intriguingly, some people, including our colleague Stuart M. Anstis, a psychologist at the University of California, San Diego, are permanently "stuck" on the young lady and cannot see the hag. Psychologist Richard L. Gregory of the University of Bristol in England refers to this inability as visual hagnosia.

Another compelling example is the rat/man illustration (*b*). When you perceive the rat, you are, effectively, agnosic for the man, and vice versa. For normal people, it is a bistable figure; but for John, perception of neither rat nor man would ever occur, despite his normal visual acuity.



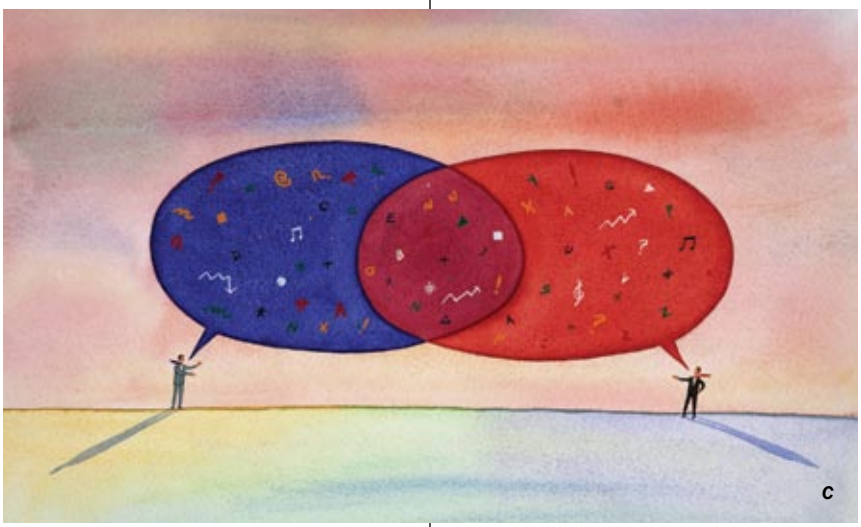
b

You can also get a feel for agnosia by thinking of what happens when you listen to a foreign tongue. You hear all the sounds, syllables, intonations and rhythms of the speech, but none of it makes any sense to you (*c*). You simply cannot create a meaningful perception from these sensations.

Problems in the Pathways

To understand GY's and John's predicaments, we will need to take a brief tour through the anatomy of the visual pathways. Those more than 30 visual-processing areas have staggeringly complex connections among them. Fortunately, despite this complexity, we can discern a simple overall pattern.

Messages from the retina of the eye get transmitted along the optic nerve before diverging into two parallel anatomical pathways, which we shall call "old" and "new" pathways to indicate their evolutionary sequence (*d*). The old pathway, also called the where pathway, goes to a structure called the superior colliculus, which forms a bump on the roof of the brain stem, the stalk that emerges from below the brain and continues as the spinal cord. The colliculus helps to determine the location of an object. When a novel or salient event occurs in your environment (for example, when there is an object looming over your left shoulder), you reflexively orient and swivel your eyeballs toward it without knowing what it is. That is, you orient to it or locate it before you proceed to identify it.



c

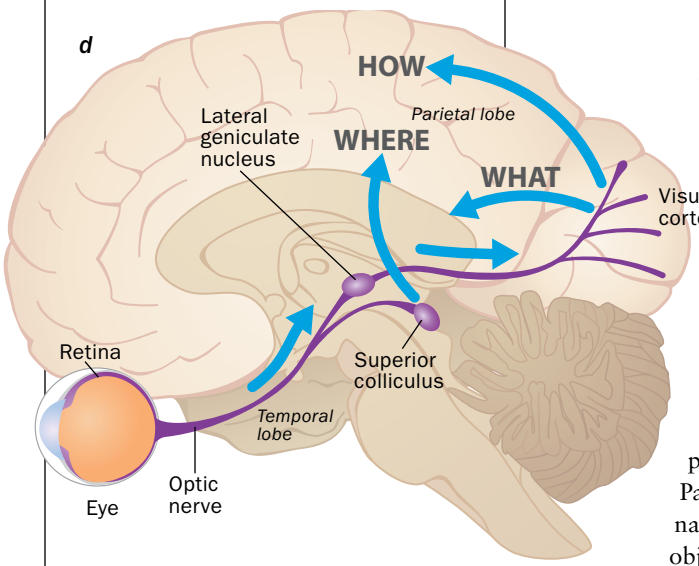
The other pathway, the newer one, as we shall see, is required for identifying an item, even though it is incapable of locating it or orienting to it. The new pathway projects to the visual cortex (V1 for short) in the back of the brain, where the features of the object are analyzed (for color, orientation of edges, movement, and so on). Information from V1 splits again into two pathways farther along the visual-processing course: the how pathway projecting into the parietal lobes ("How" do I use or interact with this object?) and the what pathway ("What" exactly is this object? What does it mean for me?) into the temporal lobes (*d*). The 30 visual areas we spoke of are shared between these pathways. Bear in mind that we have described a grossly oversimplified caricature: many fibers go back and forth between the areas; they are heavily interconnected and not entirely autonomous. But in science it is not a bad idea to start with a simple picture.

Now let us return to GY, who has blindsight. GY has complete damage to V1. No information reaches either the what or how pathway, rendering him blind in the sense that he cannot consciously see objects. But because his where pathway (going through the superior colliculus and bypassing the damaged V1 en route to higher cortical centers) is intact, he can guide his hand unerringly toward the light spot that he cannot consciously see. It is as if there is an unconscious zombie trapped in him that can point accurately even though the conscious person is oblivious. The paradox of blindsight is resolved.

A curious philosophical implication of all this is that only the new pathway is "conscious"; the old pathway can go about its business without consciousness creeping into it. Both pathways are composed of neural circuits, but only one of them (as far as we can tell) is conscious. Scientists have no idea why, although being linked to tasks such as language and meaning might be important. Activity in the what pathway even-

GETTY IMAGES (*nonsense bubbles*)

Imagine an evil genius removes your temporal lobes. What would **the world look like** when you woke up?



Schematic shows how visual information splits into processing pathways: "how" ("How" do I use or interact with this object?), "what" ("What" exactly is this object?) and "where."

tually evokes a verbal label or name ("mother") and nuances of emotions however pronounced ("terror") or subtle ("warmth").

Now imagine your V1 is normal, but an evil genius removes your temporal lobes (the what pathway) under anesthesia. What would the world look like when you woke up? Without the what pathway, you wouldn't be able to recognize, name or appreciate the meanings of things around you. Yet because the how pathway is intact, you would still "see" in the sense of being able to reach out for objects, to dodge missiles hurled at you or to avoid obstacles. It is hard to imagine this scenario, but it would be roughly equivalent to being transported to the Red Planet (without your knowledge) and waking up in a gallery of Martian abstract art. You could not recognize anything or understand it but could still find your way around, copy the shapes of things and step over fallen objects. Everything around you—chairs, tables, people, cars—would look like meaningless abstract art. You would have profound visual agnosia.

This kind of complete damage is rare, but even with partial damage a condition called Klüver-Bucy may develop. In this variant of agnosia the patient has some difficulty identifying common objects but more profound agnosia for food and appropriate "sex objects." Patients cannot discriminate food from inedible objects, so they may put pebbles in their mouth. Such people may make sexual overtures to the patient in the adjacent bed, to the doctor or even to animals, though they are mentally normal in other respects.

Seeing without Naming

John's predicament is somewhat similar. In some ways, it is more severe because he has great difficulty identifying any object. Yet he doesn't take this to the absurd lengths of trying to eat inedible objects or engaging in indiscriminate sexual behavior. In Klüver-Bucy patients there is probably relatively greater damage to regions in the temporal lobes concerned with sex, food and other primal urges, whereas in John the damage mainly affects regions involved in recognizing more neutral and commonplace objects such as chairs, goats and carrots.

Recall, especially, that he could copy pictures accurately, although he was unable to identify or name them. This is because his how pathway is undamaged, and it can guide the hand around to draw a faithful rendering. Without the what (temporal lobe) pathway, he does not know what it is. Amazingly, he could even use shears to trim the hedge in his garden (which only requires how) but could not weed the garden because he had lost the ability to discriminate weeds from flowers. But his problems were not quite as extreme as seen in Klüver-Bucy; he could often recognize the general category that an object belonged to ("it's an animal") albeit not the specific exemplar (he might say "dog" instead of the correct "goat"). Or he would identify a carrot as a paintbrush ("because it's long and has a tuft at its end").

And thus we can begin to explain the unusual perceptions of GY and John, by examining their particular deficits in terms of our detailed knowledge of the visual areas and their connections and evolutionary origins. In doing so, we have not only explained these bizarre symptoms but also gained new insights into how normal vision works. Contrary to naive intuition, vision is not a single process. Instead it involves multiple specialized areas working in parallel. How the outputs of these areas are combined to create a seamless unity of conscious perception, however, is as yet an unsolved mystery. M

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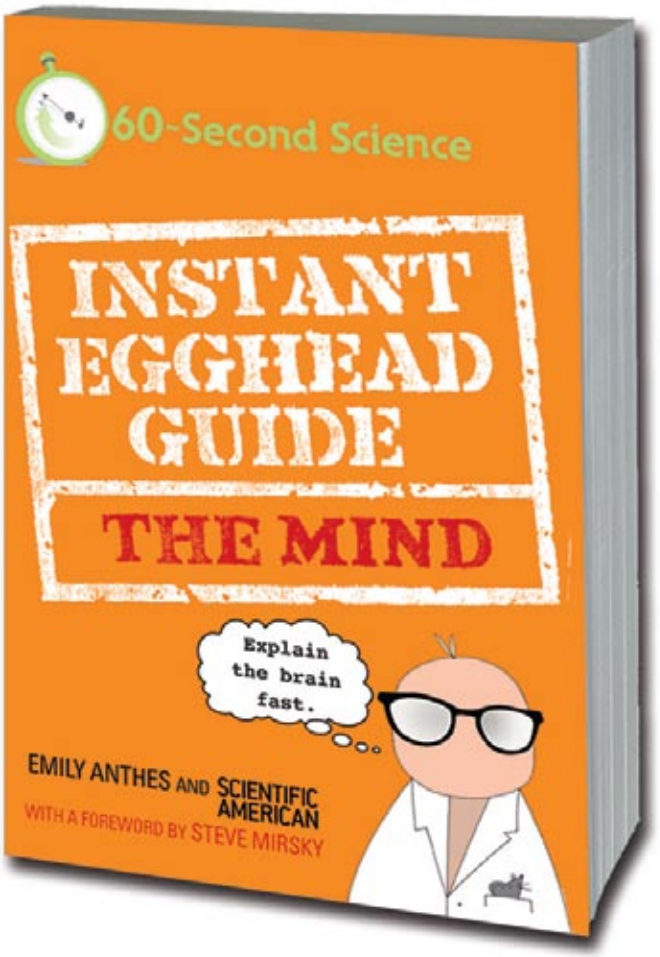
(Further Reading)

- **To See but Not to See: A Case Study of Visual Agnosia.** M. Jane Riddoch and Glyn W. Humphreys. Psychology Press, 1987.
- **The Emerging Mind: The Reith Lectures.** Vilayanur S. Ramachandran. Profile Books, 2003.
- **The Visual Brain in Action.** Second edition. Melvyn A. Goodale and A. David Milner. Oxford University Press, 2006.

MELISSA THOMAS

A USER'S GUIDE FOR THE BRAIN



DECISION MAKING

Recent research on decision-making focuses on serotonin. In one study, researchers determined that those with reduced serotonin levels were less likely to cooperate or share money fairly. ***INCREASED SEROTONIN WILL LEAD YOU TO BUY THIS BOOK.***

HAPPINESS

Implant an electrode in the right part of a rat's limbic system and he'll be deliriously happy. Certain areas of the limbic system are part of the brain's pleasure network. Stimulating them creates a natural high. These brain circuits all seem to be involved in what we label "happiness." ***LEARNING MAKES YOU HIGH.***

GESTURES AND MOTION

You want to pick up this book? Congratulations. Now your brain has to get it done. The motor cortex plans movement with a little help from the basal ganglia and the cerebellum. The cortex then sends signals to the brain-stem and the spinal cord's motor neurons. These neurons fire, telling your muscle fibers to contract. ***GET FIRED UP AND PICK UP THIS BOOK...***

(calendar)

December

10 Children inherit much more from their parents than their genes. In a most extreme example, Monika Hertwig grew up with the burden of knowing her father had been the murderous Nazi captain Amon Göth. Göth, whose brutality was chillingly portrayed by Ralph Fiennes in *Schindler's List,* tortured and killed thousands of Jews in his year and a half as commandant of the Plaszow concentration camp in Poland. In the new documentary ***Inheritance***, filmmaker James Moll explores our need to come to terms with the sins of our fathers, as he follows Hertwig on a journey to meet one of Göth's surviving victims.
PBS, 9 P.M. EST
www.pbs.org/pov/pov2008/inheritance

Ongoing
What makes humans so unique? Find out in the permanent exhibit **Who Am I?** at the Science Museum in London. Interactive exhibits demonstrate our species' ancient genetic roots, our immediate family's ancestry and our individual minds. Don't miss the related exhibition **Psychology: Mind Your Head**, a permanent collection of tools such as specialized building-block toys that psychologists have used to unravel the mysteries of the mind. Created in 2001 to celebrate the centennial of the British Psychological Society, the exhibit highlights decades of important scientific contributions from psychologists in the U.K.
London
www.sciencemuseum.org.uk/visitmuseum/galleries

January

5 **Florence Halpern**, considered the "grandmother of psychology," was born on this day in 1900. As president of the Society of Clinical Psychology, she helped to pioneer the Rorschach inkblot test used to evaluate personality and emotional function. Although its use has at times been controversial, the Rorschach test remains the second most widely employed assessment in forensic psychology today.

8 Language can reveal much about the organization of the human mind. Harvard University psychologist and best-selling author **Steven Pinker** will address language and cognition in a public lecture at the SAGE Center for the Study of the Mind at the University of California, Santa Barbara.
Santa Barbara, Calif.
www.sagecenter.ucsb.edu/lecture.htm

20–22 Many people have no exposure to neuroscience before college—let alone high school. In an effort to change that, Newcastle University researchers are hosting a series of free lectures called **My Brain and I**, open to the public and geared toward 10- to 14-year-olds. Exploring aspects of consciousness and personality, as well as technologies used to mend brain injuries, the lecturers will engage kids with hands-on demonstrations and experiments to help these heady concepts come to life.
Newcastle, England
www.ncl.ac.uk/events/noticeboard

'Tis the **Season**

Our most cherished holiday traditions have their roots in the evolved human brain—as such, psychological studies have revealed interesting and useful tips to keep in mind during the festivities.

The Holiday Dinner
Planning a feast can be stressful, but you don't have to be a top chef to please your guests. A meal's quality may be mostly in your head, according to Brian Wansink, a food psychologist at Cornell University who found that environmental cues such as appealing decor can make simple food appear gourmet.

The Gift Exchange
Who doesn't love a present? Social psychologists have found that exchanging items has a long evolutionary history of being a way to solidify bonds among members of a community. And studies have confirmed the age-old wisdom that it is frequently the giver rather than the recipient who gets the most pleasure from the encounter—so let your generosity flow.

The New Year's Resolution
Come the first of the year, it is customary to want to transform into a healthier, smarter and more successful version of yourself. But recent studies suggest that only 12 percent of resolution makers have achieved their goals a year later.

So what can people do to initiate lasting behavioral changes? A 2007 study by Richard Wiseman of the University of Hertfordshire in England found that the answer depends on gender. For most men, the best way to get results is to focus on a series of small, manageable achievements, such as losing one pound a week. And many women benefit from being encouraged to stick to their goals even after setbacks—smoking a cigarette or two after pledging to quit is only a minor misstep, not total failure.

STEVE McALISTER *Getty Images (brain)*; LAMBERT *Hulton Archive/Getty Images (inkblot)*; GREGOR SCHUSTER *Getty Images (gift)*

Compiled by Karen Schrock and Victoria Stern. Send items to editors@SciAmMind.com

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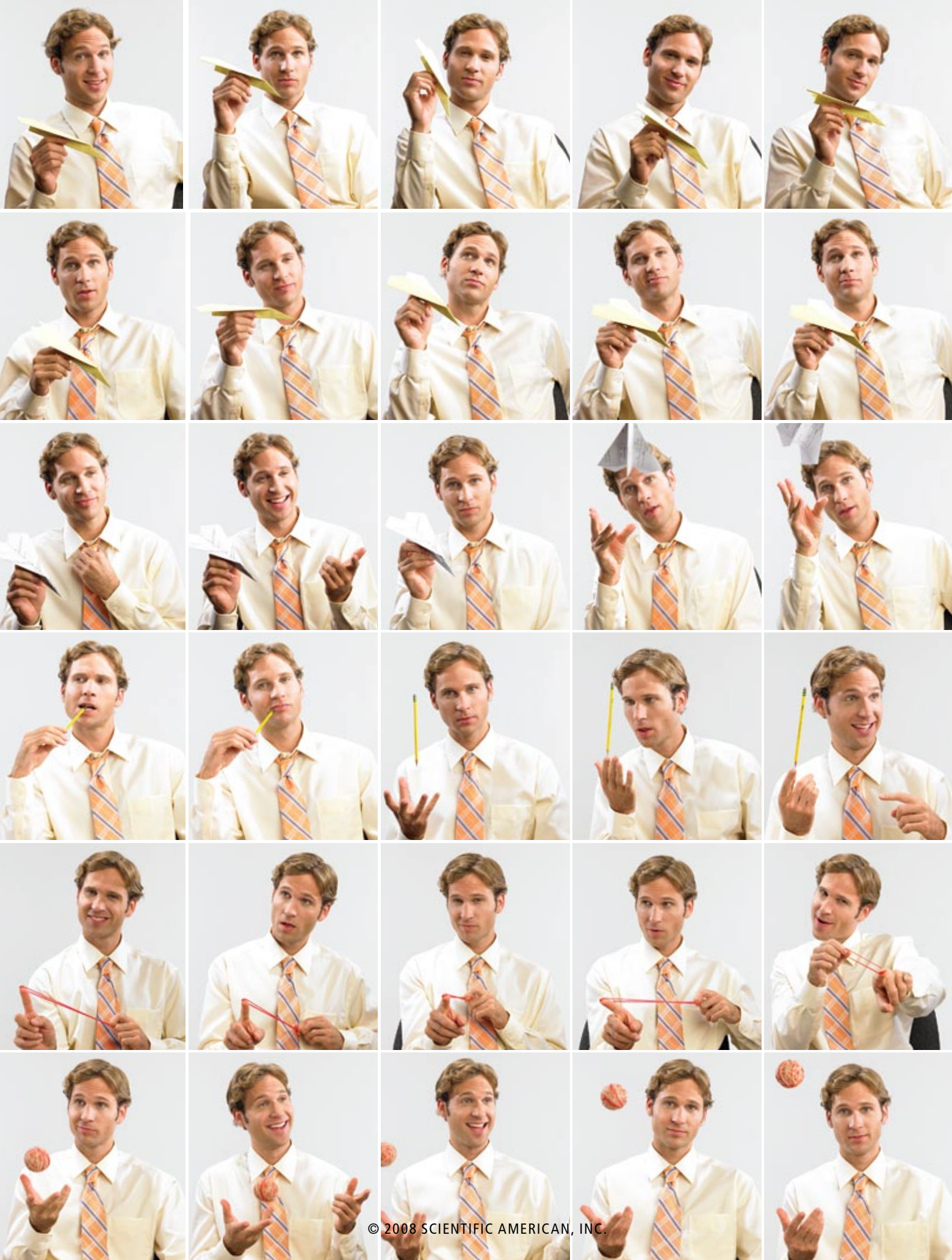

I'll Do It Tomorrow

A penchant for procrastination is damaging the careers, health and savings accounts of millions of Americans. Although biology is partly to blame for the foot-dragging, anyone can learn to kick the habit By Trisha Gura

Raymond, a high-powered attorney, habitually put off returning important business calls and penning legal briefs, behaviors that seriously threatened his career. Raymond (not his real name) sought help from clinical psychologist William Knaus, who practices in Longmeadow, Mass. As a first step, Knaus gave Raymond a two-page synopsis of procrastination and asked him to read it "and see if the description applied." Raymond agreed to do so on a flight to Europe. Instead he watched a movie. He next vowed to read it the first night at his hotel, but he fell asleep early. After that, each day brought something more compelling to do. In the end, Knaus calculated that the lawyer had spent 40 hours delaying a task that would have taken about two minutes to complete.

Almost everyone occasionally procrastinates, which University of Calgary economist Piers Steel defines as voluntarily delaying an intended course of action despite expecting to be worse off for the delay. But like Raymond, a worrisome 15 to 20 percent of adults, the "mañana procrastinators," routinely put off activities that would be better accomplished ASAP. And according to a 2007 meta-analysis by Steel, procrastination plagues a whopping 80 to 95 percent of college students, whose packed academic schedules and frat-party-style distractions put them at particular risk.

Procrastination does not mean deliberately scheduling less critical tasks for later time slots. The term is more apt when a person fails to adhere to that logic and ends up putting off the tasks of *greater* importance or urgency. That is, if just thinking about tomorrow's job pricks the hair on the back of your neck or compels you to do something more trivial, you are probably procrastinating.

A penchant for postponement takes its toll. Procrastination carries a financial penalty, endangers health, harms relationships and ends careers. "Procrastination undermines well-being on a wide scale," notes psychologist Timothy A. Pychyl, director of the Procrastination Research Group at Carleton University in Ottawa. Nevertheless, recent work

Some 40 percent of people have experienced a financial loss because of procrastination. Procrastinators also suffer from higher stress levels and more acute health problems than people who don't waste time.

hints at potential upsides to this otherwise bad habit: perpetual foot-draggers seem to benefit emotionally from their trademark tactics, which support the human inclination to avoid the disagreeable.

Procrastination is learned, but certain hardwired personality traits increase the likelihood that a person will pick up the habit. "Procrastination is a dance between the brain and the situation," Pychyl says. That nature-and-nurture view is part of a new line of research into the process and prevention of procrastination [*see box on page 32*]. Understanding why people put off projects has led to strategies for helping all of us get and stay on task.

FAST FACTS

Dissecting Deferment

1» **Almost everyone occasionally procrastinates, but a worrisome 15 to 20 percent of adults routinely put off activities that would be better accomplished right away.**

2» **A penchant for postponement carries a financial penalty, endangers health, harms relationships and ends careers. And yet perpetual foot-draggers sometimes benefit emotionally from their tactics, which support the human inclination to avoid the disagreeable.**

3» **Research into the reasons people put off projects has led to strategies for helping all of us get and stay on task.**

Built-in Bias

Procrastination is as old as humans are. For people living in agrarian societies, a late-planted crop could mean starvation. Thus, our ancestors, including Greek poet Hesiod in 800 B.C., equated procrastination with sin or sloth. The industrial revolution may have facilitated the practice of putting off important jobs. Technical advance brings some protection from the forces of storms and famine as well as an increase in leisure time, in consumer goods and in the number of possible *choices* of activities. Contemporary society offers a surfeit of distractions, including computer games, television and electronic messaging—not to mention cars and planes to take us to more stuff to see and do—all enticing us to move off task.

Succumbing to such enticements can be costly. Experts estimate that 40 percent of people have experienced a financial loss because of procrastination, in some cases severe. In 2002 Americans overpaid $473 million in taxes as a result of rushing and consequent errors. And Americans' dearth of retire-

PRECEDING PAGES: AARON GOODMAN (*collage of procrastinator*); GUSTAF BRUNDIN *iStockphoto* (*clock*); GETTY IMAGES (*to-do list*); THIS PAGE: ADRI BERGER *Getty Images*

ment savings can be attributed, in part, to people putting off putting away cash.

Procrastination can also endanger health: after screening more than 19,800 people for high cholesterol, epidemiologist Cynthia Morris and her colleagues at the Oregon Health and Science University reported in 1990 that 35 percent of those who learned they had elevated cholesterol put off consulting a physician for at least five months. In 2006 psychologist Fuschia Sirois of the University of Windsor in Ontario reported in a study of 254 adults that procrastinators had higher stress levels and more acute health problems than did individuals who completed jobs in a timely manner. The procrastinators also received less frequent medical and dental checkups and had more household accidents, a result of putting off dull jobs such as changing smoke detector batteries.

Task aversiveness is one of the main external triggers for procrastination. Who puts off doing what she loves? According to Steel's meta-analysis, half of the college students surveyed cited the nature of the task itself as the reason they put it off. Undoubtedly, few leap at the chance to write a dissertation about nematode reproduction or clean out the garage. "Procrastination is about not having projects in your life that really reflect your goals," Pychyl says.

The amount of time before a project's due date also influences the tendency to procrastinate. In particular, people are more likely to dawdle when the deadline is far away. The reason for this lies in a phenomenon known as temporal delay, which means the closer a person gets to a reward (or a feeling of accomplishment), the more valuable the reward seems and hence the less likely he is to put off performing the work needed to earn it. In other words, immediate gratification is more motivating than are prizes or accolades to be accrued in the distant future.

Such a preference may have a strong evolutionary basis. The future, for those in the Stone Age, was unpredictable at best. "Thus, there was truth to the saying 'a bird in the hand is worth two in the bush,'" Pychyl says. "For survival, humans have brains with a procrastination bias built in."

In 2004 neuroscientist Barry Richmond and his colleagues at the National Institute of Mental Health reported finding a biological basis for this bias. Richmond's team first trained monkeys to release a lever whenever a spot on a computer screen turned from red to green. As the monkeys continued to correctly let go of the lever, a gray bar increased in brightness, letting the animals know they were getting closer to a reward, a juice treat. Like human procrastinators, the animals slacked off during early trials, making lots of errors. But when the juice reward came closer, the animals stayed on task and made fewer mistakes.

Richmond's team hypothesized that the neurotransmitter dopamine, which transmits feelings of reward, might underlie this behavior. Working with Richmond, molecular geneticist Edward Ginns used a molecular decoy called DNA antisense to partially shut down production of a receptor for dopamine in a region of the monkeys' brains called the rhinal cortex that associates visual cues with reward. The treatment diminished dopamine's effects to the point that the monkeys could no longer predict when any given trial would earn them a juice treat. Thus, they hedged their bets, working hard all the time as if "they are always one trial away from the penultimate," Richmond says.

But not all the monkeys with diminished dopamine responses behaved with the same intensity. Some remained mellow after the dopamine-de-

A person is more likely to procrastinate if the task is disagreeable. Who jumps at the prospect of washing a heap of dirty clothes?

SWELL MEDIA/GETTY IMAGES (*laundry*); DENNIS HEALY (*iStockphoto* (*rubber band ball*)

"Procrastination is about **not having projects** in your life that really reflect your goals," one scientist says.

pressing treatment, failing to put in much effort even as the time to reward narrowed. That observation speaks to individuality in procrastination: some of us are more prone to it than others.

Getting Personal

At the end of the 20th century, psychologists began studying the so-called big five personality traits that blend to describe any human being: conscientiousness, agreeableness, neuroticism, openness and extroversion. According to Steel, the extent to which a person displays each of these traits helps to determine that individual's proclivity to procrastinate.

One researcher has devised a **formula to predict** who is likely to procrastinate under what circumstances.

The characteristic most strongly linked to procrastination is conscientiousness—or lack thereof. A highly conscientious person is dutiful, organized and industrious. Therefore, someone who is not conscientious has a high probability of procrastinating. A person who is impulsive also is a procrastinator at risk. "People who are impulsive can't shield one intention from another," Pychyl says. So they are easily diverted by temptations—say, the offer of a beer—that crop up in the middle of a project such as writing a term paper.

Procrastination can also stem from anxiety, an offshoot of neuroticism. Procrastinators postpone getting started because of a fear of failure (*I am so worried that I will bungle this assignment*), the fear of ultimately making a mistake (*I need to make sure the outcome will be perfect*), and the fear of success (*If I do well, people will expect more of me all the time. Therefore, I'll put the assignment off until the last minute, do it poorly, and people won't expect so much of me*).

These personality traits, as well as less influential ones, play out in particular situations in conjunction with the environment. Researchers are now trying to capture that nature-nurture interaction to unify existing procrastination theories and to predict who is likely to procrastinate under what circumstances. Steel has derived a mathematical formula that defines "utility," that is, how desirable a task is for an individual. To determine a task's utility and therefore how likely a person is to do it right away, Steel puts together four basic factors, expectancy (E), value (V), the delay until reward or punishment (D), and personal sensitivity to delay (Γ), in the following equation:

$$U = \frac{E \times V}{\Gamma \times D}$$

When a person expects to succeed at or values a particular task, she is more likely to do it. Hence, a higher number for expectancy or value will increase utility. On the other hand, if a reward or punishment lies far in the future or a person is particularly "sensitive," meaning distractible, impulsive or lacking in self-control, he is less likely to do the task, at least on time. Thus, sensitivity to delay and delay itself decrease the utility of a task and lead to procrastination.

Several scientists take issue with the idea that complex human behavior can be defined by a mathematical formula. "It leads you to believe that if I put numbers in there," Pychyl says, "I could tell you what you will be doing next Friday." Nevertheless, Steel's equation is an initial attempt to unify various motivational and psychological theories of procrastination and to provide a framework for future research.

The Psychology of Delay

Instead of measuring personality traits and solving formulas, some researchers prefer to tease out the psychology behind the behavior. Two key elements in the urge to let projects slide are an uneasy feeling about an activity and a desire to avoid that discomfort. "A procrastinator says, 'I feel lousy about a task,'" Pychyl explains, "and thus walks

Certain personality traits influence the tendency to postpone important jobs. Impulsive people, for instance, are easily diverted by tempting alternatives to dreaded tasks such as sifting through a tower of papers.

ETHAN MYERSON *iStockphoto (paper airplane)*; JUPITERIMAGES *(in and out boxes)*

Indecision is also a factor. For instance, vacillating ad infinitum about which color to paint a room could significantly delay the painting itself.

away to feel better." Psychologist Joseph Ferrari of DePaul University has coined "avoidance procrastinator" to describe a person for whom avoidance is the prime motivator.

Another psychological driver is indecision. An "indecisive procrastinator" cannot make up her mind about executing a task. Say a woman intends to visit her mother in the hospital. Rather than simply grabbing the keys and heading out, the indecisive procrastinator starts debating whether to drive or to take the train. *The train is a hassle, but parking is expensive and I'll have to drive back at rush hour. But then again, the train will be packed, too.* The internal debate continues until enough time passes that visiting hours are over.

A third oft-cited explanation for unreasonable delay is arousal. The "arousal procrastinator" swears that he works best under pressure, loving—perhaps needing—the rush of a last-minute deadline to get started. Such a person believes procrastinating affords a "peak" or "flow" experience, defined by psychologist Mihály Csíkszentmihályi of the Drucker School of Management at Claremont Graduate University as being completely involved in an activity for its own sake. Time disappears. The ego dissolves.

But procrastination does not facilitate flow, according to social scientist Eunju Lee of Halla University in South Korea. In 2005 Lee reported surveying 262 students and finding that procrastinators tended to have *fewer,* not more, flow experiences. After all, a person must be able to let go of herself to "get lost" in an experience, and procrastinators are generally self-conscious individuals who have trouble doing that.

Nor is the thrill of a looming deadline an actual reason people put off uninviting jobs. Pychyl and his graduate student Kyle Simpson measured traits associated with arousal, including thrill seeking and extraversion, in students who often procrastinated. In Simpson's unpublished doctoral thesis, Pychyl and Simpson show that neither of these qualities accounted for the dawdling the students reported. Thus, procrastinators are probably not really in need of arousal, Pychyl says, but use the belief *I need the pressure of a last-minute deadline* to justify dragging their feet, which they do for other reasons, such as circumventing unpleasantness.

Other procrastinators strategically delay projects to excuse poor performance, should it occur. They tell themselves or others, "I could have done better if I had started earlier." Such a strategy might, in some cases, serve as a shield for a fragile ego.

Tricks of the Trade

Procrastination is not always so maladaptive. In a 2007 survey of 67 self-described procrastinators

(The Author)

TRISHA GURA, based in Boston, is author of *Lying in Weight: The Hidden Epidemic of Eating Disorders in Adult Women* (HarperCollins, 2007).

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Some specialists suggest replacing the reflex to postpone with time-stamped **prescriptions for action**.

among college students, psychologist Gregory Schraw of the University of Nevada, Las Vegas, and his colleagues learned that these students found creative ways of making their bad habit work for them. For example, many students only took classes in which the professor offered a detailed syllabus rather than just a rough sketch of the assignments. Such specificity allowed for "planned" procrastination: the students could schedule how to delay their course work and thereby afford maximum time for more enticing activities.

To cope with the guilt and anxiety brought on by waiting until the last minute, some students acquired all the books for an assignment as soon as it was given and placed them on a shelf. The students said that by shelving the books they "shelved" their discomforting thoughts about the task. They also fended off guilt by telling themselves, "Hey, at least I got the books." Then, 48 hours before the project was due, the procrastinator dusted off the books and bad feelings and worked in a frenzy to get the assignment done. As a result, the students did the maximum amount of work in a minimum amount of time—with a minimal amount of pain.

So although these students were still putting off the work longer than they should, they were nonetheless managing to finish their assignment while maintaining their sanity. Schraw emphasizes that his work is not meant to advocate procrastination but to point out that the practice can engender some useful survival skills such as tactical planning to complete a task in limited time and with a minimum amount of stress. "The moral of the story is that people procrastinate so they can lead a better mental life," Schraw says.

Preventing Procrastination

Not all experts agree with Schraw. Indeed, Steel's meta-analysis suggests that 95 percent of procrastinators would like to break the habit but cannot, because it has become automatic and ingrained. "Habits become nonconscious brain processes," Pychyl says. "When procrastination becomes chronic, a person is, essentially, running on autopilot."

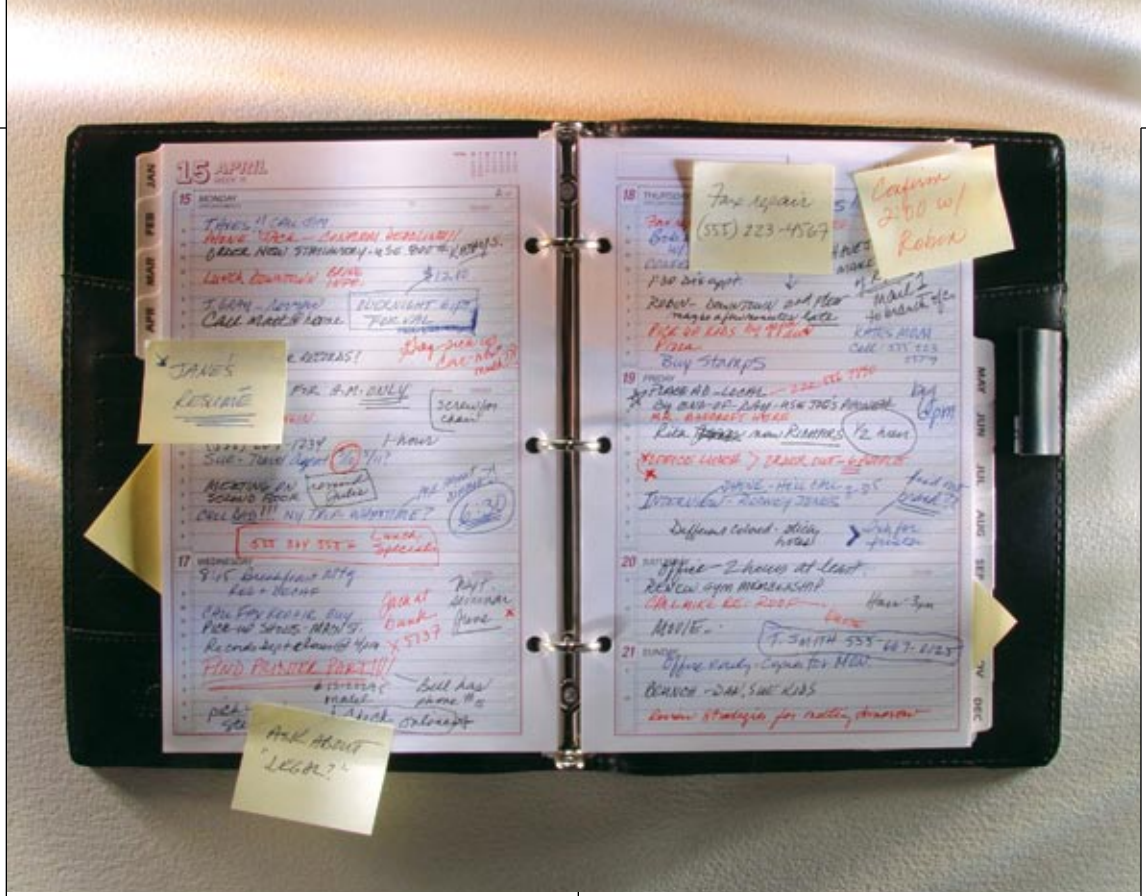
Some experts suggest replacing the reflex to postpone with time-stamped prescriptions for action. Psychologist Peter Gollwitzer of New York University and the University of Konstanz in Germany advises creating "implementation intentions," which specify where and when you will perform a specific behavior. So rather than setting a vague goal such as "I will get healthy," set one with its implementation, including timing, built in—say, "I

Parsing Postponement

Recognizing when you are procrastinating may help you cut short the dawdling and get started on your pursuit. According to clinical psychologist William Knaus, who practices in Longmeadow, Mass., six steps characterize the process of procrastination:

- You have an activity with a deadline that comes with a reward if done well or a punishment if not done correctly.
- You view the activity negatively, as boring, unpleasant, threatening or confusing.
- You magnify the onerousness of the task while discounting the incentives for acting now.
- To avoid or relieve the discomfort, you substitute another activity such as daydreaming, "organizing" or just about anything involving a computer.
- You tell yourself that you will get to the task, perhaps tomorrow. Then, when tomorrow comes, you make up another excuse.

CHRISTINE BALDERAS (*stack of papers*) AND GUSTAF BRUNDIN (*clocks*) *iStockphoto*; ADRI BERGER *Getty Images* (*man lying on file cabinets*)



Smart scheduling can prevent procrastination. One strategy could be setting interim deadlines for parts of a long-term project, which can thwart the tendency to put off the work until the last minute.

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will go to the health club at 7:30 A.M. tomorrow."

Setting such specific prescriptions does appear to inhibit the tendency to procrastinate. In 2008 psychologist Shane Owens and his colleagues at Hofstra University demonstrated that procrastinators who formed implementation intentions were nearly eight times as likely to follow through on a commitment than were those who did not create them. "You have to make a specific commitment to a time and place at which to act beforehand," Owens says. "That will make you more likely to follow through."

Smart scheduling can also thwart procrastination. In an experiment published in 2002 Duke University behavioral economist Dan Ariely, then at the Massachusetts Institute of Technology, and marketing professor Klaus Wertenbroch of INSEAD, a business school with campuses in France and Singapore, asked students in an executive-education class to set their own deadlines for the three papers due that semester. Ariely and Wertenbroch set penalties for papers turned in after the self-imposed deadlines. Despite the penalties, 70 percent of the students chose deadlines spaced out over the semester, rather than clustering them all at the end. What is more, those who set the early deadlines scored better, on average, than did students in a comparable class in which Ariely set one due date for all three papers at the end of the semester. Such planning can buck any inclination to put off the work. "The deadlines made them better performers," Ariely says.

More simply, Pychyl advises procrastinators to "just get started." The anticipation of the task often is far worse than the task turns out to be. To demonstrate this fact, his group, in work that appeared in 2000, gave 45 students pagers and checked in with the volunteers 40 times over five days to query them about their moods and how often they were putting off a task that had a deadline. "We found that when students actually do the task they are avoiding, their perceptions of the task change significantly. Many times, they actually enjoyed it."

In Raymond's case, getting to the task was, indeed, the hard part. Knaus helped him to do that by first determining the reason for his instinct to delay: Raymond feared being tested on the synopsis and looking foolish. So Knaus asked him to pick the lesser of two evils, doing his work—and risking imperfection—or avoiding difficult tasks and losing his job. When Knaus put it that way, the lawyer was able to "just grind it out." Instead of being fired, Raymond became a "superstar" at his firm. M

(Further Reading)

- **The Procrastination Workbook.** William Knaus. New Harbinger Publications, 2002.
- **The Nature of Procrastination: A Meta-analytic and Theoretical Review of Quintessential Self-Regulatory Failure.** Piers Steel in *Psychological Bulletin,* Vol. 133, No. 1, pages 65–94; 2007.
- **Predictably Irrational.** Dan Ariely. HarperCollins, 2008.
- **Don't Delay.** Timothy A. Pychyl's blog in *Psychology Today* online: **http://blogs.psychologytoday.com/blog/dont-delay**

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Speaker: **Stephen J. Freeland, Ph.D.**

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- the central dogma that unifies life
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- 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.

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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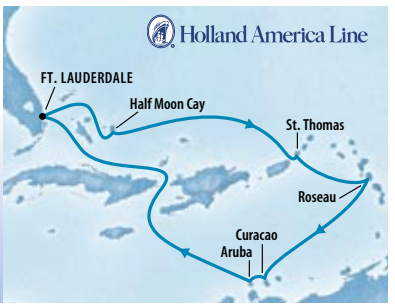

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Courtesy of the NAIC - Arecibo Observatory, a facility of the NSF

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Sparking Recovery with Brain "Pacemakers"

Applying electricity to the brain with deep-brain stimulation could ease Parkinson's disease, pain, depression, and more

By Morten L. Kringelbach and Tipu Z. Aziz

The video is brief, just a couple of minutes, but it's reality TV as riveting as anything you'll ever see. A man in his mid-50s, affable, articulate, faces the camera and talks a bit about a medical procedure he's had. He holds in his hand what looks like a remote control. "I'll turn myself off now," he says mildly. The man presses a button on the controller, a beep sounds, and his right arm starts to shake, then to flap violently. It's as if a biological hurricane has engulfed him, or perhaps it's that his arm is made of straw and some evil sprite is waving it about. With effort, the man grasps the malfunctioning right arm with his left hand and slowly, firmly, subdues the commotion, as if he were calming a child in the throes of a temper tantrum. He's breathing hard, and it's clear he can't keep it up much longer. With an almost desperate gesture, he reaches out for the controller and manages to press the button again. There's a soft beep, and suddenly it's over. He's fine.

Composed, violently afflicted, then composed again. All with the flick of a switch. As before-and-after moments go, this one is potent, verging on the miraculous. It's the kind of thing you'd expect to witness under a revival tent, not in the neurology ward of a British hospital. Once you've seen it, you'll have an indelible image of Parkinson's disease. The word "tremor" doesn't convey what can happen to people—the way they are thrashed and harassed by their own bodies. But this scene, involving a patient of ours, informs viewers about more than a disease; it's a vivid window onto a powerful medical technology known as deep-brain stimulation (you can watch the video at www.kringelbach.dk/nrn).

Sudden, radical transformation is the hallmark of deep-brain stimulation. The treatment, essentially a pacemaker for the brain, consists of a deceptively simple two-part device. A surgeon threads one or two thin wires into carefully selected locations deep within the brain, then inserts a small battery just underneath the skin near the collarbone. Pulses of electricity travel from the battery to four electrodes situated at the tip of each wire. The effects are instantaneous, usually appearing while the patient is still on the operating table—the quieting of a tremor, the ability to walk again or, in some patients with otherwise treatment-resistant depression, a renewed energy for life.

Deep-brain stimulation came into its own in the 1990s, and since then surgeons have performed it on more than 35,000 people, mostly to quell Parkinson's disease and other movement-related disorders. It is not a cure, but it can keep symptoms at bay for years. Recently, as the electrodes have become safer and the batteries smaller and longer-lasting and as advances in brain-imaging techniques such as magnetic resonance imaging have made it possible to place electrodes with greater precision, neurosurgeons have begun investigating the technology as a way to ease a host of other health problems.

The technique has made it possible for children with a disabling movement disorder called dystonia to leave their wheelchairs and lead nearly normal lives. It has brought immediate relief to people suffering from cluster headaches and other kinds of unremitting pain. It has shown tantalizing promise for some psychiatric disorders, including severe cas-

VICTOR DE SCHWANBERG *SPL/Photo Researchers, Inc.*

In the 1780s Luigi Galvani observed that by applying electricity

es of depression, obsessive-compulsive disorder and Tourette's syndrome. It has been attempted as a cure for anorexia and obesity. Some neuroscientists speculate that it could help stem the memory loss brought on by Alzheimer's disease. The brain is an electrical organ, so there is little that goes wrong with it that could not, hypothetically, benefit from finely calibrated pulses of electricity. Clinical trials of deep-brain stimulation—preliminary testing on small groups of patients—are multiplying at hospitals around the world, from Cleveland and Toronto to Bristol, Grenoble and Milan.

Despite the recent advances, technologically speaking, deep-brain stimulation is not yet fully mature. Today's devices are programmed to deliver steady, unchanging pulses of electricity. Over the next decade we expect to see a much "smarter" device, one that would turn itself on and off as needed, tailoring its therapy to what is happening moment to moment in the patient's brain.

FAST FACTS

The Electric Cure

1» Brain cells, called neurons, communicate with one another through electrical impulses.

2» In deep-brain stimulation, a battery implanted in a person's chest delivers steady pulses of electricity to a targeted area of the brain. The artificial current interrupts or corrects dysfunctional electrical activity that is causing medical problems. Doctors can tailor the speed, strength and length of the pulses to get the desired result.

3» Well established as a way of quelling the tremors that can afflict people with Parkinson's disease, deep-brain stimulation is showing promise for a host of other ailments, including chronic pain and depression.

The Body Electric

Often when people want to make a difficult task seem easier, they say, "After all, it's not brain surgery." And for good reason. Although we know a lot about the brain, there is still a lot of mystery packed into the three pounds of wrinkled tissue that house a human consciousness, and we neuroscientists must proceed with a combination of humility and hubris.

But deep-brain stimulation has an advantage over most other kinds of neurosurgery—namely, it is reversible. If the electrodes malfunction or if they are simply ineffective, they can be turned off or removed. The procedure is not without risk—1 to 3 percent of patients experience bleeding that leads to a stroke, and a slightly larger number develop treatable infections. Unlike most surgeries, however, deep-brain stimulation does not change the physical structure of the brain; electricity does all the work.

Awareness of the role of electricity in the body dates to A.D. 43, when Scribonius Largus, court physician to the ancient Roman emperor Claudius, wrote that headaches and gout could be soothed by the touch of the torpedo fish, which emits an electrical charge when startled. In 1774 Benjamin Franklin noted that static electricity can lead to muscle contraction, and a decade later Italian physician Luigi Galvani observed that by applying electricity to the sciatic nerve he could make the leg of a dead frog twitch in a lifelike manner. His breakthrough inspired Mary Shelley's *Frankenstein*, in which a monster cadged together from parts of dead people was animated by a massive electrical charge.

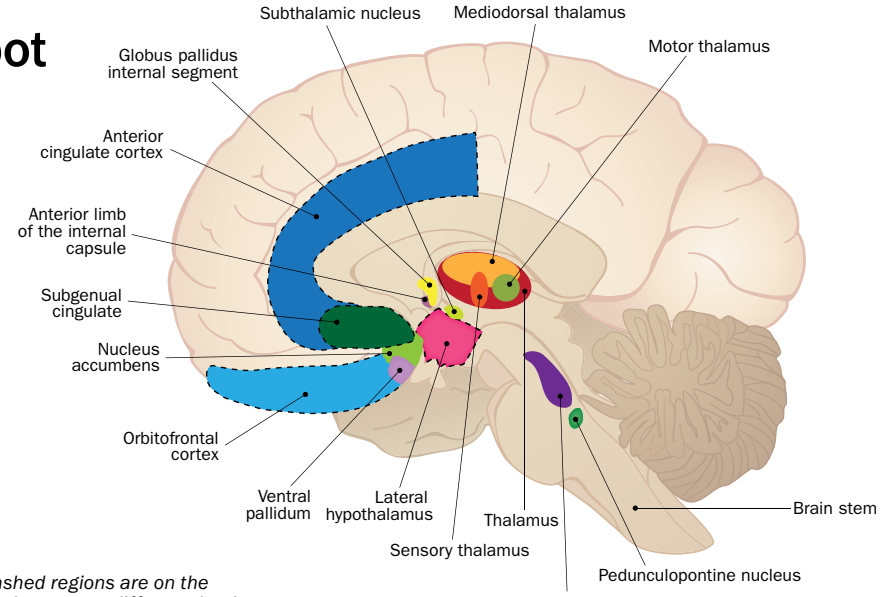
Galvani's discovery did more than ignite sci-fi fantasies; it ushered in a host of medical advances. In 1870 German neuropsychiatrist Eduard Hitzig and anatomist Gustav Fritsch selectively manipulated the limbs of a live dog by stimulating specific areas of the brain region now known as the motor cortex—in other words, they showed that each muscle of the body, every finger and toe, is controlled by electrical impulses from a dedicated patch of brain tissue. In the 20th century researchers had the tools to investigate the cellular level. They deciphered

GETTY IMAGES (*head with switch*); PASIEKA SPL/Photo Researchers, Inc. (*electric brain in banners*)

to the sciatic nerve he could make the leg of a dead frog twitch.

Finding the Right Spot

The first puzzle for neurosurgeons attempting to treat patients with deep-brain stimulation is figuring out where in the brain to place the electrode. Much of this work is done through animal experimentation. Noninvasive brain scans of people suffering from various disorders also offer clues to which brain areas are involved in controlling the problematic behaviors and sensations.



NOTE: Dashed regions are on the midline; others are at different depths.

DISORDER	ESTABLISHED SITES	PROMISING SITES	POTENTIAL SITES
Parkinson's disease	Motor thalamus, globus pallidus internal segment, subthalamic nucleus, pedunculopontine nucleus		
Dystonia	Globus pallidus internal segment		
Essential tremor	Motor thalamus		
Depression		Subgenual cingulate, nucleus accumbens	Orbitofrontal cortex, anterior cingulate cortex, ventral pallidum, mediodorsal thalamus
Pain	Periventricular gray/periaqueductal gray, sensory thalamus		Orbitofrontal cortex, anterior cingulate cortex
Obsessive-compulsive disorder	Anterior limb of the internal capsule		
Cluster headache	Lateral hypothalamus		
Minimally conscious			Thalamus

how electricity travels through a single brain cell, or neuron, and from there to its neighbor, creating the complex networks that dictate our thoughts, actions, memories and desires.

Before long, investigators asked: But what happens when those neural networks short-circuit? In the 1950s and 1960s neurosurgical pioneers, including Natalia Bechtereva in the U.S.S.R., Robert Heath of Tulane University and J. Lawrence Pool of the Neurological Institute of New York, began experimentally applying electricity to the brains of people suffering from chronic pain, depression and movement disorders. The batteries then available were much too large to be implanted, so the devices were kludgy and the relief, sporadic. Still, these investigations established a medical precedent for targeted electrical pulses.

Parkinson's disease turned out to be an ideal proving ground. In this disorder, neurons die off in a brain area that coordinates movement, the basal ganglia. In a healthy brain, neurons in the basal ganglia communicate in an intricate call-and-response with groups of neurons in other areas, including the thalamus and the motor cortex. For movements to be quick and fluid, these parts of the brain must work together. Messages traveling between them are called oscillations. They bounce back and forth, moving at different frequencies, some serving to initiate movement, others, to moderate it. But what is key is that the sender and recipient neurons, like

MELISSA THOMAS

There are no nerve endings in the brain, which meant that our

two girls rhythmically swinging a jump rope for a third to hop over, must be in sync. In Parkinson's, diseased neurons lose their ability to keep up, and the oscillations become unbalanced. Neurons fire wildly, and a person moves in a chaotic way or is unable to initiate movement at all.

In the late 1980s surgeons found that if they stimulated either the thalamus or the globus pallidus (a part of the basal ganglia) with fast pulses—up to 180 times per second—they could override the faulty connections. Scientists do not completely understand how deep-brain stimulation works, but we do know that the pulses sent to the electrode sometimes drive and sometimes inhibit the natural activity of neurons. Faster pulses, such as those used in Parkinson's patients, tend to overwhelm and thus inhibit activity, whereas slower pulses tend to drive it by creating a tempo that the neurons strive to meet.

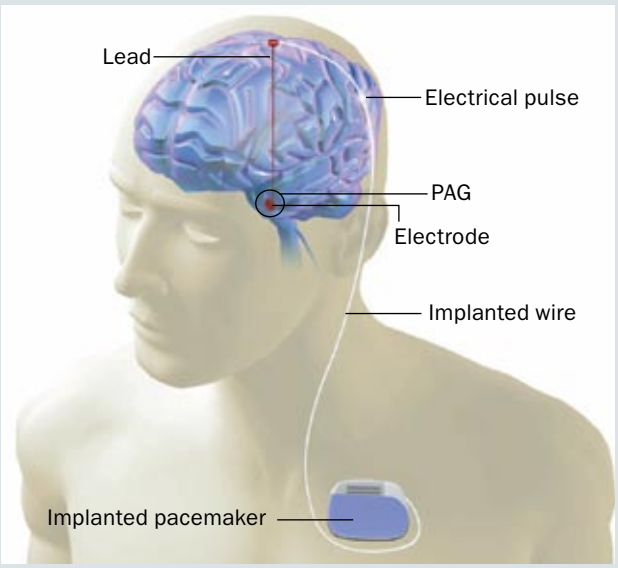
Working with monkeys that had been given parkinsonian symptoms, one of us (Aziz), as well as other teams led by neuroscientists Mahlon R. DeLong of Emory University and Abdelhamid Benazzouz of the Bordeaux Neuroscience Institute in

Deciphering Brain Signals

Today's deep-brain-stimulation devices are relatively simple: the battery sends constant, unchanging pulses through the wire lead to the electrode. The surgical team tailors those pulses to be of the precise strength, frequency and duration that will best ease the patient's symptoms, but after that the battery is set to run indefinitely and does not change its signals in response to the patient's symptoms.

In the future, however, neuroscientists envision a device that will analyze the patient's neural activity, searching for problematic patterns. Most of the time, this next-generation pacemaker will simply monitor the brain, delivering no electricity. But when it detects a problem—say, a tremor or a seizure about to occur—it will deliver a specially calibrated series of pulses designed to derail that event.

To program such next-generation deep-brain-stimulation devices, neurologists first need to decode the brain patterns that signify trouble and those that represent normal activity.

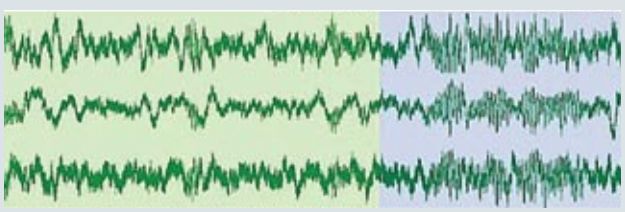


Our team made an exciting discovery last year that is a step in this direction for patients with chronic pain. We may have discovered a brain "signature" for pain: a specific pattern in which neurons fire when people are in intense distress.

Neurosurgeon Alex Green, our colleague at John Radcliffe Hospital in England, designed a study using 12 patients who had had electrodes implanted in their thalamus or in a part of the brain stem known as the periventricular gray/periaqueductal gray (PAG) to treat chronic pain. We recorded activity from the electrodes while team members touched either a painful or a pain-free area of the patients' bodies. We also asked patients to rate their pain at one-minute intervals. We found that the brain activity measured by the electrodes correlated perfectly to the amount of subjective pain the patients felt. The recordings showed spindles—a specific neural code that peaked at a frequency of 10 to 12 hertz—at precisely the moments when the patients reported the greatest discomfort.

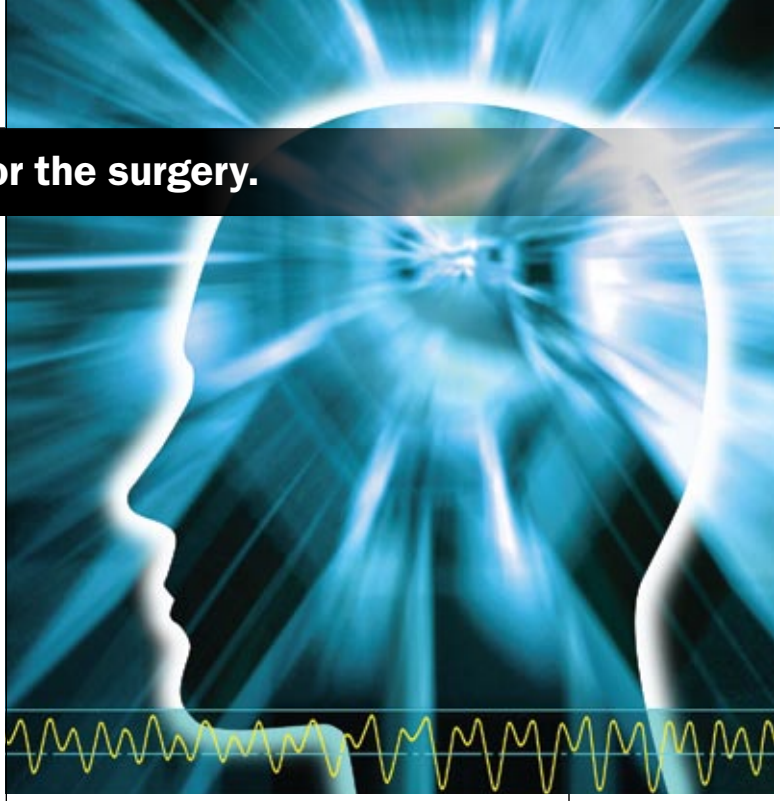
Neuroscientists could theoretically program an advanced electrode to listen for these pain spindles and send jolts of corrective electricity whenever they appear. —*M.L.K. and T.Z.A.*

Still experimental, but highly successful, is the use of deep-brain stimulation (*left*) to relieve debilitating pain. Recently, investigators recorded neural signals from patients who had undergone the procedure and discovered a spiking electrical pattern that correlated to patients' subjective feelings of pain (*below*). This work—deciphering brain signals that correspond to various disease states—could usher in future "smart" deep-brain-stimulation devices.



BRYAN CHRISTIE DESIGN (*pacemaker illustration*); ALEX GREEN *Oxford Functional Neurosurgery* (*electrical pattern*)

patient could be fully awake for the surgery.



France, helped to establish that another part of the basal ganglia, the subthalamic nucleus, can be an even more effective implantation spot (it has since become the most popular stimulation target). More recently, Aziz discovered a fourth target for the 20 percent of Parkinson's patients who do not respond to medication or to stimulation in the three established brain regions. After observing that a part of the brain stem called the pedunculopontine nucleus was underactive in a parkinsonian monkey, Aziz showed that stimulating this area brought stunning results to human patients for whom until recently nothing could be done. Many people who would otherwise be freezing in mid-step or falling over find themselves suddenly able to walk again.

Thanks to this kind of research and to the fact that the requisite batteries are now as small as the ones in cell phones, more than 250 hospitals in the U.S. alone perform deep-brain stimulation for movement disorders. Although other applications are considered experimental, in part because they are not yet approved by the Food and Drug Administration, strong evidence is mounting in their favor. Take, for example, the treatment of pain. Over the past 30 years more than 700 people have had deep-brain stimulation for otherwise treatment-resistant pain; the average long-term success rate is 60 to 70 percent, and when doctors are skilled in patient selection, the success rate approaches 100 percent.

A Sudden Calm Descends

In May 2001 a man named Robert Matthews fell and broke his left leg. The fracture did not heal properly, and the leg developed a stubborn antibiotic-resistant infection. Fearing that it would spread, doctors amputated his leg above the knee, but Matthews's problems did not end there. Although his leg was gone, he felt as if it were still there and in excruciating pain. He tried medications, hypnosis and stimulation of the spinal cord nerve, but nothing helped.

When Matthews was referred to us, he was 58 years old and had been suffering from phantom-limb pain for four years. He was taking large daily doses of opiates and, understandably, felt anxious and depressed. We had previously shown that stimulation of the brain stem, the most ancient part of the brain, can ease otherwise treatment-resistant pain; Matthews seemed an ideal candidate.

On the day of the surgery, our team clamped Matthews into a stereotactic frame—a metal rectangle that surrounds the head and provides three-dimensional coordinates for any point within the brain. We scanned his brain twice—with MRI before the frame was attached (metal objects are unsafe in an MRI machine) and with computed tomography afterward—and used software to merge the images. Like a nose or a foot or any other body part, the brain varies slightly from person to person, so structures deep within it will not always be found in exactly the same location. Now Aziz had a personalized map he could use to plot his trajectory with millimeter precision.

Matthews received an injection of local anesthesia so that he would not feel Aziz drill a small hole in his skull. There are no nerve endings in the brain itself, though, which meant Matthews could be fully awake—and we would need his participation to make the hour-long operation come off. Aziz gently guided a wire tipped with four platinum-iridium electrodes through the jellylike brain tissue and into the area known as the periventricular gray/periaqueductal gray (PAG). While methodically

(The Authors)

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PASIEKA SPL/Photo Researchers, Inc.

One depressed woman found her world

electrifying first one, then another, of the four electrode prongs, Aziz asked Matthews to describe out loud what he felt.

This is one of the trickiest moments in deep-brain stimulation—banishing the symptom without causing side effects by accidentally activating the wrong spot. The electrode is only about a millimeter and a half wide, but it straddles up to a million neurons. Packed tightly within the PAG are cells that communicate with each part of the body; we wanted to affect only those related to Matthews's left leg. If he reported feeling tingling or warmth in his hands, arms, face or other leg, Aziz would move the electrode, stimulate a different prong or change the pulses. Moreover, we were prepared for reactions even further afield. The PAG is the seat of the so-called fight-or-flight response, and in the past we have had a patient suffer an anxiety attack on the table. Side effects that can result from imperfect electrode placement in other parts of the brain include eye bobbing, inappropriate laughter and depression.

We gave Matthews a relatively mild amount of current: 1.5 volts—the strength of an AA battery. As for the speed, or frequency, of the pulses, we knew that fast pulses make pain worse, so we started him at about 10 per second and ultimately settled on seven. When we stimulated two of the prongs at these specifications, Matthews felt a sudden calm descend—a comfortable feeling of warmth in his phantom leg. After four years, finally, relief.

Aziz affixed the electrode-tipped wire to Matthews's skull and implanted a battery over his right pectoral muscle. The battery connects to the electrode by a lead that runs under the skin of Matthews's chest and neck and behind his ear to his scalp. Matthews has a magnetic remote control to turn the deep-brain stimulator on or off—but he rarely uses it, because as soon as he does, the agony returns. He reports that his pain is 75 percent reduced, and he has been able to resume his life.

Good as that outcome is, in the future we should be able to do better, using technology similar to that of today's cardiac pacemakers. Computer software in these devices monitors the patient's heart, sending a jolt of electricity only when it recognizes that the heart is not beating properly. When brain pacemakers become this precise, they will not have to be on all the time, which means, among other things, that the batteries will not have to be changed as often (they currently typically require surgical replacement every six months to five years, although rechargeable batteries are also starting to become available). Before deep-brain stimulation can advance, however, scientists must decode the language of neurons. We need to learn the details of how brain regions communicate, such as which electrical patterns might signify an oncoming tremor, headache or epileptic seizure. Then we can program the device to recognize when a problem is coming on and to deliver the specific pattern of pulses that will short-circuit it. Our team has made an intriguing advance toward discovering just such a "brain signature" [*see box on page 40*], and other studies are under way.

The Hype and the Potential

The transformative power of deep-brain stimulation is especially striking in the psychiatric realm. Investigators in Toronto, Leuven, Bonn and elsewhere have been enthusiastically reporting results from small trials. There is the report of a 31-year-old man who had such violent tics from Tourette's syndrome that he could not get a decent job or go out in public without being snickered at, whose body suddenly relaxed. There is the story of a woman whose world literally became brighter—looked newly washed—as soon as the electrode was activated. Other depressed patients said their sensations of "painful emptiness" disappeared. These changes abruptly vanished when patients' electrodes were switched off.

This is heady stuff, given that we do not understand exactly how deep-brain stimulation works nor do we know for sure what goes wrong in depression, Tourette's or many of the other syndromes for which stimulation is being attempted, such as obsessive-compulsive disorder, anorexia, overeating and drug addiction. There is potential here—the work on de-

KIYOSHI TAKAHASE SEGUNDO /*Stockphoto*

literally became brighter as soon as the electrode was activated.

pression in particular seems promising. But some scientists are getting ahead of themselves, and the media have been delighted to assist. In August 2007 neuroscientists at New York–Presbyterian Hospital/Weill Cornell Medical College and the Cleveland Clinic Foundation received lots of attention when they reported using deep-brain stimulation to wake a 38-year-old man from a minimally conscious state. Six years after a brutal beating, the man can eat without a feeding tube and speak a few words, an undeniable improvement. But the fact is that Japanese neurosurgeons have experimented for decades with deep-brain stimulation for just this kind of patient and found that such revivals are rare.

In another recent incident, a man undergoing experimental deep-brain stimulation to treat obesity incidentally retrieved a long-forgotten memory, whose clarity intensified when doctors turned up the voltage. Consequently, some have expressed optimism about brain implants for Alzheimer's. The problem is that deep-brain stimulation is a relatively blunt tool—it either inhibits or excites a brain region (and in turn, the other brain structures that region talks to). That is fine for Parkinson's, in which an overactive brain area may need quieting. But in Alzheimer's what we see are neurons that lose their connections to one another and can no longer store memories. It is unlikely that deep-brain stimulation could repair such intricate connections.

Perhaps contributing to all the excitement about deep-brain stimulation is the fact that it is more than a promising therapy. It is a powerful tool neuroscientists can use to gain insights into the fundamental structure and function of the brain.

Until now our best view of the living human brain has been through imaging studies such as MRI and positron-emission scans, but what we get from them is vague, along the lines of "When a person does such-and-such or thinks such-and-such, there are changes in blood flow or oxygenation in certain parts of the brain that are likely related to changes in neural activity." With deep-brain stimulation, on the other hand, what you essentially have is an on-off switch located in a specific part of the brain. By observing what happens to the brain as a whole when that switch is activated, you can glean detailed information about how various brain structures interconnect. One particularly exciting avenue that we have pioneered is to combine deep-brain stimulation with an imaging technique called magnetoencephalography (MEG). MEG tracks neural activity on the scale of milliseconds (MRI, in contrast, gives average brain activity over a six-second period and PET over a scale of minutes), providing an exceedingly accurate, moment-to-moment report.

When we used this technique on Matthews, the phantom-limb patient, we saw that the electrode in his brain stem appeared to drive activity in many other brain regions. Among the most active when he felt pain relief was the midanterior orbitofrontal cortex. This structure, located just above the eyes, has been shown in other studies to play a pivotal role in pleasurable (or rewarding) activities such as eating, using drugs and sex. Thus, cessation of pain is an intense form of pleasure, along the lines of snorting a line of cocaine or devouring a delicious pastry. This finding confirms that the orbitofrontal cortex might be an effective new stimulation target for people suffering from anhedonia, a lack of pleasure, which is common to depression and other mental illness.

We expect more revelations. By studying people with brain implants, we might answer questions such as how the brain coordinates learning a new language or solving an algorithm. We might even get new big-picture perspectives, such as how something as elusive as subjective experience can arise from electrical activity. Perhaps most important, we will be able to identify the brain areas where electrical stimulation will be most effective, further helping patients in dire need. M

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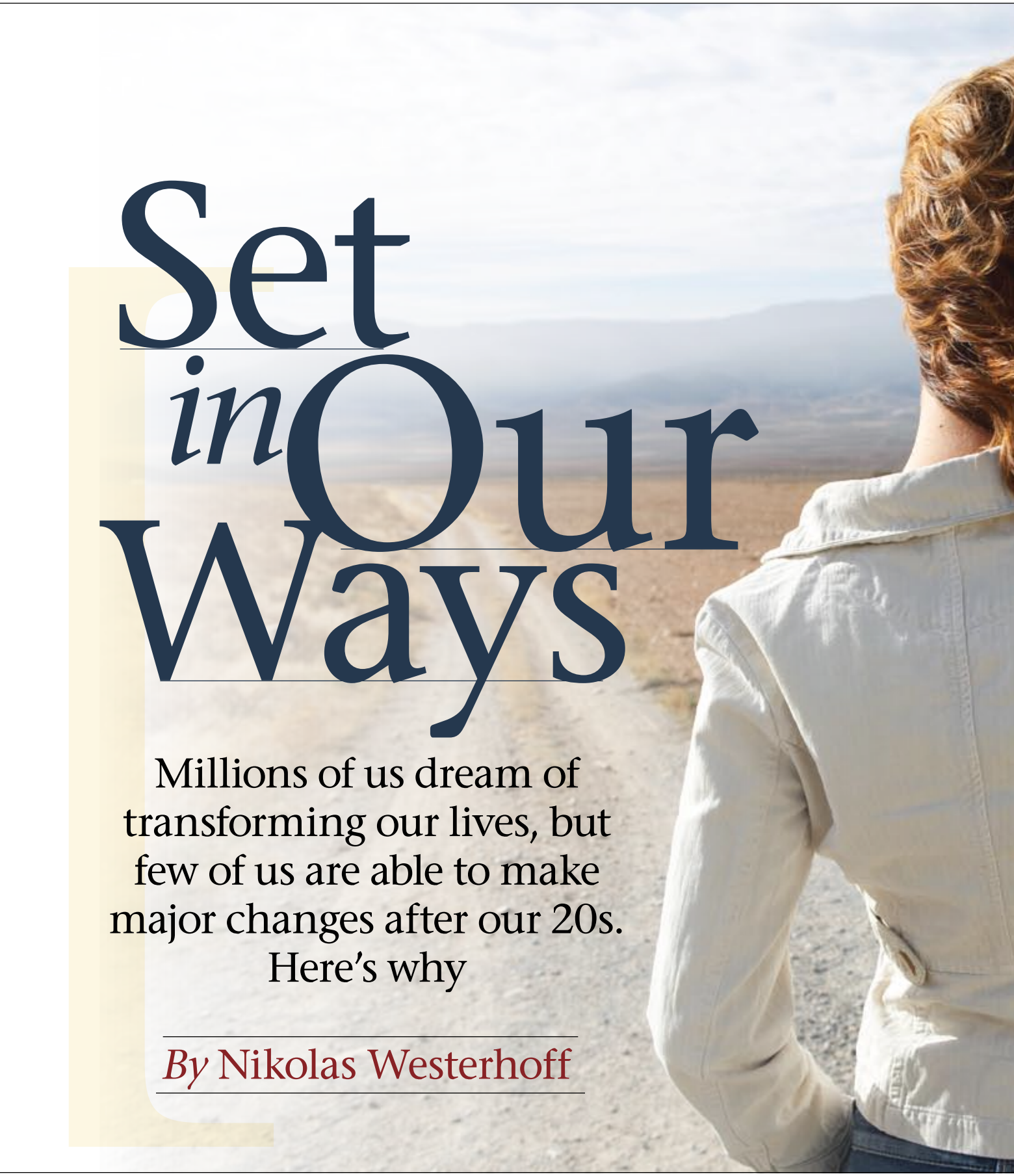
Set in Our Ways

Millions of us dream of transforming our lives, but few of us are able to make major changes after our 20s. Here's why

By Nikolas Westerhoff



"The shortest path to oneself leads around the world."

So wrote German philosopher Count Hermann Keyserling, who believed that travel was the best way to discover who you are.

That was how 22-year-old Christopher McCandless was thinking in the summer of 1990, when he decided to leave everything behind—including his family, friends and career plans. He gave his bank balance of $24,000 to the charity Oxfam International and hitchhiked around the country, ending up in Alaska. There he survived for about four months in the wilderness before dying of starvation in August 1992. His life became the subject of writer Jon Krakauer's 1996 book *Into the Wild,* which inspired the 2007 film of the same name.

Not every newly minted college graduate is as impulsive and restless as McCandless was, but studies conducted since the 1970s by personality researchers Paul Costa and Robert R. McCrae of the National Institutes of Health confirm that people tend to be open to new experiences during their teens and early 20s. Young people fantasize about becoming an adventurer like McCandless rather than following in the footsteps of a grandparent who spent decades working for the same company. But after a person's early 20s, the fascination with novelty declines, and resistance to change increases. As Costa and McCrae found, this pattern holds true regardless of cultural background.

Although people typically lose their appetite for novelty as they age, many continue to claim a passion for it. Voters cheer on politicians who pledge change. Dieters flock to nutritional programs advertising a dream figure in only five weeks. Consumers embrace self-help books promising personal transformation. And scientists tell us that novel stimuli are good for our brains, promoting learning and memory [see "Learning by Surprise," on page 47].

Yet even as people older than 30 yearn for what is new, many find themselves unable or unwilling to make fundamental changes in their lives. Researchers say this paradox can be largely explained by the demands of adult responsibilities and that unrealistic expectations may also play a part in thwarting our best intentions. Change is rarely as easy as we think it will be.

The Age of Openness

Psychologists have long identified openness to new experiences as one of the "Big Five" personality traits, which also include extroversion, agreeableness, conscientiousness and neuroticism. Considerable disagreement exists about how much these personality traits change after age 30, but most research suggests that openness declines in adulthood.

THE ROAD NOT TAKEN: For some, the long path to self-discovery begins with expanding one's geographic horizons.

CALL OF THE WILD: To fulfill a dream, 22-year-old Christopher McCandless hitchhiked across the U.S. in the 1990s, making his way to the Alaskan wilderness. His adventurous life was the subject of the film *Into the Wild,* starring Emile Hirsch.

VINCENT BESNAULT *Getty Images (preceding pages);* RIVER ROAD/PARAMOUNT/THE KOBAL COLLECTION (*still from* Into the Wild)

"Clear age trends are observable," says psychologist Peter Borkenau of Martin Luther University Halle-Wittenberg in Germany. "People tend to become more reliable and agreeable with age, but their openness to novelty drops at the same time."

In a comprehensive survey of more than 130,000 participants published in 2003, psychologist Sanjay Srivastava, now at the University of Oregon, and his colleagues assessed the Big Five traits in 21- to 60-year-olds using standard psychological tests on the Internet. They found that openness increased modestly up to age 30 and then declined slowly in both men and women. The survey results suggest that men begin adulthood slightly more open to new experiences than women but decline in openness during their 30s at a faster rate than women.

Age 30 is not a magical turning point, however. Openness declines gradually over many years, often beginning in the 20s. As the years wear on, novelty becomes less and less stimulating, and the world outside someone's own private and professional sanctums becomes increasingly less attractive.

This change happens to almost everyone, regardless of individual personality. That does not mean that everyone reaches the same level of openness in later life, however. Some toddlers love to go back to the same playground day after day, whereas others get bored after a day or two of digging in the same sandbox with the same shovel. Children who are less open to new experiences than their peers are will continue in adulthood to cleave to the conventional more than their more adventurous childhood friends will. As psychologist Richard W. Robins of the University of California, Davis, showed in a longitudinal study, those who begin life with a more open personality remain relatively more open in their later years.

Nature or Nurture?

The fact that an age-dependent pattern of decreasing openness appears around the globe and in all cultures suggests, according to biopsychologists, a genetic basis. But the jury is still out. As psychologist and personality researcher Rainer Riemann of Bielefeld University in Germany points out, it is conceivable that people all over the globe are simply confronted with similar life demands and societal

FAST FACTS

Personality through the Years

1» Studies of personality development often focus on traits such as extroversion, conscientiousness, agreeableness, neuroticism and openness to new experiences. In most people, these traits change more during young adulthood than any other period of life, including adolescence. Openness typically increases during a person's 20s and goes into a gradual decline after that.

2» This pattern of personality development seems to hold true across cultures. Although some see that as evidence that genes determine our personality, many researchers theorize that personality traits change during young adulthood because this is a time of life when people assume new roles: finding a partner, starting a family and beginning a career.

3» Personality can continue to change somewhat in middle and old age, but openness to new experiences tends to decline gradually until about age 60. After that, some people become more open again, perhaps because their responsibilities for raising a family and earning a living have been lifted.

Learning by Surprise

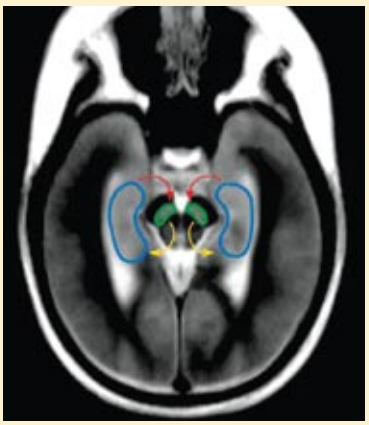
Novelty enhances memory. That fact has practical implications for educators

By Daniela Fenker and Hartmut Schütze

You take the same route to work every day, driving the same car, crossing the same intersection with the same median strip. Same old, same old. But this morning something new catches your eye: a cow grazing in the median. It takes a couple of honks to remind you that the light has turned green.

If you are like most people, you will remember this moment in your morning commute for a long time—the sun was shining, daffodils had just pushed up in the median, and "We Are the Champions" was playing on the radio. Yet all the other countless times you have driven through this intersection are long forgotten.

Psychologists have known for some time that if we experience a novel situation within a familiar context, we will more easily store this event in memory. But only recently have studies of the brain begun to explain how this process happens and to suggest new ways of teaching that could improve learning and memory.



FEEDBACK LOOP: The hippocampus (*circled in blue in brain cross section*) responds to novel stimuli by sending a burst of the messenger substance dopamine (*red*) to the substantia nigra and the ventral tegmental area (SN/VTA; *circled in green*), according to the hippocampal-SN/VTA loop model. From the SN/VTA, nerve fibers run back to the hippocampus (*yellow*), triggering the release of additional dopamine in response to novelty. These brain structures deteriorate with age, which may help account for why seniors sometimes have trouble remembering new information.

Novelty Detector

One of the most important brain regions involved in discovering, processing and storing new sensory impressions is the hippocampus, located in the temporal lobe of the cerebral cortex. Novel stimuli tend to activate the hippocampus more than familiar stimuli do, which is why the hippocampus serves as the brain's "novelty detector."

The hippocampus compares incoming sensory information with stored knowledge. If these differ, the hippocampus sends a pulse of the messenger substance dopamine to the substantia nigra (SN) and ventral tegmental area (VTA) in the midbrain. From there nerve fibers extend back to the hippocampus and trigger the release of more dopamine. Researchers, including John Lisman of Brandeis University and Anthony Grace of the University of Pittsburgh, call this feedback mechanism the hippocampal-SN/VTA loop (*above right*).

This feedback loop is why we remember things better in the context of novelty. As Shaomin Li and his colleagues at Trinity College Dublin discovered in 2003, the release of dopamine in the hippocampus of rats activates the synapses among nerve cells, creating stronger connections that lead to long-term memory storage. We wondered whether this same neuronal loop facilitates the retention of other information that is perceived along with novel stimuli.

At the University of Magdeburg's Institute for Cognitive Neurology, in collaboration with Emrah Düzel and Nico Bunzeck of University College London, we used functional magnetic resonance imaging to measure the activity of various brain regions based on blood flow. We presented one group of test subjects with a set of already known images and a second group with a combination of known and new images. Subjects in the second group were better at remembering the images than subjects in the first group were, and the fMRI data showed greater activity in the SN and VTA areas of the brain when the subjects were viewing unfamiliar images. This correlation may help explain how novelty improves memory.

Increased Retention

Are the effects of novelty on memory merely temporary? To answer this question, we showed test subjects a variety of photographs and measured their brain activity using fMRI. We also gave the participants a series of words to sort according to their meaning.

The experiment continued the next day when we showed some of the test subjects new images while others viewed familiar ones. Then we asked all the subjects to recall as many words from the previous day's exercise as they could. Recall was significantly better in the group that had just viewed new images.

In other words, novelty seems to promote memory. This finding gives teachers a potential tool for structuring their lessons more effectively. Although most teachers start a lesson by going over material from the previous class before moving on to new subject matter, they should probably do just the opposite: start with surprising new information and then review the older material.

Daniela Fenker and Hartmut Schütze are researchers at the University of Magdeburg's Neurology Clinic II in Germany.

COURTESY OF HARTMUT SCHÜTZE

The "Big Five" Personality Traits

In the 1970s two research teams led by Paul Costa and Robert R. McCrae of the National Institutes of Health and Warren Norman and Lewis Goldberg of the University of Michigan at Ann Arbor and the University of Oregon, respectively, discovered that most human character traits can be described using five dimensions. Surveys of thousands of people yielded these largely independent traits:

>> **Extroversion** The most broadly defined of the Big Five factors measures cheerfulness, initiative and communicativeness. Those who score high for extroversion are companionable, sociable and able to accomplish what they set out to do. Those with low scores tend to be introverted, reserved and more submissive to authority.

>> **Openness** People with high scores here love novelty and are generally creative. At the other end of the scale are those who are more conventional in their thinking, prefer routines, and have a pronounced sense of right and wrong.

>> **Agreeableness** This trait describes how we deal with others. High values show that someone is friendly, empathetic and warm. Shy, suspicious and egocentric individuals score low on the spectrum.

>> **Conscientiousness** This dimension measures a person's degree of organization. Those with high scores are motivated, disciplined and trustworthy. Irresponsible and easily distracted people are found at the low end of the scale.

>> **Neuroticism** This scale measures emotional stability. People with high scores are anxious, inhibited, moody and less self-assured. Those at the lower end are calm, confident and contented.

Where are you on the Big Five scale? You can find out by taking a free personality test at **www.outofservice.com/bigfive** —*N.W.*

expectations. Young men and women everywhere have to go out into the world and find a partner and a livelihood. Later, they have to care for their children and grandchildren. These life tasks require commitment and consistency and may serve as a catalyst for personality change.

Once a family and career are in place, novelty may no longer be as welcome. New experiences may bring innovation and awakening but also chaos and insecurity. And so most people dream of novelty but hold fast to the familiar. Over time we become creatures of habit: enjoying the same dishes when we eat out, vacationing in favorite spots and falling into daily routines [see "Foraging in the Modern World," on page 82].

"The brain is always trying to automate things and to create habits, which it imbues with feelings of pleasure. Holding to the tried and true gives us a feeling of security, safety, and competence while at the same time reducing our fear of the future and of failure," writes brain researcher Gerhard Roth of the University of Bremen in Germany in his 2007 book whose title translates as *Personality, Decision, and Behavior.*

But even negative events may have thoroughly positive results, according to sociologist Deborah Carr of Rutgers University. For example, many widows are able to start life over again and to develop talents they never knew they had. People who have been diagnosed with cancer learn to redefine themselves as a result of the disease—and may even conquer their cancer in the process. Survivors of natural catastrophes often discover new strengths. But we should not draw sweeping conclusions from these examples, says psychologist William R. Miller of the University of New Mexico. Many older people report that they have changed little in spite of major life experiences.

In a recent experiment psychologist Kate C. McLean of the University of Toronto Mississauga asked 134 volunteers of different ages—some older than 65 and others ranging in age from late adolescence through young adulthood—to describe three self-defining memories. She found that both old and young participants reported novel experiences such as the death of a partner, an unexpected career advancement or a cross-country move. The older people ascribed different meanings to these events than the younger people did, however. For younger people, external changes were more likely to lead to internal transformation, but that was not the case for older individuals.

These very different narratives are no coinci-

(The Author)

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NICHOLAS MONU *iStockphoto*

dence. Personality traits change more during young adulthood than any other period of life, according to psychologist Brent W. Roberts of the University of Illinois, who together with two colleagues analyzed 92 studies of personality development. They concluded that some personality changes occur well past the age of 30 but that typically these changes are small in magnitude compared with the changes that occur between the ages of 20 and 40.

Even major life events such as a divorce or the death of a loved one, though stressful, are unlikely to result in profound personality changes. The middle years of life are often a time of reflection and reevaluation, but few people experience a genuine "midlife crisis."

The structure of one's personality becomes increasingly stable until about age 60. "That means that a person who is particularly conscientious at the age of 40 will be conscientious at 60 as well," Borkenau says. Stability decreases again, however, after the age of 60. It seems that people are only able to become more open to new experiences once they have fulfilled their life obligations—that is, after they have retired from their careers and their children have flown the nest.

False Hope Springs Eternal

Even after age 60 it is difficult to completely reframe your life. In fact, those who seek to make large changes often end up failing even to make the most minor corrections. The more an individual believes he can set his own rudder as he pleases, the more likely he is to run aground. That's one reason why so many smokers who tell you that they can quit whenever they want are still smoking 20 years later.

In 1999 psychologists Janet Polivy and C. Peter Herman of the University of Toronto Mississauga coined a term for this phenomenon: false hope syndrome. Over and over, they say, people undertake both small and large changes in their lives. Most of these attempts never get anywhere, thanks to overblown expectations [see "Picture Imperfect," by David Dunning, Chip Heath and Jerry M. Suls; Scientific American Mind, Vol. 16, No. 4, 2005].

Take the woman who believes that if she can lose 20 pounds she will finally meet the man of her dreams and live happily ever after. This fantasy is based on the notion that one positive change—losing weight—automatically brings with it other desired changes. But the reality is that it is difficult to keep weight off over the long term, and finding an ideal life partner is often dependent on luck. Even if dieting proves successful, other goals may remain out of reach. But the false hope syndrome seduces people into trying to overhaul their entire lives all at once: the smoker and couch potato is suddenly inspired to become a nonsmoker and marathon runner, but because he attempts too much too fast, he is doomed to fail.

The cure for false hope is to set more reasonable goals and recognize that achieving even modest change will be difficult. And if you are older than 30, remember that your openness to new experiences is slowly declining, so you are better off making a new start today than postponing it until later. Perhaps most important of all, try to appreciate the person that you already are.

As the ancient Greek philosopher Epicurus put it: "Do not spoil what you have by desiring what you have not; but remember that what you now have was once among the things only hoped for." M

MARK JOHNSON *jupiterimages*

HIGH FLIERS: Paragliding, parachuting and bungee jumping are a welcome change from the daily routine for some—for others, a nightmare.

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Impact on the Brain

Mild traumatic brain injury represents a silent but brutal plague among combat veterans and a hidden threat to the health of civilians

By Richard J. Roberts

As a combat engineer in Iraq, Jeremy was supposed to find roadside bombs. They found him instead. Within 72 hours of each other, two improvised explosive devices (IEDs) went off within 15 feet of this father in his late 20s. The first set of blast waves, a moving wall of highly compressed air that emanates from an explosion, knocked him out briefly. The second left him dazed for about 30 minutes and produced ringing in his ears that disappeared within a week. These detonations did not visibly injure Jeremy (not his real name)—but he was never the same.

After his tour in Iraq, Jeremy became more irritable with his spouse and child. At his job as a manager of a national firm, he would get very frustrated when customers were abrupt or business was brisk. Jeremy's memory had deteriorated, too, and he had to use a daily planner to remind himself of even the most basic tasks. He also had incapacitating headaches, spells of panic or confusion, mood swings, and sensory illusions such as a metallic taste or ringing in his ears. Neuropsychological tests revealed that Jeremy had real deficits in mental processing, attention and short-term verbal memory.

Jeremy was diagnosed with a "mild" traumatic brain injury (TBI), in which trauma to the head produces only a brief loss of consciousness or a transient disturbance of mental or sensory function. Such trauma is deemed mild, moderate or severe based on its immediate consequences rather than its long-term effects. Thus, some patients diagnosed with severe TBI—because they spent four days in a coma, for example—eventually return to work without incident, whereas some 10 to 15 percent of civilian patients who sustained mild TBI never fully recover from its effects.

According to the Centers for Disease Control and Prevention, 1.4 million American civilians sustain a TBI every year, three quarters of them mild. Indeed, mild TBI is the most common neurological condition in the U.S. other than headache, a category that includes migraines. In addition, as many as 320,000 U.S. service members have experienced a probable TBI of any severity in Iraq or Afghanistan, according to a 2008 report from RAND Corporation.

A blast strong enough to cause TBI is also powerful enough to produce emotional trauma and the psychiatric condition post-traumatic stress disorder (PTSD). Thus, many veterans, Jeremy included, experience both ailments. In particular, the combination of mild TBI and PTSD is considered the signature injury of the Iraq War. Responding to this emerging problem, the U.S. Congress allocated $300 million in 2007 to investigations into mild TBI and PTSD.

SOVEREIGN, ISM/SPL/PHOTO RESEARCHERS, INC. (*brain MRI*); GETTY IMAGES (*mushroom cloud*)

Every year in the U.S. about 300,000 mild traumatic brain injuries, or concussions, result from sports.

GARY HOULDER *Corbis*

Meanwhile scientists have identified a number of ways in which blunt-force trauma (being hit in the head) damages the brain, including the creation of bruises, stretched or torn nerve cells, and electrical misfiring. They have also built a case for brain injury resulting directly from the pressure waves unleashed by explosions, even in cases where a soldier's head did not strike any solid object. The new knowledge is spawning research into treatments for mild TBI, which may include antiepilepsy medications and various forms of psychotherapy.

Blunt Force

By far the most common type of brain trauma in ordinary life is closed head injury—in which no bullet, knife or other object actually penetrates—resulting from the skull hitting a surface in a car crash, fall, sports activity, assault, or other incident or pursuit. Physician Claudia Osborn, now at the Michigan State University College of Osteopathic Medicine, sustained a mild TBI from a bicycle accident that permanently diminished her ability to practice medicine and cope with daily life. She describes her struggle to overcome her disability in *Over My Head: A Doctor's Own Story of Head Injury from the Inside Looking Out* (Andrews McMeel Publishing, 1998).

About 300,000 mild TBIs (also referred to as concussions) result from sports every year in the U.S. Former professional wrestler and Harvard University defensive tackle Chris Nowinski has been knocked out, seen double and become disoriented many times after blows to the head. Most of the time he kept playing, but after six concussions Nowinski had to stop wrestling professionally. Repeated concussions have also ended the careers of a number of professional football players. Long-term consequences include a heightened risk of dementia and epilepsy.

Our brains are encased in a bony skull and a triplet of membranes called meninges. In addition, the brain floats in a clear liquid called cerebrospinal fluid (CSF), which provides a modest cushion against the effects of blunt-force trauma to the skull. These protective pieces prevent damage from minor falls or being hit in the head by wooden clubs and small rocks—the kinds of injuries typically experienced during the evolution-

FAST FACTS

Head Wounds

1» **Traumatic brain injury (TBI) is deemed mild, moderate or severe based on its immediate consequences rather than its long-term effects. Thus, some patients diagnosed with severe TBI—because they spent four days in a coma, for example—eventually return to work without incident, whereas some 10 to 15 percent of civilian patients who sustained mild TBI never fully recover from its effects.**

2» **Blunt-force trauma can damage the brain by bruising it, stretching or tearing nerve cells, or triggering electrical misfiring. The pressure waves unleashed by explosions can also induce brain damage, even in cases where a soldier's head did not strike a solid object.**

3» **A blast strong enough to cause TBI is also powerful enough to produce emotional trauma and post-traumatic stress disorder (PTSD). The combination of mild TBI and PTSD is considered the signature injury of the Iraq War.**

4» **The growing appreciation of the problem of mild TBI is spawning research into treatments, which may include antiepilepsy medications and various forms of psychotherapy.**

ary history of humans. But because the brain's biological barriers have not had time to respond to selective pressures from recent technological advances, they do little to shield the brain from a blast wave from a roadside bomb or a high-speed collision with a telephone pole. Even impacts from contact sports such as boxing, football and wrestling or from falls from riding horseback or skiing can inflict serious brain damage.

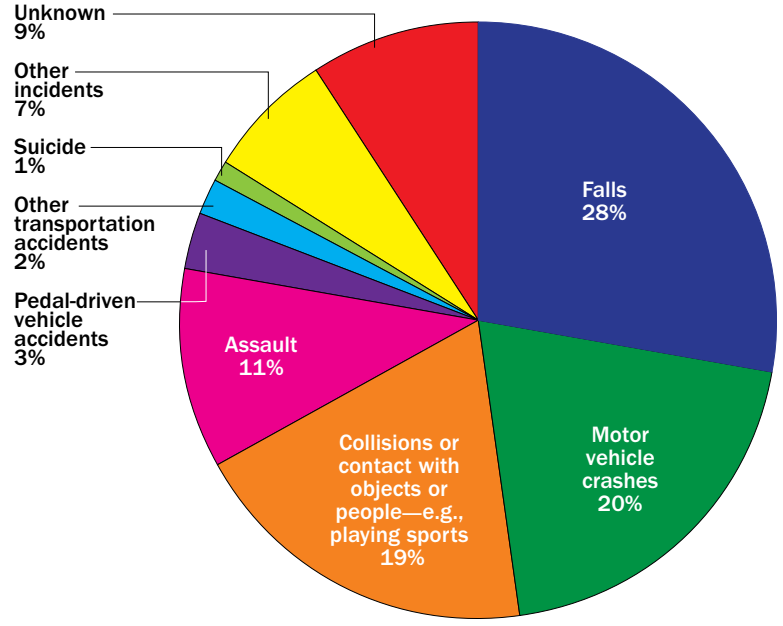
Concussions typically result from blows to the head or from the head hitting a hard surface or being shaken or spun. In response to such forces, the brain may smash against the skull, popping blood vessels and bruising brain tissue. Sometimes the impact causes the brain to bounce off one side of the skull and back into the other, producing a coup contrecoup injury in which the brain is injured at the site of the impact and on the opposite side. This type of injury may also occur without blunt-force trauma, say, when a soldier's head is displaced a short distance extremely rapidly by an IED blast.

When brain structures move relative to one another and to the skull, tissue may stretch or even shear. In particular, the force can distend nerve axons, the long, slender fibers that extend from the main cell bodies and transmit messages among neurons. Axons are normally elastic, but when rapidly elongated they become brittle and weak. Often an axon swells and tears, killing the neuron.

Such cellular disintegration can also cause a neuron to release toxic levels of neurotransmitters (chemical messengers), damaging other neurons. This process sparks further degeneration of axons as well as apoptosis, or programmed cell death, throughout the cerebrum. Such diffuse axonal injury may underlie many of the persistent cognitive problems experienced by victims of mild TBI. In addition, mechanical forces can set off other problematic chemical cascades that can lead to latent symptoms, which may not appear until days after the initial assault.

Concussions may alter the firing patterns of nerve cells. Neurons damaged by trauma can become electronically unstable and thereby induce a type of neuronal static in small brain regions that, though too small to show up on an electroen-

Causes of Traumatic Brain Injury



Blunt-force trauma to the head can injure axons, the long fibers (*orange strands*) that extend from neurons' cell bodies (*orange circular objects*) and relay messages among neurons.

CENTERS FOR DISEASE CONTROL AND PREVENTION (*pie chart*); PASIEKA *SPL/Photo Researchers, Inc.* (*nerve cells*)

U.S. Army and Iraqi soldiers run through smoke after an improvised explosive device (IED) put their Stryker armored vehicle out of commission. The rapid changes in atmospheric pressure produced by IED blasts can damage soldiers' brains.

EROS HOAGLAND *Redux*

Brain injuries caused by the blast waves from exploding ordnance are appearing in record numbers among Iraq War veterans.

cephalogram (EEG), can spawn illusions, memory gaps and mood swings.

Although victims of mild TBI rarely display conventional epilepsy, many of their symptoms resemble an epileptic syndrome called simple partial seizures, in which an abnormal burst of cellular electrical activity in a restricted part of the brain produces brief motor, sensory, or even cognitive or emotional oddities while a person is conscious. (Which type of peculiarity—experiencing a memory gap, hearing an imaginary voice or feeling a burst of anxiety—depends on the part of the brain affected.)

Concussion patients typically have a wider spectrum of complaints than patients with simple partial seizures do. In this regard, they may even more closely resemble people diagnosed with epilepsy spectrum disorder, which is characterized by a variety of sensory, cognitive and emotional symptoms similar to those Jeremy experienced.

Shell Shock

Aside from blunt-force trauma, soldiers on the battlefield may experience brain damage from penetrating missiles such as bullets and shrapnel—the dominant brain injury in past wars such as Vietnam—and the blast waves from IEDs, bombs, mortars and the like. The blast-wave brain injuries are appearing in record numbers among veterans of the wars in Iraq and Afghanistan. Hundreds, if not thousands, of U.S. soldiers are returning from Iraq with symptoms similar to Jeremy's.

Such blast-related problems are not new to these wars. As early as World War I, soldiers reported psychiatric symptoms as well as sensory and cognitive impairments that appeared after explosions that caused no external visible injury. British army physician Fred Mott ascribed most such cases of "shell shock" to psychic trauma or emotional distress. Other doctors believed that the condition arose from an organic injury to the brain, citing changes on an EEG similar to those seen from closed head injuries.

But nobody seriously followed up on the brain damage theory until the 1990s, when neurologist Ibolja Cernak, now at the Johns Hopkins University Applied Physics Laboratory, noticed the effects of blast exposure in her medical practice at the Military Hospital in Belgrade during the war in the Balkans. Cernak repeatedly observed soldiers with memory lapses, dizziness and speech problems—clear signs of brain damage—who had never experienced any direct, blunt-force trauma to their heads. In brain-imaging studies, Cernak saw signs of injury: bleeding or enlarged ventricles (spaces in the brain filled with CSF).

Since then, studies by Cernak and others have hinted that blast concussions may indeed lead to brain damage directly and not just through psychological trauma. In 1998, for example, psychiatrist David Trudeau, then at the Minneapolis Veterans Affairs Medical Center, and his colleagues reported that 27 of 43 war veterans diagnosed with PTSD who had also been briefly knocked out or dazed by nearby explosions showed abnormal brain activity, as assessed by quantitative electroencephalography. Their quantitative EEG pat-

terns differed from those of the 16 PTSD patients who had not had a history of mild TBI. In addition, 88 percent of the veterans who had experienced concussion blasts had significant problems related to attention and impulsivity as compared with 60 percent of the control group, indicating that the blasts had effects above and beyond stress.

Cernak reported similar findings in a 1999 study of 1,300 patients who had sustained wounds to their lower bodies but not their heads. She found that 30 percent of those who had been injured in a blast showed abnormal brain activity a year later as compared with only 4 percent of patients who had been wounded by projectiles.

But how could a roadside explosion affect the brain? Of course, brain damage could occur from blunt-force trauma associated with the explosion. A person may be hit in the head by an object—shrapnel, say, or debris from surrounding buildings—propelled by the blast. Similarly, an individual may be blown out of a vehicle or up against some solid structure, sustaining an injury similar to one that would occur from a head striking a car's windshield.

Too Much Pressure

In addition—or in the absence of any impact with a solid object—rapid changes in atmospheric pressure produced by the explosions could cause brain damage, according to a 2006 paper by neurologist Deborah L. Warden of Walter Reed Army Medical Center and two of her colleagues.

During an explosion, the researchers explain, a solid or liquid is almost instantaneously converted into gases. These gases temporarily occupy the same volume as the solid or liquid and are thus under extremely high pressure. The gases then expand, compressing the surrounding air and forming a pulse of pressure called blast overpressure. As the gases continue to spread out behind the high-pressure region, they create a huge pressure drop.

Brain tissue itself has the consistency of firm custard—but custard of differing densities. As the shock wave reaches a soldier, the high- and then low-pressure air accelerates body tissues of differing densities at different rates. Inside the brain, the varied accelerations could shear and stretch axons just as blunt-force trauma does.

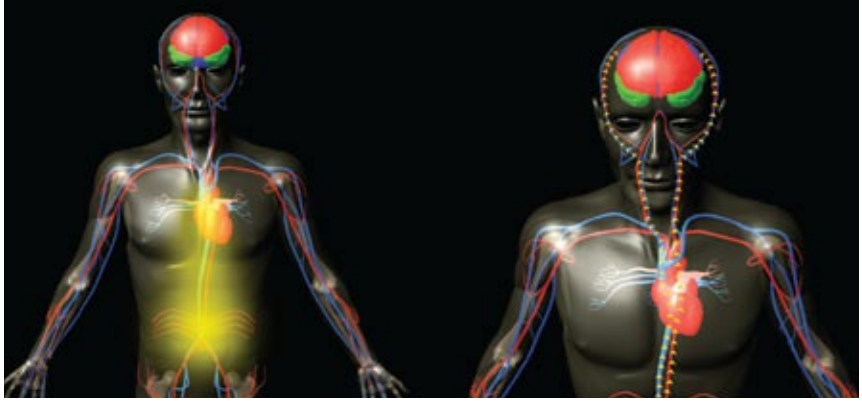
Yet a compression wave may also initiate brain damage in ways distinct from blunt-force trauma. According to neurologist P. Steven Macedo of the Washington Medical Group, shock waves can cause cavitations, or gas bubbles, in brain tissue. These bubbles can then pop, leaving holes.

Cernak, however, favors a different explanation. She speculates that blast waves pushing against the body's surface create oscillating pressure waves in major blood vessels, similar to the rippling of open water in stormy weather. These ripples then travel up a person's torso through his or her neck and into the brain, which is extremely sensitive to mechanical perturbation. Thus, the kinetic energy (energy of motion) of this blood could damage neurons, which may lead to neurological deficits [*see box above*]. If such an indirect mechanism is involved in mild TBI, Cernak suggests, prevention of these injuries in soldiers must extend beyond better helmets or other measures that protect only the head.

Whatever the exact physical mechanism, animal research bolsters the notion that compression waves alone—in the absence of blunt-force trauma—can hurt the brain. In a 2007 study researchers at Tohoku University in Japan exposed adult male rats to shock waves of differing magnitudes from experimental explosions after removing a section of their skull to expose their brain. The scientists found that high-pressure shock waves, those similar in magnitude to ex-

Ripple Effect

In one theory, blast waves from an explosion can lead to brain damage by compressing the body (*yellow, left image*), creating oscillating pressure waves in major blood vessels (*yellow arrows, right image*) that lead to the brain.



JOHNS HOPKINS UNIVERSITY APPLIED PHYSICS LABORATORY

(The Author)

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The author wishes to express appreciation to numerous professional colleagues with whom he discussed aspects of this article and to Kathryn Elizabeth Roberts for fact-checking and reference work.

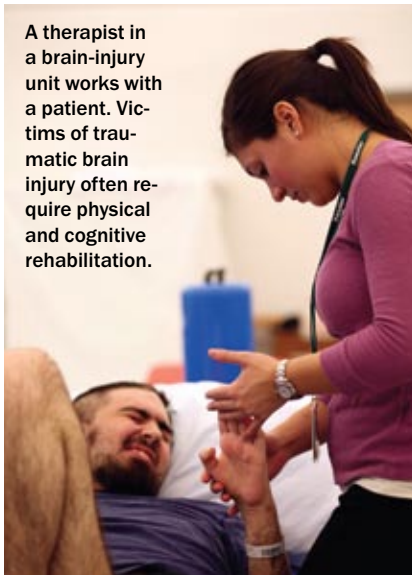
Patients who have sustained traumatic brain injuries often improve with a class of drugs typically used to treat epilepsy and bipolar disorder.

plosions at close range, cause cerebral bruising and bleeding that induce neurons to commit cell suicide.

Lower-pressure waves, such as those that might arise from a tire blowing out near your face, can distort the shape of neurons. The findings suggest, the authors write, "that the threshold for shock-wave induced brain injury may be lower than 1 MPa [megapascal], which is a lower level than that reported for other organs." (One MPa is about 10 times normal atmospheric pressure.) Moreover, they say, the damage from these shock waves resembles that from other types of traumatic brain injury.

On top of these physical forces, the psychological stress of being near a detonation may cause brain damage or dysfunction through excessive secretion and action of stress hormones in the brain. Brain injury often co-occurs with PTSD, and elevated levels of stress hormones such as cortisol associated with PTSD may exacerbate or slow the healing of any blast-induced brain damage. Jeremy's symptoms may have, in fact, arisen from both disorders, given that he shows clear signs of PTSD: he experiences flashbacks, avoids war reminders and is easily startled.

What is more, some researchers such as Harvard neurologist Michael P. Alexander still maintain that emotional and psychiatric issues are the main if not sole cause of the problems experienced by veterans like Jeremy. In a 1995 paper in the journal *Neurology,* Alexander suggested that telling patients they have



A therapist in a brain-injury unit works with a patient. Victims of traumatic brain injury often require physical and cognitive rehabilitation.

hurt their brain could stall their recovery by making them perceive their problems as more intractable than they are.

And when psychiatrist Charles W. Hoge of Walter Reed Army Institute of Research and his colleagues surveyed 2,525 U.S. Army infantry soldiers three to four months after their return from a year of duty in Iraq, they found that PTSD was strongly associated with mild TBI. The researchers conclude in their 2008 paper in the *New England Journal of Medicine* that PTSD and depression—rather than the physical impact to the brain—were the probable causes of the veterans' neurological complaints, which included irritability and concentration lapses, because these psychiatric disorders have been linked to a wide range of physical health problems.

Treating Trauma

No matter the relative roles of emotional fallout versus organic brain damage after an explosion, fall, car accident or sports injury, both psychiatric issues and brain injury are part of the medical equation in many patients. When a patient suffers from PTSD or depression, doctors often prescribe an antidepressant and psychotherapy, including individual and group counseling, both of which Jeremy received for his PTSD.

In particular, patients with PTSD often respond to cognitive-behavior therapy, in which practitioners try to dismantle distorted thought patterns and correct maladaptive behaviors. One behavior-modification technique is exposure therapy, in which a counselor uses experiences similar to those that gave rise to the traumatic stress to help a patient get used to these situations, reducing their emotional impact. Patients may sometimes receive such exposure through virtual-reality computer programs that reenact war zones, the 9/11 attacks on the World Trade Center or other harrowing scenarios [see "Fantasy Therapy," by Nikolas Westerhoff; Scientific American Mind, October/November 2007].

When a patient is also likely to have sustained a bona fide brain injury, he or she often improves with a class of drugs known as anticonvulsant mood stabilizers, which include valproic acid and carbamazepine, most often used to treat classic epilepsy and bipolar disorder. In 1997 neuropsychiatrist Bruno Wroblewski, then at the Greenery Rehabilitation Center in Boston, and his colleagues reported that treatment with valproic acid markedly reduced destructive and aggressive behaviors in patients who had experienced blunt-force TBI. Jeremy took the same drug and found that it helped reduce his memory lapses, sensory illusions and mood swings.

In a similar vein, in 2000 psychologist Michael A. Persinger of Laurentian University in Ontario reported that 12 of 14 patients who took carbamazepine after blunt-force brain trauma resulting from motor vehicle accidents "experienced marked reductions in the incidence of sudden confusion and depression, increased attention and focus, and either elimination or reduction of an aversive sensed presence" (the last is an illusion of movement in peripheral vi-

FRED R. CONRAD *New York Times/Redux Pictures*

An Iraqi soldier transports an old artillery shell to a pit for destruction. Old shells are fodder for roadside bombs, whose blasts have damaged the brains of record numbers of U.S. troops.

ATEF HASSAN *Reuters/Landov*

sion). No one is sure why such agents might be effective, because mild TBI patients rarely have classic epilepsy, but perhaps the drugs help to alleviate some of the electrical instability among neurons that brain injuries can induce.

The brain also tries to repair itself after injury, and scientists are trying to learn more about those repair processes in hopes of boosting them with medications. They are developing treatments to be given during the first hours after a TBI designed to limit any ongoing injury [see "Duct Tape for the Brain," by Lucas Laursen, on page 58]. A more futuristic approach might involve the implantation of neural stem cells, immature cells that can give rise to different types of mature cells in the central nervous system, to repair or replace damaged brain tissue.

But for now, patients must make do with more symptomatic relief from antidepressants, sleep medications and, in some cases, anticonvulsants. Many also receive cognitive rehabilitation in which they learn strategies that enable them to circumvent their deficits. For instance, when introduced to someone new, the patient might rehearse his or her name several times or use visual imagery as a memory cue.

Becoming better organized is another useful skill for the cognitively enfeebled. Some tricks include using a weekly pillbox or finding one place for key items such as a wallet and cell phone. Technology can also help patients manage daily life. Jeremy, for instance, now uses a PalmPilot to serve as an electronic prosthesis for his inconsistent memory functioning. "Smart" phones and tape recorders can also serve as backups for fragile human memory, enabling the brain-injured (not to mention the rest of us) to record key information as soon as they receive it.

Sometimes patients must alter their way of life to accommodate their decreased ability to function. They may, for example, have to avoid social situations that are too stimulating, radically adjust their work hours, leave a risky or stressful job, or even enter a residential program for the brain-injured. Jeremy decided to resign from his demanding managerial position and is now interviewing for another job. He hopes to find work assisting fellow veterans who are, like him, looking for a new career in civilian life. M

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Duct Tape for the Brain

Low-tech emergency room therapies

By Lucas Laursen

Kirsten Timmons was navigating a frozen overpass one night when a passing car skidded out of control and slammed into her vehicle. As her car came to a stop, Timmons's head probably snapped around its own axis, decelerating sharply when it struck the seat-belt holder next to her.

The impact produced a severe traumatic brain injury (TBI), knocking Timmons out and setting the stage for lasting brain damage. Luckily for her, emergency services rushed her to the hospital within an hour of the crash, greatly boosting her chances of survival. Prompt medical attention can, for example, prevent dangerous pressure buildup in the brain, remove perilous blood clots and thwart other life-threatening consequences of severe TBI.

After eight days in a medically induced coma, Timmons woke up to a daughter she did not recognize. Today, three years after the accident, Timmons knows her child but struggles to concentrate, recall numbers and perform simple calculations—disabilities that ended her career as a nurse practitioner. Similar problems often plague victims of mild TBI [see "Impact on the Brain," by Richard J. Roberts, on page 50]. "We're not bad at getting people to survive [severe TBI]," says neurologist David Brody, a member of Timmons's medical team at Washington University in St. Louis, "but we're worse at getting good cognitive recovery."

The best hope for improved healing lies neither in new medications, which have been disappointing so far, nor in exotic fixes involving stem cells and neural regeneration, which are at least a decade away, researchers say. Rather the biggest gains will likely result from advances in emergency room and intensive care practices that curtail the secondary damage from TBI. The methods include slowing the brain's metabolism with cooling techniques, removing part of the skull to relieve intracranial pressure and injecting an experimental polymer "glue" to repair damaged brain cells.

On Ice

After a severe TBI, such as the one Timmons sustained, blood vessels broken in the initial injury can bleed into the brain, raising pressure inside the skull. These vessels also may dilate to feed oxygen-starved brain regions, increasing brain volume further. If the swelling goes unchecked, the brain pushes out in every direction. Not only does this expan-

(The Author)

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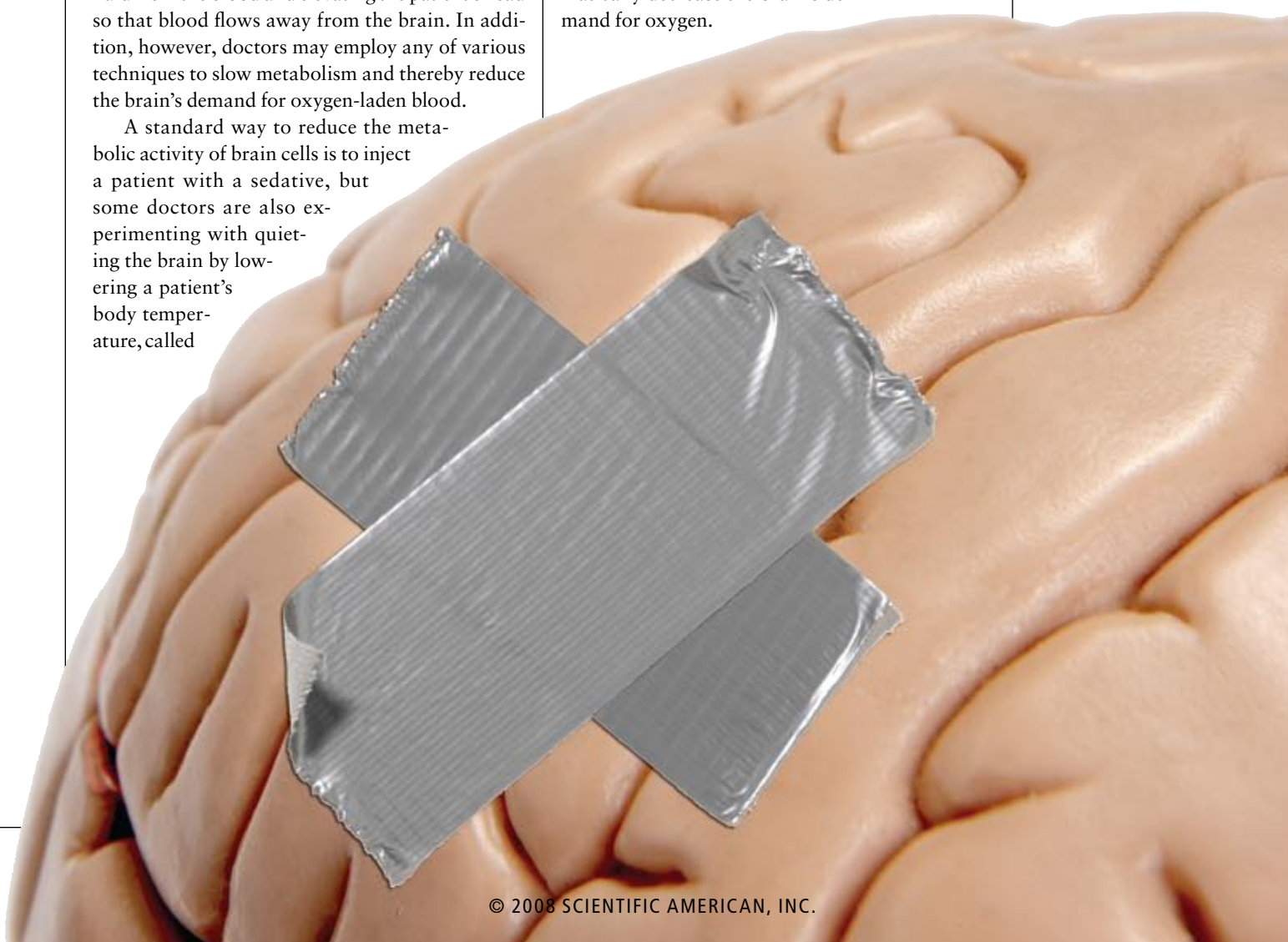
JUPITERIMAGES (*brain*); GETTY IMAGES (*duct tape*)

can stem the damage from traumatic brain injuries

sion complicate oxygen delivery, but it may also push the brain through the only available hole, at the base of the skull, crushing the brain stem and killing the patient.

Initial treatment to prevent or relieve such swelling includes an agent such as a diuretic that extracts fluid from the blood and elevating the patient's head so that blood flows away from the brain. In addition, however, doctors may employ any of various techniques to slow metabolism and thereby reduce the brain's demand for oxygen-laden blood.

A standard way to reduce the metabolic activity of brain cells is to inject a patient with a sedative, but some doctors are also experimenting with quieting the brain by lowering a patient's body temperature, called hypothermia therapy—say, by injecting chilled saline or covering a patient with a blanket that circulates cool water. Cooling acts as a brake on cellular metabolism. People who have fallen into icy lakes, for instance, often recover from long periods without breathing because the cold temperatures dramatically decrease the brain's demand for oxygen.



Some doctors are experimenting with quieting the damaged brain by lowering the patient's body temperature, slowing cellular metabolism.

A 2007 analysis by the Brain Trauma Foundation published in the *Journal of Neurotrauma* suggested that although hypothermia therapy had little or no effect on survival rates for TBI victims, it did improve mental capacity and responsiveness among survivors. In addition to slowing brain metabolism, hypothermia therapy also appears to suppress inflammation and other chemical reactions that can damage brain cells, according to intensive care specialist David Menon of the University of Cambridge.

When faced with a persistent pressure problem, physicians may resort to surgery. In one relatively simple technique, physicians drill a small hole in the base of the skull to drain excess cerebrospinal fluid. But in the most vexing cases, surgeons may remove a large flap of bone from the top of the skull so that the brain can expand into a larger space, effectively decompressing the brain and preventing it from crushing itself. An international team of doctors led by University of Cambridge neurosurgeon Peter Hutchinson is now comparing the efficacy of bone-flap surgery with that of last-resort nonsurgical remedies (such as drug-induced comas) in a 600-patient trial that the researchers aim to complete in 2012.

Bad Chemistry

In the wake of a TBI, the release of biological poisons also threatens brain function: toxins ooze out of ruptured neurons and wreak havoc on neighboring cells. Some clinics monitor these minute chemical imbalances in the spaces between brain cells. In one such technique, intensive care specialists insert a millimeter-thick tube through the skull. The tube collects trace amounts of chemicals in the brain and delivers them to a nearby microdialysis machine for analysis.

Keeping a close eye on brain chemicals, such as the neurotransmitter glutamate, that exude from dying cells can help doctors fine-tune their treatments. Abnormally high levels of glutamate, for example, usually indicate a rapid rate of cellular damage. Such a sign might prompt physicians to try more aggressively to save cells by cooling the brain to decrease oxygen demand or boosting ventilation rates to improve oxygen delivery. Or if microdialysis indicated that cells near a blood clot were fading quickly, doctors might remove the clot to stem the destruction.

Thus, many specialists believe that tracking a TBI patient's brain chemistry can promote good cognitive recovery. At Addenbrooke's Hospital in Cambridge, England, the introduction of a specialized brain injury intensive care unit in which doctors routinely perform microdialysis raised the fraction of TBI survivors who retained their indepen-

FAST FACTS

Wetware Repair

1» **Doctors can often save the life of a victim of severe traumatic brain injury if they reach the patient soon enough—but are far less able to preserve the person's mental abilities.**

2» **The best hope for improved healing lies neither in new medications, which have been disappointing so far, nor in exotic fixes involving stem cells and neural regeneration, which are at least a decade away.**

3» **The biggest gains in cognitive recovery will likely result from advances in emergency room and intensive care practices such as slowing the brain's metabolism by cooling the body, removing part of the skull to relieve intracranial pressure and injecting an experimental polymer "glue" to repair damaged brain cells.**

LIQUID LIBRARY/JUPITERIMAGES

dence from 40 to 60 percent. But no one really knows if microdialysis accounts for the difference. "There is not yet a consensus on whether [microdialysis] should be used for routine care and, if so, what value it adds," Brody says. (The technique is more typically used in basic science experiments.)

In addition to responding to chemical warnings, ICU doctors ideally would like to prevent the release of toxic compounds from damaged cells in the first place. Biomedical engineer Richard Borgens of Purdue University and his colleagues are developing a technique that would repair cell membranes soon after injury using polymers such as polyethylene glycol. Just as bicycle tube sealant fills holes in bicycle tires, the polymer seals punctured membranes, restoring their ability to contain harmful chemicals.

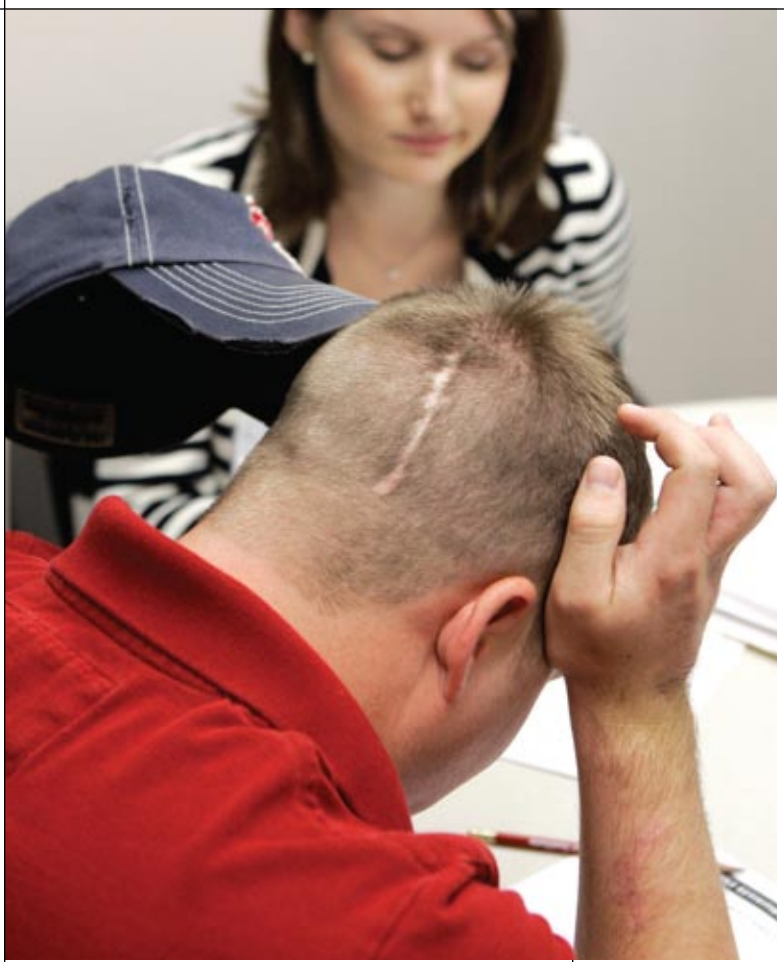
In 2001 Borgens's team confirmed in spinal cord tissue that polyethylene glycol mechanically mends burst cell membranes. More recently, in a study published in the June 2008 *Journal of Biological Engineering*, the researchers tested the technique on brain-injured rats. They injected the animals with polyethylene glycol at various time points after the injury. Rats given the injections within four hours navigated mazes, which test their spatial learning and memory, more proficiently than untreated rats did. No one knows whether polymer therapy would produce similar results in humans, but the scientists hope that ambulance workers might one day inject the polymer at the scene of an accident, jump-starting repair even before a patient reaches the hospital.

New Connections

For now, improving a TBI victim's quality of life often means extensive occupational, speech and physical therapy. These remedies can help form new neuronal links in the brain to circumvent the damaged pathways, rebuilding connections that underpin important skills and thought patterns. "We think there's more than one way to get from A to B" in the brain, Brody says. "You've got [neuronal] wiring that goes from A to C and C to B, and you haven't used it much—but with practice it gets stronger."

For Timmons, such interventions have met with only partial success. The former nurse can now carry on a normal conversation and care for her daughter, but her injury has left her unable to manage the stressful multitasking necessary to return to work. She also continues to struggle to add or subtract numbers, a deficit she called "a major reality check" because she had been good at performing such calculations before the accident. Timmons describes her life as a frustrating blend of independence and disability.

Doctors hope that advances in intensive care for TBI victims will reduce the daily aggravations of patients like Timmons. Studies that point to the best low-tech TBI treatments and that evaluate new techniques to prevent secondary brain damage should help intensive care specialists create a standard of therapy that will improve the lives of thousands of brain injury victims every year. M



MARK HUMPHREY *AP Photo*

A 22-year-old victim of traumatic brain injury, which he sustained in a rocket attack in Baghdad, works with a speech pathologist in Nashville, Tenn. Speech therapy can build new neuronal pathways to circumvent damaged ones.

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Why Do Men Buy Sex?

Some researchers say johns seek intimacy on demand; others believe these men typically want to use and dominate women

By Nikolas Westerhoff

Arthur is an alleged john, a man who patronizes prostitutes. After his arrest on September 5, 2008, a photograph of this 41-year-old appeared on the Web site of the Chicago Police Department. Arthur (not his real name) was far from the only person so branded on this Internet portal. Samuel, 59, and José, 34, (whose names were also changed to protect their privacy) were on this online pillory for a month after their September 5 arrests.

The apprehensions of Arthur, Samuel, José and many others represent the huge demand among males for prostitutes. In the U.S., police officers detained about 78,000 people in 2007 for prostitution-related crimes, according to the Federal Bureau of Investigation. Experts believe that about 10 percent of these arrests are of the sex patrons, almost all of whom are men.

Overall, an estimated 16 percent of men pay for sex in the U.S., according to a 2005 report by social work professor Sven-Axel Månsson

AMY GUIP *jupiterimages (stripper)*; CHRISTINE BALDERAS *iStockphoto (silhouette)*

of Malmö University in Sweden. And a study published in 2000 of 998 street prostitutes and 83 call girls in Los Angeles led by sociologist Janet Lever of California State University, Los Angeles, suggests that 28 percent of men who patronize prostitutes and nearly half of those who employ call girls buy sex regularly, with the rest being occasional customers.

The proportion of patrons seems to vary considerably by country and by study. Månsson reported that 14 percent of Dutch men have bought sex as compared with nearly 40 percent of men in Spain. (Prostitution is legal in both countries.)

And according to HYDRA, a Berlin-based organization that provides legal advice and other aid to prostitutes, up to three quarters of men in Germany, which also has legalized prostitution, have paid for sexual services. Meanwhile other estimates for Germany put the proportion far lower, at about one fifth. In Thailand, where prostitution is illegal but socially accepted, one study suggested that a whopping 95 percent of men have slept with a prostitute.

Whatever the numbers, the behavior is prevalent enough that psychologists cannot easily write it off as pathological. Rather men's motives for buying sex are hotly contested among researchers. Some believe the practice serves as a salve for common psychological afflictions, such as an unfulfilled appetite for sex, love or romance. Others paint a dimmer portrait of johns, believing they are typically driven by chauvinistic motives, such as a desire to dominate and control women. A similar debate rages among experts about the morality of prostitution itself [*see box on page 65*].

Basic Instinct

Of course, the simplest explanation for men buying sex is that they like it. After all, people are generally willing to pay for activities they enjoy as much as they do sex. On the other hand, a man can usually get sex for free in the context of an ordinary intimate relationship. So why pay good money for it, especially given the social and health risks of having sex with a prostitute? Are all johns so unappealing that they cannot get sex any other way?

Most researchers do not think so. Johns come from all socioeconomic classes, according to culture researcher Sabine Grenz of Humboldt University of Berlin. They may be stockbrokers, truck drivers, teachers, priests or law-enforcement officials. Many are married with children. "There are no social characteristics that basically distinguish johns from other men," says Grenz, who published her interviews with a large number of johns in a 2005 book.

Nor are these men defined by obvious personality problems. In a survey published in 1994 psychologist Dieter Kleiber

Some johns hope their money can buy them love—or at least romance. Researchers have identified a type who wants to bond with the prostitute he patronizes.

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of the Free University of Berlin had some 600 johns fill out the Freiburg Personality Inventory and found no particular abnormalities. The only correlations he found applied to risk taking and unprotected sex. For example, the men who demanded sex without condoms tended to score higher on aggression, and married and well-to-do customers practiced unprotected sex more frequently than others did. "The more secure and orderly a man's life is, the more he believes in his own invulnerability," Kleiber concludes.

The research underscores the diversity of the men who pay for sex. Accordingly, these individuals seek prostitutes for varied reasons. Some of them may indeed be driven purely by sexual impulse. In a study of johns sponsored by the Rosa Luxemburg Foundation, sociologist Udo Gerheim of Bremen, Germany, found that many of these men are either sexually frustrated (because they are not getting satisfying sex elsewhere) or hedonists who want to live out their erotic fantasies in a red-light setting.

Representatives of HYDRA similarly say that men go to prostitutes to appease a sexual appetite. Many men feel freer to experiment within the context of commercial sex than with their wives or girlfriends, enabling them to expand their sexual range and to experience greater sexual fulfillment.

Fee for Romance?

Yet some researchers have identified emotional and psychological motivations among the men who purchase sex. Gerheim spotted a type of romantic john who imagines that he is having a genuine relationship with a prostitute based on mutual trust. Kleiber also saw a romantic streak in many of his interviewees. These men, Kleiber explains, seem to be pursuing the ideal of love in a fee-for-service setting.

When Kleiber and his colleagues asked johns to characterize their prostitutes, most rated them as "charming" and "open." Some also said these women were "intelligent" and "witty." Many of the men painted a picture of a perfect

FAST FACTS

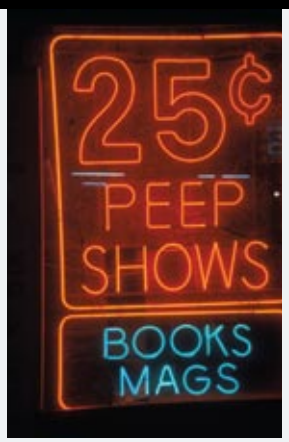
Purchasing Power

1» In the U.S., police officers detained about 78,000 people in 2007 for prostitution-related crimes, according to the Federal Bureau of Investigation. Only about 10 percent of these arrests are of the sex patrons, who almost exclusively are men.

2» A considerable proportion of men worldwide buy sex from female prostitutes, with most estimates of lifetime prevalence ranging from 7 to 39 percent, depending on the country and study. Many experts argue that it is a male appetite—and not the choices of prostitutes—that fundamentally drives the sex trade.

3» Men's motives for buying sex are hotly contested among researchers. Some believe the practice serves as a salve for common psychological afflictions, such as an unfulfilled craving for sex or romance. Others, meanwhile, paint a dimmer portrait of johns, believing they are driven by chauvinistic motives, such as a desire to dominate and control women.

An Oppressive Act or a Harmless Game?



Although prostitution, as a business or behavior, is generally frowned on in the U.S. as immoral in principle, philosophers may assign deeper meaning to the practice of buying and selling sex. These theorists, however, disagree dramatically about what that meaning is. Whereas some believe prostitution is a manifestation of the tendency of men to exploit women, others contend that the behavior more likely reflects the repression of sexual impulses by monogamous societies. Here are arguments from both sides of the street:

Critics of prostitution see it as a patriarchal act in which the goal of the john is to subjugate and exploit women. They view the contractual regulation of sexual acts between men and women as fundamentally illegitimate—and not only in the context of prostitution. When men enter into marriage contracts, they are often using their financial power to gain unlimited access to female bodies. Even if forcing a partner to engage in sex is legally considered rape, as long as women are in an economically inferior position many experts, such as philosopher Christine Overall of Queen's University in Ontario, see an element of force in sex between married partners as well as between a john and a prostitute.

Supporters of prostitution see it as a type of harmless sexual play that enables experimentation by both parties: one person may like oral sex, whereas another prefers bondage or cross-dressing. Prostitution is simply role-playing for a fee. For instance, philosopher Andrea Günter, who wrote a chapter in a 1994 book about prostitution, believes our sexual desires have to be suppressed to meet the requirements of a monogamous society. Human beings buy sex, she says, because of the difficulty of engaging in sexual intercourse outside established couples relationships. Sexual services are aimed primarily at men not because men want to dominate women but because of the oppressive cultural myth of the chaste woman. Some advocates for this view, such as sociologist Sabine Kleinhammes, who authored a 1988 volume on the subject, believe that a utopian society would seek not to eliminate prostitution but rather to offer a comparable service for women. —*N.W.*

TED POLHEMUS *jupiterimages*

woman whom they would like to get to know better. A few even penned statements such as "I can easily imagine the prostitute to whom I go as my wife." "These men have emotionally charged relationships with prostitutes," Kleiber says. They portray these relationships as intimate despite their commercial nature and limited scope, he adds.

The behavior of male customers during their encounters with prostitutes also may suggest that they seek a social connection outside of coitus. From her interviews with Los Angeles prostitutes, Lever learned that purchasers of sex often ask indiscreet questions such as "Where do you come from?" or "Is Lara your real name?" before and after the act.

As if to continue their "relationship," many if not most johns prefer to go back to the same prostitute over and over again. According to Kleiber's study, more than two thirds of devotees used the services of a particular prostitute more than 50 times. One in four had sex with the same prostitute more than 100 times.

But why would a man turn to a prostitute—as opposed to a girlfriend, wife or other consensual female lover—to satisfy his need for a social bond? One reason may be that real relationships with women are risky and complicated, features that men do not always want and cannot always handle. Prostitutes are far less exacting than girlfriends and wives and may even be soothing to the psyche.

That is, an ordinary female date might reject a man or happen to be tired, distant or not in the mood. In contrast, sex workers generally accept their customers unconditionally and offer intimacy on demand, whatever their true feelings, says gender researcher Gunda Schumann, who coauthored a 1980 book on the psychology of prostitution. "They offer the men emotional involvement, psychic stability and empathy," she observes. In this view, ordinary men buy sex to deal with their psychological insecurities as well as their sexual needs.

Prostitutes "offer the men emotional involvement, psychic stability and empathy," one researcher observes.

The idea that sex with a prostitute can be therapeutic dates back thousands of years. In the *Epic of Gilgamesh,* a poem from ancient Mesopotamia, Enkidu—a friend of the king who is half wild—is civilized by having sex with a whore. The tale portrays the prostitute as sacred because she

(The Author)

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Prostitution Laws around the World

The legality of prostitution varies from country to country. Here is a sampling of international policies relating to prostitution.

Illegal
Prostitution and related crimes such as pimping and brothel ownership are banned. Providers of sexual services and their customers can be prosecuted.

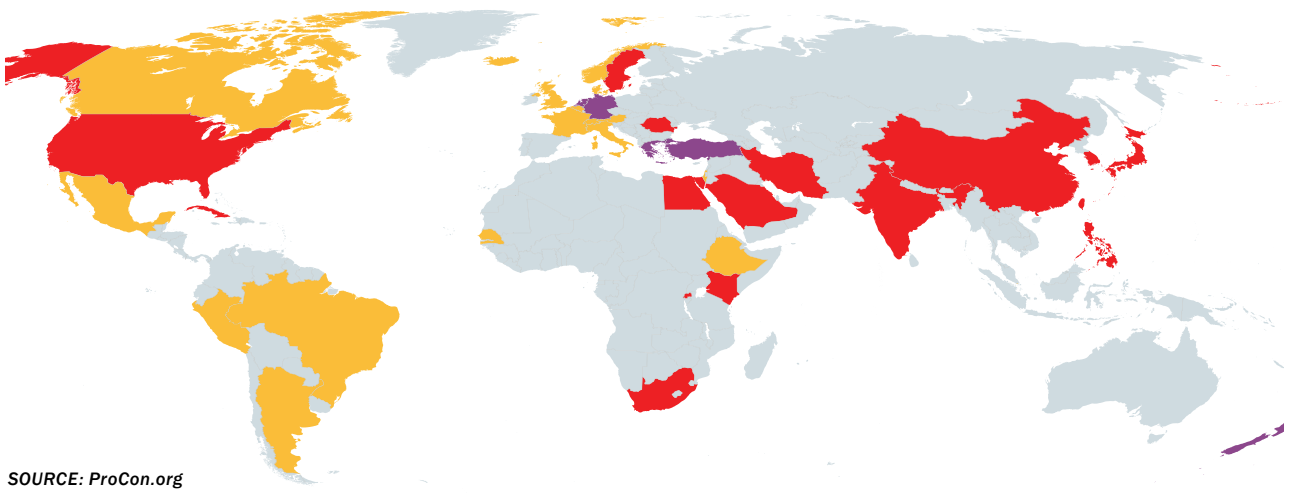
Examples: China, Cuba, Egypt, India, Iran, Japan, Kenya, the Philippines, Romania, Rwanda, Saudi Arabia, South Africa, South Korea, Taiwan, U.S. (with the exception of Nevada), Sweden (where selling sex is not a crime, but buying sex is)

Legal with Restrictions
Prostitution is either legal or not specifically criminal. Brothel ownership and pimping, however, are prosecuted in these countries, some of which also regulate prostitution, requiring, for example, the female professionals to register with the state and undergo regular health examinations.

Examples: Argentina, Austria (also regulated), Belgium, Brazil, Canada, Denmark, England, Ethiopia, France, Iceland, Israel, Italy, Mexico (also regulated), Norway, Peru, Senegal (also regulated), Singapore (also regulated), Switzerland

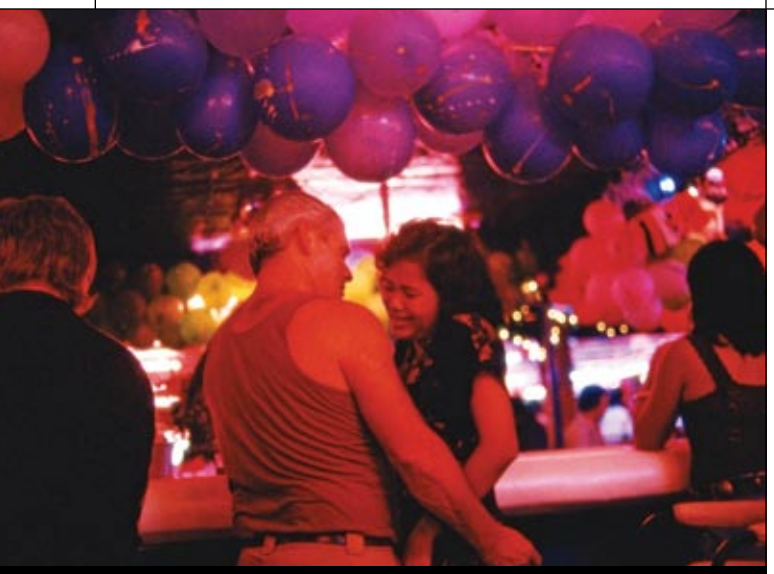
Legal and Regulated
Prostitution and related services are permitted, typically with controls such as a ban on forced prostitution and age limits, registration and regular health examinations for prostitutes.

Examples: Germany, Greece, the Netherlands, New Zealand, Turkey



SOURCE: ProCon.org

HANS-BERNARD HUBER *Getty Images (handcuffs)*; JOHN FOXX *Getty Images (red-light district)*



Some men are hedonists who want to live out their fantasies in a red-light setting. But sociologists warn that many johns are turned on by the idea of dominating or using women.

CHRISTOPHER PILLITZ *Getty Images (bar scene)*

sacrifices herself to the man to cleanse him of destructive inner forces.

"Material" Girls

Other researchers disagree that prostitutes serve as a balm for the woes of essentially normal men. Sociologist Julia O'Connell Davidson of the University of Nottingham in England characterizes johns as necrophiliacs who commit their acts on socially "dead" women. These are men, she says, whose sexual desire is switched on by *not* having to care about the prostitute as a human being—the opposite of the intimacy hypothesis.

"What turns the john on is the woman's powerlessness," O'Connell Davidson concludes. Sex with a prostitute, she says, is more about seeking revenge on women or exerting control over them than about a quest for intimacy and romance.

In a speech he gave to the European Parliament in 2006, Månsson pointed out that johns frequently speak about sex "as a consumer product rather than an expression of intimate relations." One man, he reported, compared sex with a prostitute to "going to McDonald's." Indeed, on the Internet, where a person can remain relatively anonymous, many johns refer to women as "material," Gerheim notes, and may also describe misogynistic submission fantasies.

Some sex purchasers may even have a social agenda to go along with their personal predilections. For many of them, Månsson opines, a prostitute's bed represents the last bastion of antifeminism. Only there can men reestablish the traditional male dominance over women.

Catering to such men, brothels in countries where these institutions are legal hawk women like merchandise on their Web sites. Meanwhile nudist clubs in nations such as Germany attract customers with "all-inclusive" deals: for a fixed price (often less than $100), men can have sex with any of the

Some men view sex as a consumer product. One man compared sex with a prostitute to "going to McDonald's."

women present. Some clubs even offer happy-hour specials.

Månsson believes that johns are usually psychologically disturbed and in need of counseling and treatment. Many Swedish johns similarly view their sexual behavior as "out of control" or "psychologically toxic," a self-characterization certain scientists reject. In the opinion of these dissenters, johns in the U.S. and other countries that ban prostitution are unjustly criminalized and labeled mentally unstable.

However toxic the activity might be to the men, the women often end up more seriously wounded by it. At the very least, prostitutes suffer psychologically from trying to wall off their own emotions so that they can sell intimacy as a commodity. In addition, they often suffer from physical abuse at the hands of johns. The 2006 annual report of KARO, an organization trying to thwart prostitution in the region dividing Germany and the Czech Republic, noted many incidents of brutality related to the selling of sex. Prostitutes in the U.S. are also subject to high levels of violence.

Prostitution is not a profession women pursue because they like the work. As stated on the KARO Web site: "Very few women have ever said that they voluntarily became prostitutes." Poverty, drug addiction or fear of violence from pimps often pushes women into the sex trade.

Thus, many experts argue that the female sex workers are not the real drivers of prostitution. Instead the business survives because of demand from the legions of males who have problems in their relationships with women. This rationale lies behind the law in Sweden that came into force in 1999 under which selling sex is legal but buying sex is not. The same notion also propels a growing crop of workshops and classes in the U.S. aimed at discouraging offending males from repeating an act that many consider a crime against women. M

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Our intuitions about consciousness in other beings

Can a Robot, an Insect or God Be AWARE?

and objects reveal a lot about how we think

By Joshua Knobe

Can a lobster ever truly have any emotions? What about a beetle? Or a sophisticated computer?

The only way to resolve these questions conclusively would be to engage in serious scientific inquiry—but even before studying the literature, many people have pretty clear intuitions about what the answers are going to be. A person might just look at a computer and feel certain that it could not possibly be feeling pleasure, pain or anything at all. That is why we do not mind throwing a broken computer in the trash. Likewise, someone putting a lobster in a pot of boiling water does not worry too much about the crustacean feeling angst about its impending doom. In the jargon of philosophy,

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By analyzing how people think about three abstract

Each week in Mind Matters, www.SciAmMind.com, researchers of mind and brain explain and discuss their disciplines' most notable recent findings. Mind Matters is edited by Jonah Lehrer, the science writer behind the blog The Frontal Cortex and the book *Proust Was a Neuroscientist*.

these intuitions we have about whether a creature or thing is capable of feelings or subjective experiences are called "intuitions about phenomenal consciousness."

The study of intuitions about consciousness has long played a crucial role in the discipline of philosophy, in which facts about intuitions such as these form the basis for some complex and influential arguments [see "The Movie in Your Head," by Christof Koch; SCIENTIFIC AMERICAN MIND, Vol. 16, No. 3, 2005]. But traditionally, the examination of these intuitions has employed a somewhat peculiar method. Philosophers did not actually ask people what intuitions they had. Instead each philosopher would simply think the matter over for himself or herself and then write something like: "In a case such as this, it would surely be intuitive to say …"

The new field of experimental philosophy introduces a novel twist on this traditional approach. Experimental philosophers continue the quest to understand people's ordinary intuitions, but they do so using the methods of contemporary cognitive science—experiments, statistical analyses, cognitive models, and so forth. Just in the past year or so, a number of researchers have been applying this new approach to the study of intuitions about consciousness. By analyzing how people think about three different types of abstract entities—a corporation, a robot and God—we can better understand how people think about the mind.

The Mental Bottom Line on Corporations

In one recent study, philosopher Jesse Prinz of the University of North Carolina at Chapel Hill and I looked at intuitions about the application of psychological concepts to organizations composed of groups of people. Consider Microsoft Corporation, for example. One might say that Microsoft "intends to adopt a new sales strategy" or that it "believes Google is one of its main competitors." In sentences such as these, people seem to be applying certain psychological concepts to a corporation.

Does a company have feelings?

But which psychological concepts are people willing to use in this way? The study revealed an interesting asymmetry. Subjects were content to apply concepts that did not attribute any feeling or experience. For example, they indicated that it would be acceptable to use sentences such as:

- Acme Corporation believes that its profit margin will soon increase.
- Acme Corporation intends to release a new product this January.
- Acme Corporation wants to change its corporate image.

But they balked at all the sentences that attributed feelings or subjective experiences to corporations:

- Acme Corporation is now experiencing great joy.
- Acme Corporation is getting depressed.
- Acme Corporation is experiencing a sudden urge to pursue Internet advertising.

These results seem to indicate that people are willing to apply some psychological concepts to corporations but that they are not willing to suppose that corporations might be capable of phenomenal consciousness.

Bots and Bodies

Perhaps the issue here is that people attribute phenomenal consciousness only to creatures that have the right type of body. To test this hypothesis, we can look to other kinds of entities that might

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FAST FACTS

Intuitions about Experience

1» We do not hesitate to toss a broken computer in the trash, because we assume it has no feelings or awareness. Such intuitions can be revealing to scientists.

2» The new field of experimental philosophy employs the methods of contemporary cognitive science to probe people's notions about consciousness.

3» Studies are finding a pattern of responses that might lead to a unified theory about this aspect of thought.

have mental states but do not have bodies that look anything like the bodies that human beings have.

One promising approach in this case would be to look at people's intuitions about the mental states of robots. Robots look very different from humans from a physical perspective, but we can easily imagine a robot that acts very much like a human does. Studies could then determine what kinds of mental states people are willing to attribute to a robot under these conditions. This approach was taken up in work by experimental philosophers Justin Sytsma and Edouard Machery of the University of Pittsburgh and in separate work by Larry (Bryce) Huebner of Tufts University. All the experiments arrived at the same basic answer.

In one of Huebner's studies, for example, subjects were told about a robot that acted exactly like a human and asked what mental states that robot might be capable of having. Strikingly, the study revealed the same asymmetry observed in the case of corporations. Subjects were willing to say, for instance:

A robot can look like us, but it's not close enough.

- It believes that triangles have three sides.

But they were not willing to say:

- It feels happy when it gets what it wants.

Here again we see a willingness to ascribe certain kinds of mental states but not those that require phenomenal consciousness. Interestingly enough, this tendency does not seem to result entirely from the fact that the robot has a central processing unit in place of an ordinary human brain. Even when the researchers controlled for whether the creature had a CPU or a brain, subjects were more likely to ascribe phenomenal consciousness when it had a body that made it look like a human being.

God in the Machine

What if an entity has no body at all? How does that change our intuitions about whether it is capable of conscious experience? To address this question, we can turn to intuitions about the ultimate disembodied being: God. A study published in 2007 by Harvard University psychologists Heather M. Gray, Kurt Gray and Daniel M. Wegner looked at people's intuitions about which kinds of mental states God could have. By now you have probably guessed the result. People were content to say that God could have psychological properties such as:

- Thought.
- Memory.
- Planning.

But they did not think God could have states that involved feelings or experiences, such as:

- Pleasure.
- Pain.
- Fear.

God has no body: Now how do our intuitions change?

In subsequent work, the researchers directly compared attributions of mental states to God with attributions of mental states to Google Corporation. These two entities—different though they are in so many respects—elicited exactly the same pattern of responses.

If we look at the results from these various studies, it is hard to avoid having the sense that scientists should be able to construct a single unified theory that explains the whole pattern of people's intuitions. Such a theory would describe the underlying cognitive processes that lead people to think that certain entities are capable of a wide range of psychological states but are not capable of truly feeling or experiencing anything. Unfortunately, no one has proposed such a theory thus far. Further theoretical work is badly needed. M

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One World,

We are used to thinking of humans as occupying the sole pinnacle of evolutionary intelligence. That's where we're wrong

By Paul Patton

We were talking about politics. My housemate, an English professor, opined that certain politicians were thinking with their reptilian brains when they threatened military action against Iran. Many people believe that a component of the human brain inherited from reptilian ancestors is responsible for our species' aggression, ritual behaviors and territoriality.

One of the most common misconceptions about brain evolution is that it represents a linear process culminating in the amazing cognitive powers of humans, with the brains of other modern species representing previous stages. Such ideas have even influenced the thinking of neuroscientists and psychologists who compare the brains of different species used in biomedical research.

Many Minds

Over the past 30 years, however, research in comparative neuroanatomy clearly has shown that complex brains—and sophisticated cognition—have evolved from simpler brains multiple times independently in separate lineages, or evolutionarily related groups: in mollusks such as octopuses, squid and cuttlefish; in bony fishes such as goldfish and, separately again, in cartilaginous fishes such as sharks and manta rays; and in reptiles and birds. Nonmammals have demonstrated advanced abilities such as learning by copying the behavior of others, finding their way in complicated spatial environments, manufacturing and using tools, and even conducting mental time travel (remembering specific past episodes or anticipating unique future events). Collectively, these findings are helping scientists to understand how intelligence can arise—and to appreciate the many forms it can take.

The Tree of Life

To understand why a new view of the evolution of brains and minds is only now coming to full fruition, it is useful to review historical notions. Medieval naturalists placed living things along a linear scale called the great chain of beings, or *scala naturae*. This hierarchical sequence ranked creatures such as worms and slugs as lowly and humans as the highest of earthly beings. In the late 1800s the enormous mass of evidence contained in Charles Darwin's masterwork, *On the Origin of Species*, convinced most of his scientific contemporaries that evolution was a reality. Darwin explained that modern species were related by physical descent and saw the relations among species as resembling the diverging branches of a family genealogical tree. Few, however, fully grasped the revolutionary im-

It is now apparent that a simple linear hierarchy cannot adequately account for the evolution of brains or intelligence.

plications of this tree of life—in which modern species represent the tips of the branches and inner branches represent past species, forming junctions where two lineages branch from a common ancestor.

So when comparative neuroanatomy first blossomed at the end of the 19th century, most researchers interpreted its findings in terms of the old linear scale. They believed modern invertebrates (animals without backbones), fish, amphibians, reptiles, birds, mammals and humans to be living representatives of successive evolutionary steps toward a more complex brain, with new brain components added at each step. Given the relative lack of interest in comparative neuroanatomy during the mid-20th century, these ideas persisted unchallenged for decades. The traditional ideas about sequential brain evolution appeared, for example, in the late neuroscientist and psychiatrist Paul D. MacLean's triune brain model, formulated in the 1960s. MacLean's model promoted the belief that the human brain contains a "reptilian complex" inherited from reptilian ancestors.

Beginning in the 1980s, the field of comparative neuroanatomy experienced a renaissance. In the intervening decades evolutionary biologists had learned a great deal about vertebrate evolutionary history, and they developed new and effective methods of applying Darwin's concept of the tree of life to analyze and interpret their findings. It is now apparent that a simple linear hierarchy cannot adequately account for the evolution of brains or of intelligence. The oldest known multicellular animal fossils are about 700 million years old. By the Cambrian period, about 520 million years ago, the animal kingdom had branched into about 35 major groups, or phyla, each with its own distinctive body plan. As a separate branch of the tree of life, each lineage continued to evolve and diversify independently of the others. Complex brains evolved independently in multiple phyla, notably among the cephalopod mollusks of the phylum Mollusca and, of course, among various groups of vertebrates. Vertebrate evolution has likewise involved repeated branching, with complex brains evolving from simpler brains independently along numerous branches.

Alien Minds

Cephalopod mollusks, a group that includes octopuses, squid and cuttlefish, have evolved the most sophisticated nervous system of all invertebrates—and their cognitive abilities reflect that complexity. The brain of an octopus contains an estimated 170 million neurons, a number comparable to that of the brains of some vertebrates. In relation to body size, this brain is as large as that of some birds. Having evolved independently in another phylum, the structure of the octopus's brain looks utterly alien as compared with the more familiar brains of vertebrates. The exquisitely sensitive and flexible tentacles of the octopus contain as many neurons as its brain does, and severed tentacles remain capable of coordinated movements.

Behavioral studies show that octopuses can distinguish and classify objects based on size and shape, much as rats do. They can learn to navigate simple mazes and to solve problems, such as removing a tasty food item from a sealed container. In 1992 two Italian neuroscientists, Graziano Fiorito of the Dohrn Zoological Station in Naples and Pietro Scotto, then at the University of Reggio Calabria in Catanzaro, published surprising evidence that an octopus can learn to accomplish a task by watching another octopus perform it. They trained octopuses to choose between a red ball and a white ball. If the octopus opted for the correct ball, it got a piece of fish as reward. If it selected incorrectly, it received a mild electric shock as punishment.

FAST FACTS

Brains of the Species

1» **Despite cartoons you may have seen showing a straight line of fish emerging on land to become primates and then humans, evolution is not so linear. The brains of other animals are not merely previous stages that led directly to human intelligence.**

2» **Instead—as is the case with many traits—complex brains and sophisticated cognition have arisen multiple times in independent lineages of animals during the earth's evolutionary history.**

3» **With this new understanding comes a new appreciation for intelligence in its many forms. So-called lower animals, such as fish, reptiles and birds, display a startling array of cognitive capabilities. Goldfish, for instance, have shown they can negotiate watery mazes similar to the way rats do in intelligence tests in the lab.**

PRECEDING PAGES: EVA SERRABASSA (*Stockphoto (background)*; JUPITERIMAGES (*goldfish and octopus*); CATHERINE LEDNER (*parrot*); KARL SHONE (*Thai water dragon*) AND STEVE MASLOWSKI (*scrub jay*) Getty Images

Goldfish have demonstrated the ability to navigate a watery maze—a cognitive skill once thought limited to mammals.

Once the training was completed, the investigators let an untrained octopus watch a trained animal perform the task from behind a glass barrier. The untrained animals did monitor the trained animals, as indicated by movements of their head and eyes. When allowed to select between the two balls themselves, the observer octopuses then made correct choices, which they could only have learned by watching. The ability to learn by studying others has been regarded as closely related to conceptual thought.

Undersea Smarts

Unlike the octopus, bony fishes and their cartilaginous cousins are fellow vertebrates and seafaring members of our own phylum, Chordata. Research in the past few years has shown that these animals display some cognitive abilities once thought unique to mammals. In a series of studies starting in 1994, a team of investigators at the University of Seville in Spain tested the spatial smarts of goldfish, a familiar bony fish. The goldfish swam through watery versions of mazes such as those traditionally used to test similar cognitive skills in rats. They showed many of the same basic spatial abilities that rodents do, including the ability to use distant visual cues to find a particular place, even when the surrounding maze has been reoriented.

The forebrains of fishes endow them with these abilities. The forebrains of most vertebrates also directly receive and process smell information. Early comparative neuroanatomists, guided by their belief in a linear evolutionary scale, thought the forebrains of "primitive" fishes and amphibians were olfactory centers that did little else. We now know that, as in mammals, the forebrains of fishes and amphibians receive the full panoply of sensory information. The main modern group of bony fishes, the teleosts, first appeared about 200 million years ago, well after vertebrates ancestral to humans had emerged onto land, further proof of the independent development of their intelligence. In body-relative terms, the brains of these fishes are often comparable in size to those of land-dwelling reptiles. In the old phylogenetic scale, fish were considered "lower" than reptiles.

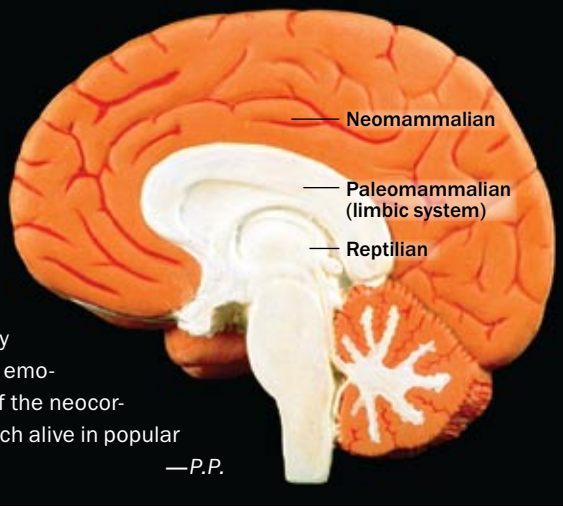
Cartilaginous fishes constitute a separate lineage from bony fishes, and their defining trait is a skeleton consisting of cartilage. Modern examples of this group

PETER CADE Getty Images (*goldfish in head*); PASCAL GOETGHELUCK SPL/Photo Researchers, Inc. (*triune brain model*)

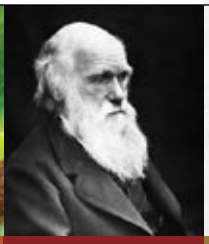
Evolutionary Missteps

Paul D. MacLean's widely popularized triune model of the vertebrate brain from the 1960s held that human brains were the culmination of linear evolution progressing from simpler animals. Drawing on the work of pioneering comparative neuroanatomist Ludwig Edinger, MacLean proffered four sequential steps: a "neural chassis" corresponding to the brains of fish and amphibians; a reptilian complex, consisting of the basal ganglia, which were held to dominate the brains of reptiles and birds; a paleomammalian component, consisting of the brain's limbic system, which supposedly emerged with the origin of mammals and which was responsible for emotional behavior; and finally a neomammalian component, consisting of the neocortex, the site of higher cognitive functions. These ideas are still very much alive in popular culture and even within psychology.

—*P.P.*



Minds through Time


Middle Ages

Medieval naturalists rank living things along a linear scale called the great chain of beings, or *scala naturae*. Creatures such as worms and **slugs** are considered lowly and humans the highest of earthly beings.

1860s

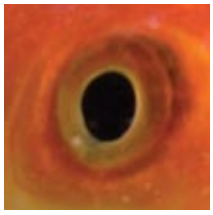
In *On the Origin of Species* (1859), **Charles Darwin** views species as related to one another by physical descent. His tree of life places modern species at the tips of the branches; inner branches represent past species, forming junctions where two lineages branch from a common ancestor.

1870s to 1930s

Improvements to the microscope and techniques for staining to render neurons visible under the microscope make comparative neuroanatomy feasible, but most biologists retain aspects of the hierarchical *scala naturae* in their thinking.

1940s to 1950s

Konrad Lorenz, Nikolaas Tinbergen and Karl von Frisch found the field of ethology, the scientific study of innate animal behaviors. Tinbergen and Lorenz study egg-rolling behavior in the **greylag goose** and conclude nonmammals are instinct-driven automatons. In contrast, von Frisch discovers that **worker bees** communicate the location of nectar sources to their nest mates via a "dance language"—the



In 300 million years of separate evolution, two groups evolved sophisticated abilities based on different forebrain plans.

include sharks, skates and rays. Though once regarded as primitive, some members of this lineage have evolved the largest brains in relation to their bodies of any nonmammalian aquatic vertebrate. In 2005 neuroethologists Vera Schluessel and Horst Bleckmann, both at the University of Bonn in Germany, repeated some of the Spanish group's spatial tests on the freshwater stingray. It exhibited place-finding abilities akin to those found in goldfish.

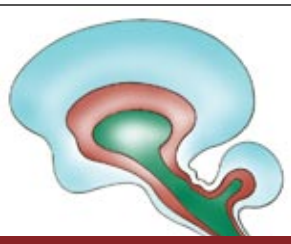
By performing tests on goldfish after parts of their forebrain had been destroyed, the Spanish team showed in a study published in 2006 that the spatial abilities of goldfish derive from a part of the roof, or pallium, of the forebrain that may correspond to the hippocampus in mammals. Together these new studies indicate that the common ancestor of cartilaginous fishes, bony fishes and land vertebrates may already have possessed a hippocampuslike structure and the spatial cognitive abilities it confers. The hippocampus, which is also involved in processing emotions, is the main pallial component of the limbic system; in MacLean's triune brain scheme, it was supposed to have originated with mammals. A variety of other limbic system structures are now known to exist in nonmammals.

Birds and Reptiles

When a lineage of bony fishes left the seas for land about 365 million years ago, it eventually gave rise to all the four-limbed land vertebrates alive today—and two major types of brain organizational plans. These vertebrates branched into two main groups. The first group, the synapsids, appeared 320 million years ago and eventually evolved into modern mammals, whereas the second, the sauropsids, appeared 10 million years later and evolved into modern birds and reptiles (as well as the extinct dinosaurs). In their 300 million years of separate brain evolution, some members of each of the two groups have evolved quite sophisticated cognitive abilities based on very different forebrain organizational plans.

This difference in forebrain organization initially caused confusion among comparative neuroanatomists. When seen in cross section, each hemisphere of the vertebrate forebrain consists of a mass of neural tissue surrounding a central fluid-filled cavity called the ventricle. The forebrains of reptiles and birds include a prominent mass of neural tissue that bulges into this ventricle, in some cases largely obliterating it. Early comparative neuroanatomists mistook this bulge for a part of the basal ganglia, a structure in the floor of the forebrain. They concluded that the forebrains of reptiles and birds were dominated by the basal ganglia and possessed only a rudimentary pallium. The pallium is the structure that has elaborated into the cerebral cortex in mammals. Pioneering behavioral studies reinforced the interpretation suggested by the apparent-

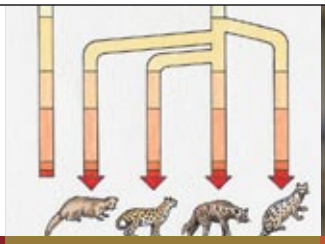
OTTMAR DIEZ *Getty Images (slug)*; CORBIS *(Darwin)*; BETTMANN/CORBIS *(microscope)*; RICHARD CUMMINS *Corbis (goose)*; SCOTT CAMAZINE *Photo Researchers, Inc. (bees)*



1960s to 1970s

first hint of higher cognition outside mammals.

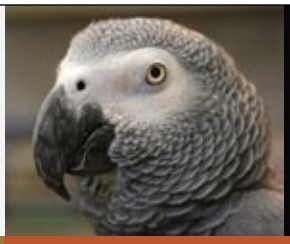
Paul D. MacLean's **triune brain model**, which specifies "primitive" complexes in the human brain inherited from animal ancestors, still reflects traditional ideas about sequential evolution nearly 100 years after Darwin [see *box on page 75*]. Though

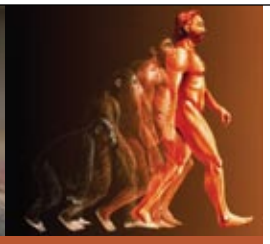


1980s

never widely accepted among neuroscientists, MacLean's ideas were popularized by Carl Sagan's 1977 Pulitzer Prize–winning best seller, *The Dragons of Eden.*

R. Glenn Northcutt, then at the University of Michigan at Ann Arbor, and others introduce **modern cladistic analysis** into comparative neuroanatomy. Cladistic analysis determines evolutionary relations by comparing structures across related species using objective quantitative principles grounded in Darwin's concept of the tree of life. It soon becomes apparent that complex brains have evolved from simple brains, not once but many





1990s to present

times independently, along different evolutionary lineages.

Cognitive ethologists show that **sophisticated cognition** has arisen independently in multiple groups of animals, representing different instances of the evolution of complex brains and different branches of the tree of life.

ly rudimentary pallium. "The bird, its brain dominated by its basal nuclei, is essentially a highly complex mechanism with little learning capacity," concluded comparative anatomist Alfred Romer in 1955. As it turns out, these seemingly consistent neuroanatomical and behavioral findings were both mistaken.

A series of comparative neuroanatomical studies in the 1960s, beginning with the work of Harvey J. Karten, now at the University of California, San Diego, has conclusively shown that the bulging mass of neural tissue in sauropsid forebrains, now known as the dorsal ventricular ridge (DVR), is not a part of the basal ganglia. It is instead a part of the pallium and appears to be the sauropsid counterpart of the mammalian neocortex. In mammals the neocortex is the largest part of the pallium and is involved in sophisticated cognitive abilities such as executive planning, learning and memory, reasoning, fine-motor control and perception; in humans it accounts for language. The basal ganglia in fact make up no larger part of the forebrain in sauropsids than they do in mammals. Mammals have nothing like the DVR. Neuroanatomical terminology for birds was revised to reflect this new awareness only in 2002.

The neocortex of mammals and the DVR of reptiles and birds are dramatically different in structure. The former is an extended thin sheet of tissue, with nerve cells organized into layers and with different territories of the sheet essentially performing different functions. The latter is a bulk mass of neural tissue structured into a series of clusters of nerve cells, or nuclei, with nuclei specialized for various functions. Despite these structural differences, the neocortex and DVR share similar connections to other parts of the brain as well as apparently similar cognitive functions. For example, there is now evidence that a part of the DVR in birds, called the nidopallium caudolaterale, may be involved in planning and executive control of behavior, much like the frontal lobes of the neocortex in mammals. In its internal structure and connections with other brain parts, the DVR in reptiles is generally simpler than that in birds. Despite their common forebrain plan, birds typically have much larger forebrains in relation to their bodies than reptiles do.

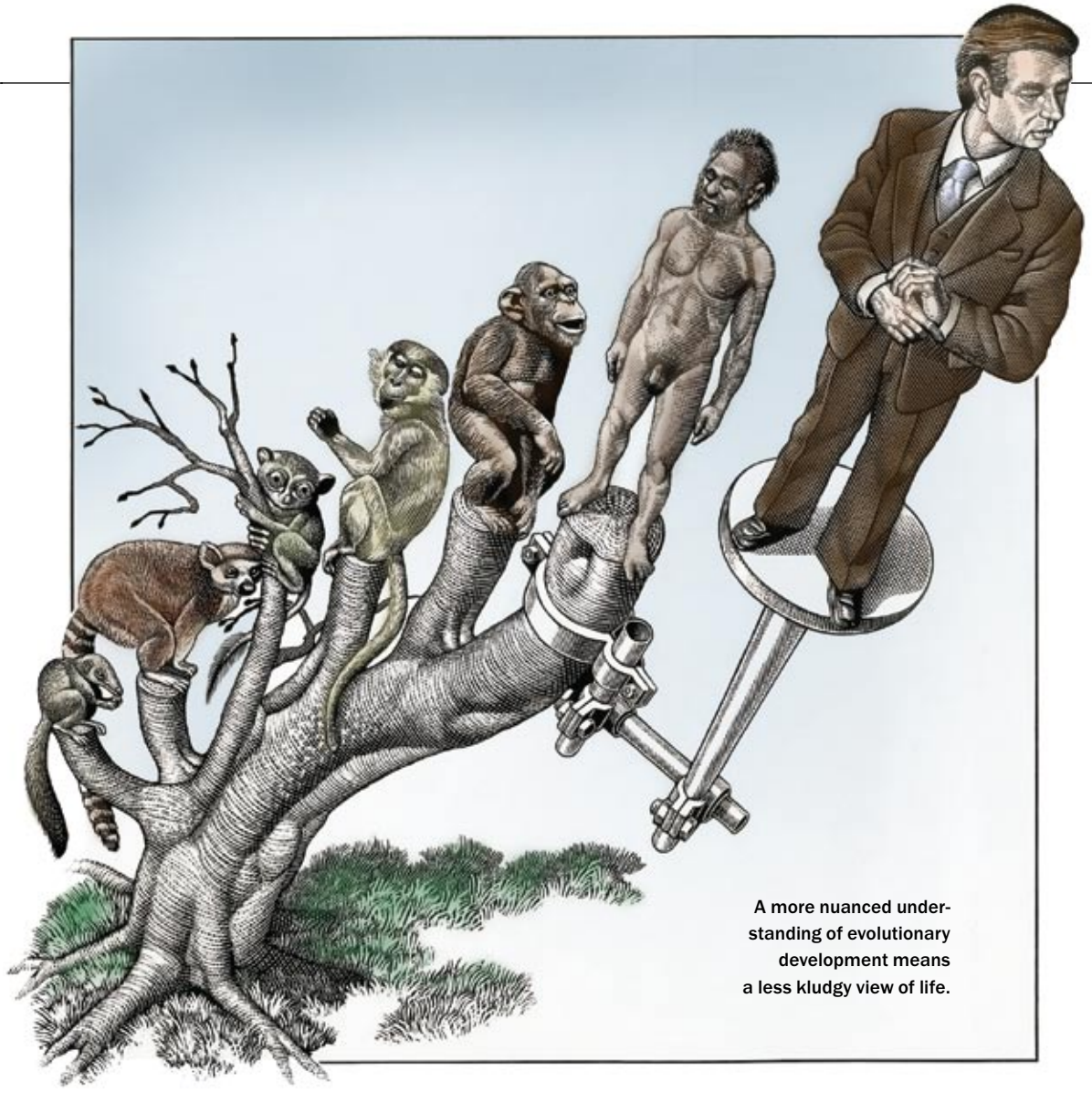
Far from being "birdbrains," our feathered friends have displayed clever behaviors. Among birds, the largest forebrains are those of parrots and corvids (a group that includes crows, jays, ravens and jackdaws). Relative to body size, the brain of a parrot is as large as that of a chimpanzee, although, in absolute terms, it is about the size of a walnut. In recent years researchers have documented stunning cognitive abilities in these two groups of birds.

In the wild, for example, New Caledonian crows manufacture two types of simple tools to gain access to otherwise unobtainable foods. They trim and sculpt twigs to fashion hook tools to poke out insect larvae from holes in trees. And they make probes for finding insects under leaf detritus by stripping off pieces of the barbed pandanus leaves to sharpen them to a point. Psychologists Gavin Hunt and Russell Gray, both at

(The Author)

PAUL PATTON, a computational and behavioral neuroscientist, is research associate at Bowling Green State University. His work focuses on spatial behaviors and sensory systems in the Mexican blind cavefish.

SCIENTIFIC AMERICAN MIND (*triune brain model*): DORLING KINDERSLEY (*cladistic analysis*); RICK FRIEDMAN *Corbis* (*Alex the parrot*); DAVID GIFFORD *SPL/Photo Researchers, Inc.* (*evolution illustration*)



A more nuanced understanding of evolutionary development means a less kludgy view of life.

BILL SANDERSON SPL/Photo Researchers, Inc.

the University of Auckland in New Zealand, reported in 2003 that New Caledonian crows' tools have some features that appear more sophisticated than those of chimpanzees. The crows can craft a diverse variety of tools, modified by innovation from a common design. They can add cumulative improvements to their tools and can teach other members of their group to copy good designs faithfully.

Nicola S. Clayton, now at the University of Cambridge, has demonstrated, in a series of papers beginning in 1998, striking cognitive abilities in the Florida scrub jay, another type of corvid. These birds stash food in hundreds of different hidden caches dispersed over a wide area. They can remember the locations of all their hoards and retrieve food from them at a later time. Nonperishable foods, such as seeds, may remain in storage for months on end. Perishable foods, such as grubs and worms, must be retrieved just hours or days later.

Clayton and her students were able to use this naturally occurring behavior to show that Florida scrub jays can recall specific episodes in their past. The birds were provided with perishable worms and nonperishable nuts, which they cached in the individual compartments of sand-filled ice cube trays. They cached in different trays on different days and were then denied access to the trays for a specified period. If the birds could not access the trays for a short time, they should have tried to retrieve the worms, which are their preferred food, from the appropriate compartments of the appropriate trays. On the other hand, if the birds were denied access to the trays for a longer time, the worms no longer would have been fresh, and the jays should have tried to retrieve the nuts. To solve this problem, the birds needed to recall what they cached, where they cached it and when they did so. The birds successfully performed this complex task. Such an ability has yet to be demonstrated in a nonhuman mammal.

Even more amazingly, Clayton showed that the birds can anticipate unique future events. She allowed jays to observe others of their kind cache food and then permit-

ted them to pilfer the caches. Later these birds cached their own food, either alone or in the presence of another jay. Birds that had acted as thieves took great precautions to conceal their food-caching activities when in the presence of another jay. Although the jays had experienced food theft only in the role of thief, they nonetheless were able to imagine themselves in the role of victim. The ability to recall specific episodes in the past and to predict future occurrences is known as mental time travel [see "Intelligence Evolved," by Ursula Dicke and Gerhard Roth; Scientific American Mind, August/September 2008]. Before Clayton's work, this cognitive ability was thought to be unique to humans.

Perhaps most stunning, an African gray parrot named Alex became famous for his ability to name 50 different objects. Alex learned the labels for seven colors and five shapes. In 1996 psychologist Irene M. Pepperberg, then at the University of Arizona, reported that Alex could classify objects by color and shape. Alex could ask for objects by name using phrases such as "want banana." Alex even learned number labels from one to six and seemed to grasp the concept of zero, as evidenced by an appropriate use of "none." A host of control experiments showed that Alex's feats were genuinely cognitive and not the result of simple conditioned learning. Similar cognitive abilities had never been demonstrated outside humans and their closest primate relatives [see "Bird Brains? Hardly," by Christine Scholtyssek; Scientific American Mind, April/May 2006].

Although scientists have yet to discover birdlike cognitive abilities in reptiles, the view of them as instinct-driven automatons appears likewise to have been misconceived. Reptiles are the victims of biased intelligence tests. Mammals, with their high and constant body temperatures, must incessantly seek food to fuel their energy-costly metabolism. They can thus easily be induced to perform all manner of learning tasks for a food reward. Reptiles lack a comparably powerful demand for food and often perform poorly when it is offered as a reward. They are now known to exhibit a variety of forms of simple learning when provided with species-appropriate rewards, such as the warmth of a sun lamp. Experiments with spatial mazes, for example, have demonstrated that turtles possess spatial skills similar to those described for fishes earlier, including the ability to find a particular place based on distant visual cues, despite rotational displacement of a maze.

Scientists still do not have answers for a great many questions about animal intelligence and its evolution. A major problem involves the identification of species-appropriate tests of cognition. Clayton's demonstration of mental time travel in Florida scrub jays exploited a naturally occurring behavior of that species. We will not know whether this knack is an unusual quirk of scrub jays and other food-caching birds or a widespread capacity until behaviorally appropriate tasks are identified for other species. The cognitive facilities demonstrated for birds, mammals and cephalopod mollusks depend on very different nervous systems. What allows them all to serve similar cognitive functions? Our understanding of intelligence and the brain in nonmammals is still in its infancy.

Although the jays had experienced food theft only in the role of thief, they were able to imagine themselves in the role of victim.

In recent decades scientists have cast aside a linear, sequential view of brain evolution in which the human brain incorporates components resembling the brains of modern fishes, amphibians, reptiles and birds and have adopted a new view of divergently branching brain and mind evolution. Substantial cognitive abilities have evolved multiple times, based on differing neural substrates—including the mental agility that enables us humans to decipher brain evolution and its meaning. M

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Altered States

Is hypnosis a distinct form of consciousness?

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

THE HYPNOTIST, dangling a swinging pocket watch before the subject's eyes, slowly intones: "You're getting sleepy … You're getting sleepy …" The subject's head abruptly slumps downward. He is in a deep, sleeplike trance, oblivious to everything but the hypnotist's soft voice. Powerless to resist the hypnotist's influence, the subject obeys every command, including an instruction to act out an upsetting childhood scene. On "awakening" from the trance half an hour later, he has no memory of what happened.

In fact, this familiar description, captured in countless movies, embodies a host of misconceptions. Few if any modern hypnotists use the celebrated swinging watch introduced by Scottish eye surgeon James Braid in the mid-19th century. Although most hypnotists attempt to calm subjects during the "induction," such relaxation is not necessary; people have even been hypnotized while pedaling vigorously on a stationary bicycle. Electroencephalographic (EEG) studies confirm that during hypnosis subjects are not in a sleeplike state but are awake—though sometimes a bit drowsy. Moreover, they can freely resist the hypnotist's suggestions and are far from mindless automatons. Finally, research by psychologist Nicholas Spanos of Carleton University in Ontario shows that a failure to remember what transpired during the hypnosis session, or so-called posthypnotic amnesia, is not an intrinsic element of hypnosis and typically occurs only when subjects are told to expect it to occur.

The Consciousness Question

The iconic scene we described at the article's outset also raises a deeper question: Is hypnosis a distinct state of consciousness? Most people seem to think so; in a recent unpublished survey, psychologist Joseph Green of Ohio State University at Lima and his colleagues found that 77 percent of college students agreed that hypnosis is a distinctly altered state of consciousness. This issue is of more than academic importance. If hypnosis differs in kind rather than in degree from ordinary consciousness, it could imply that hypnotized people can take actions that are impossible to perform in the waking state. It could also lend credibility to claims that hypnosis is a unique means of reducing pain or of effecting dramatic psychological and medical cures.

Despite the ubiquitous Hollywood depiction of hypnosis as a trance, investigators have had an extremely difficult time pinpointing any specific "markers"—indicators—of hypnosis that distinguish it from other states. The legendary American psychiatrist Milton Erickson claimed that hypnosis is marked by several unique features, including posthypnotic amnesia and "literalism"—a tendency to take questions literally, such as responding "Yes" to the question "Can you tell me what time it is?" We have already seen that posthypnotic amnesia is not an inherent accompaniment of hypnosis, so Erickson was wrong on that score. Moreover, research by Green, Binghamton University psychologist Steven Jay Lynn and their colleagues shows that most highly hypnotizable subjects do not display literalism while hypnotized; moreover, participants asked to simulate hypnosis demonstrate even higher rates of literalism than highly hypnotizable subjects do.

Other experts, such as the late University of Pennsylvania psychiatrist Martin Orne, have argued that only hypnotized participants experience "trance logic"—the ability to entertain two mutually inconsistent ideas at the same time. For example, a hypnotist might suggest to a subject that he is deaf and then ask him, "Can you hear me now?" He may respond

COURTESY OF SCOTT O. LILIENFELD (*left*); COURTESY OF HAL ARKOWITZ (*right*); BRUCE T. BROWN *Getty Images* (*man and watch*)

"No," thereby manifesting trance logic. Nevertheless, research by the late Theodore X. Barber, then at the Medfield Foundation, and his colleagues showed that participants asked to simulate hypnosis displayed trance logic just as often as hypnotized people did, suggesting that trance logic is largely a function of people's expectations rather than an intrinsic component of the hypnotic state itself.

Brain Changes

Still other investigators have sought to uncover distinct physiological markers of hypnosis. Under hypnosis, EEGs, especially those of highly suggestible participants, sometimes display a shift toward heightened activity in the theta band (four to seven cycles per second). In addition, hypnotized participants frequently exhibit increased activity in their brain's anterior cingulate cortex (ACC).

Yet neither finding is surprising. Theta activity is typically associated with states of quiet concentration, which frequently accompany hypnosis. The ACC is linked to the perception of contradictions, which many hypnotized participants experience as they imagine things—such as childhood experiences in the present—that seem to conflict with reality. Further, psychologists have reported similar brain changes among awake subjects. For example, the ACC becomes activated during the famous Stroop task, which requires subjects to name the colors of ink (such as "green") in which competing color words (such as "blue") are printed. Thus, these brain changes are not unique to hypnosis.

Fueling the perception of hypnosis as a distinct trancelike state is the widespread assumption that it leads to marked increases in suggestibility, even complete compliance to the therapist's suggestions. Nowhere is this zombielike stereotype portrayed more vividly than in stage hypnosis shows, in which people are seemingly induced to bark like dogs, sing karaoke and engage in other comical behaviors in full view of hundreds of amused audience members.

Yet research shows that hypnosis exerts only a minor impact on suggestibility. On standardized scales of hypnotic suggestibility, which ask participants to comply with a dozen suggestions (that one's arm is raising on its own power, for example), the increase in suggestibility following a hypnotic induction is typically on the order of 10 percent or less. Moreover, research demonstrates that a formal hypnotic induction is not needed to produce many of the seemingly spectacular effects of hypnosis, such as reduction of extreme pain or various physical feats, popular in stage hypnosis acts, such as suspending a participant horizontally between the backs of two chairs. One can generate most, if not all, of these effects merely by providing highly suggestible people with sufficient incentives to perform them. Stage hypnotists are well aware of this little secret. Before beginning their shtick, they prescreen audience members for high suggestibility by providing those people with a string of suggestions. They then handpick their participants from among the minority who comply.

We agree with Lynn and psychologist Irving Kirsch of the University of Hull in England, who wrote in 1995 that "having failed to find reliable markers of trance after 50 years of careful research, most researchers have concluded that this hypothesis [that hypnosis is a unique state of consciousness] has outlived its usefulness." Increasingly, evidence is suggesting that the effects of hypnosis result largely from people's expectations about what hypnosis entails rather than from the hypnotic state itself. Still, it is always possible that future studies could overturn or at least qualify this conclusion. In particular, research on potential physiological markers of hypnosis may elucidate how hypnosis differs from other states of consciousness. Although hypnosis poses fascinating mysteries that will keep scientists busy for decades, it seems clear that it has far more in common with everyday wakefulness than with the watch-induced trance of Hollywood crime thrillers. M

> In hypnosis shows, people are **seemingly induced** to bark like dogs, sing karaoke and engage in other comical behaviors.

MICHAEL SIMPSON *Getty Images*

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Send suggestions for column topics to editors@SciAmMind.com

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Foraging in the Modern World

Some of us prefer the tried and true, and others search high and low for novelty. Why?

BY WRAY HERBERT

I LIVE in a town with hundreds of restaurants serving many of the world's cuisines: sushi bars, pizza parlors, pho, tapas, KFC, you name it. My family eats out a fair amount, and we appreciate these tastes, so we could conceivably explore a different menu every outing. But we don't. Some years ago we discovered a neighborhood café that we all really like, and that's pretty much where we go. It is our place.

I know that other people are different. We're basically opting for certainty and predictability, whereas others prefer exploration and change. But why do people differ on this trait? What motivates some to constantly seek out the next best thing, the greener grass, and others to stick with what is known and safe? How do we know there's not a new and better favorite eatery just around the corner? Are we trading off curiosity and novelty for the luxury of not having to make a decision?

Psychologists are very interested in this question, and some believe it may reflect a fundamental difference in cognitive style, wired into our neurons. Think of it this way: our ancient ancestors had to forage in the savanna for food and water, but there was no telling where they would find these resources. The environment was patchy, with a watering hole here and an antelope herd there, but no uniformity or predictability. So what was the best search strategy? Once you find a hunting ground with some antelope in it, do you set up camp and make it your own, or do you go looking for a better hunting ground, then a better one still?

Familiar, safe settings can be comforting to some people, boring to others.

An Uncertain World

Now fast-forward to modern times. Our challenges are perhaps more intellectual and abstract, but we still have to decide how to deal with an uncertain world. Faced with a problem or decision or choice, do we bear down and exploit one idea for all it is worth, or do we move rapidly on from one solution to another to another? Or maybe we do both, depending on the problem, toggling back and forth until we find what works.

Indiana University psychologists Thomas T. Hills, Peter M. Todd and Robert L. Goldstone decided to explore these questions in the laboratory. They wanted to see if people do indeed have a consistent cognitive style for foraging, whether it is for food or for ideas. They also wanted to see if jostling those ancient foraging neurons—triggering either exploration or exploitation instincts—influences the way people approach modern problems.

Because they could not actually ask people to root around for food in the wild, they used some modern tools: a computer and a board game. They had a group of volunteers manipulate icons to

> We're basically opting for **certainty and predictability**, whereas others prefer exploration and change.

ANDREW VRACIN Getty Images

Those who were primed for exploration in the wild were also more **restless and exploratory** in Scrabble.

"forage" in a computerized world. Volunteers could move around until they stumbled on a hidden supply of food or water, at which point they had to decide if and when to move on, to continue the search (and in which direction), and so forth. The scientists tracked their movements.

But the volunteers explored two very different worlds: Some foraged in a "clumpy" world, which had fewer but richer supplies of nutrients. Others explored a "diffuse" environment, which had many more but much smaller supplies. The idea was to "prime" the unconscious mind to use the optimal foraging strategy for each possible world. Those who looked for resources in a diffuse world would in theory do better to give up on any one spot quickly, moving on rapidly and navigating to avoid any duplication. Those in a clumpy world would be more likely to stay put, exploiting the rich lodes of nutrients rather than keeping up the search.

Volunteers in an experiment demonstrated different methods to "forage" their abstract environment by playing a game of Scrabble.

Scrabbling for Words

That was the first part of the experiment. Afterward, the volunteers participated in a more abstract, intellectual search task: the board game Scrabble. They didn't actually play Scrabble, but they got letters as if they were going to play, and they had to search their memory for as many words as they could make with those letters. As with the board game, they could also choose to trade in their letters for new ones, but in the experiment they could do it whenever they wanted to. The wholesale trading of letters is what the psychologists were actually observing: they wanted to compare the volunteers' Scrabble strategies with their foraging strategies, to see if they stuck with the letters they were given—or rapidly abandoned one set of letters for another (more promising) set. In other words, would those who were mentally primed for a clumpy world see their Scrabble letters as rich clumps, worth sticking with, whereas those primed for a diffuse world would quickly abandon one set of letters for another?

The results were striking. As reported in the August issue of the journal *Psychological Science,* those whose neurons were primed for exploration in the wild were also more restless and exploratory in Scrabble, whereas those primed for exploitation were more focused and persevering when they switched to the abstract mental challenge. Put another way, the human brain appears capable of toggling back and forth between exploration and exploitation, depending on the demands of the task.

The psychologists also found that individuals were consistent in their cognitive style. That is, the most persevering foragers were also the most persistent Scrabble players, just as gadabouts in the food search tended to gallivant in intellectual matters as well. And presumably in life: they would probably be too antsy to settle for a "good enough" neighborhood café.

But dining out is trivial. These findings have more serious implications related to other recent work on brain chemistry and cognitive disorders. Exploratory and inattentive foraging—actual or abstract—appears to be linked to decreases in the brain chemical dopamine. Similarly, many problems related to attention—including attention-deficit hyperactivity disorder, drug addiction, some forms of autism, and schizophrenia—have been associated with a dopamine deficit. It is possible, psychologists say, that computer foraging might reveal one's underlying cognitive style—either having persistence or lacking it. It is even possible that simulated foraging could have long-term effects on thinking style and possibly even lead to therapies for cognitive disorders. That is something worth exploring. 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)

◆ **Search in External and Internal Spaces: Evidence for Generalized Cognitive Search Processes.** Thomas T. Hills, Peter M. Todd and Robert L. Goldstone in *Psychological Science,* Vol. 19, No. 8, pages 802–808; August 2008.

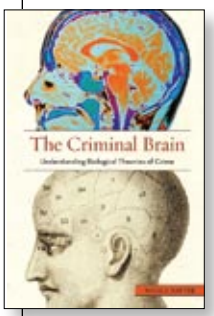
ISABELLE SCHNOECKEL *Getty Images*

books

BORN TO OFFEND?

The Criminal Brain: Understanding Biological Theories of Crime

by Nicole Rafter. New York University Press, 2008 ($24)



In the sci-fi movie *Minority Report* "Precrime" police units stop murders before they happen by relying on the visions of people who can see the future. Clairvoyants who possess precognition will likely remain fiction. But the idea of preventing individuals from committing crimes may be on the threshold of becoming reality, according to Northeastern University criminologist Nicole Rafter. Recent scientific advances, such as the decoding of the human genome and, growing out of that, studies that examine gene-environment interactions, have opened new avenues to explore the biological bases of character traits, including the propensity to commit crimes. As a result, Rafter says, criminologists are now shifting their attention toward biological reasons for delinquent behavior after decades of trying to define crime mainly on the basis of sociological factors.

In *The Criminal Brain*, Rafter warns of the potentially dangerous consequences of this trend: "We already have genetically modified crops; maybe gene policing and genetically modified criminals are not far behind." Whether we will head toward such a brave new world scenario, however, depends on how specialists and the general public evaluate research and policy in the booming field of biocriminology, she explains. Rafter provides the tools to do just that.

The book takes readers on a fascinating journey through the history of criminology and details where the field stands today. Even though we still do not know what exactly a "criminal brain" is, current research suggests that some people are more genetically predisposed to offend than others, Rafter says. Still, "no one is destined to commit crime," because environmental factors also play a role, even for those who are most at risk.

Rafter illustrates nicely how science develops in different social and political contexts. In the past, theories of a link between low intelligence and criminal behavior, for example, sparked a movement of "coercive eugenics," which resulted in forced sterilizations in the name of crime control. Today theories of links between genetics and behavior have led to what Rafter calls "'new' or 'liberal' eugenics" that involves the elimination of "bad" genes by choice, such as the abortion of fetuses that test positive for mental retardation. From here the step to "eugenic criminology" might be small, Rafter argues, particularly if "manipulative politicians and ignorant citizens" took charge of such a movement.

The Criminal Brain is a wake-up call that highlights the need to think hard about which direction we allow biocriminology to move, especially "now that memories of Nazi eugenics have faded." —*Nicole Branan*

BLESSING OR CURSE?

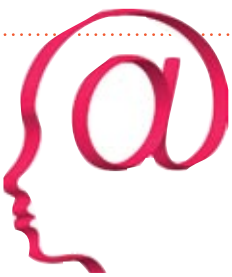
Obsession: A History

by Lennard J. Davis. University of Chicago Press, 2008 ($27.50)

Admit it: at some point in your life, you've been completely obsessed. Obsessed with a particular project perhaps, or a great author, or that hot senior who smiled at you once when you were a freshman. Obsession is common and typically harmless, often a powerful motivator and a source of artistic inspiration. Yet its extremes are also feared and reviled, because they form the foundation for obsessive-compulsive disorder (OCD), a disease that has apparently exploded in prevalence in recent decades. How exactly can we reconcile two conflicting notions of the same phenomenon?

Perhaps we can't—but we can glean some insight by taking a closer look at society's complex history with obsession, Lennard J. Davis posits in his new book. Since the 18th century our understanding of obsession has evolved from believing it to be an incurable "madness," thought to afflict a small number of people who were typically poor, to a potentially curable disease afflicting many, including the upper classes. Mental illnesses such as OCD and depression (or at least the tendencies toward them) have practically become a hallmark of passion. This association could partially explain why such illnesses are now so commonly diagnosed, Davis contends—since 1970 diagnoses of OCD have increased at least 40-fold.

Those with a keen interest in (or perhaps an obsession with) obsession and its place in human culture will



Best of the Web

The Internet is vast, and it can be difficult to find quality Web sites devoted to mental health. The truly great resources compile easy-to-read information with tools to help sufferers enrich their lives. Here are some of the best—sometimes fun, sometimes touching and, above all, useful.

For a comprehensive overview of all types of mental illness, visit **Psych Central**. Launched in 1995, the site is one of the longest-running mental health outposts online, and it was named one of Time.com's 50 Best Websites in 2008. You will find places to network with peers, a medication library and quizzes, such as "Do I need therapy?"

Mental Help Net is nearly as old and also award-winning. The amount of information here is staggering, but do not miss "Depression: A Primer" by a blogger and illustrator named "Ellen" who has struggled with the disease. To hear from other patients in their own words, go to **Schizophrenia.com**. In addition to a collection of blogs by people who have schizophrenia, it offers a comprehensive guide to living with the illness.

Millions of people endure anxiety, eating disorders and obsessive-compulsive disorder—but few realize that these ailments are all related. At the oddly named but excellent site called **BrainPhysics**, sufferers can explore the roots of these obsessive-compulsive spectrum disorders, find local doctors and support groups, and chat with others who have gone through similar experiences.

EMANUELE FERRARI *iStockphoto (face icon)*

enjoy Davis's book, which also provides biographies of famous artists and psychiatrists with obsessive tendencies. Those who have a purely scientific interest in OCD, however, may find themselves a little bored at times. Despite Davis's occasional long-windedness, he does make several interesting points. For one thing, Davis says, the difference between OCD and healthy obsession may simply be self-perception. People with OCD feel they are abnormal and wish they could change; obsessive people who do not have OCD—including people with "obsessive-compulsive personality," considered by psychiatrists to be normal—feel just fine. The two groups' tendencies and behaviors, however, are nearly identical.

Considering the close relation between OCD and "healthy obsessions," Davis argues that we tend to draw too strong a line between the healthy and the pathological. Many people have careers that require repetitive—almost obsessive—attention, and most of us heed warnings to take careful precautions in our daily routines to stay healthy and protect ourselves from crime and financial problems. "We suffer from the manifold requirements of modern life that make us focus on one thing, or many single things," Davis writes. OCD, he explains, is simply a subcategory of what we all do every single day. —*Melinda Wenner*

RICK FRIEDMAN *Corbis (Sweeney)*

dvds

COMIC CONVERSION

Letting Go of God

by Julia Sweeney. Indefatigable, Inc., 2008 ($20)

Scheduled to air on Showtime in early 2009

"So I'm in the bookstore, and I see this book by Steven Pinker, *How the Mind Works,*" says comic and former *Saturday Night Live* star Julia Sweeney, "And I think, 'How *does* the mind work?'" So launches a memorable journey, both in Sweeney's life and in the new film of her one-woman stage show, *Letting Go of God,* an extraordinarily engaging account of her walk across the religion-science divide. Sweeney found that the mechanistic answers that Pinker offered about the mind—the brain-based mechanisms of thought and consciousness being discovered by modern neuroscience—inspired her to replace her Catholic faith with science's empirical skepticism, which she finds, after many hilarious detours, "a much more powerful and reliable tool for understanding the world."

Sweeney's I'm-not-too-bright comic persona (clearly a ruse, given her marvelous grasp of science's deeper principles) is the perfect foil for this conversion story. Her argument for atheistic empiricism is devoid of the highbrow snobbery—call it "intelligentsiasis"—that infects some attacks on religious faith. The sorrow with which she surrenders religion's comforts only strengthens her case. I have never heard anyone describe so sympathetically the attractions of both religion and science—or describe so humbly and humorously a choice between the two. ***—David Dobbs***

PsychCentral: **http://psychcentral.com**
Mental Help Net: **www.mentalhelp.net**
Schizophrenia.com: **www.schizophrenia.com**
BrainPhysics: **www.brainphysics.com**
LD Online: **www.ldonline.org**
afterdeployment: **www.afterdeployment.org**

The Internet seems to be saturated with information for parents about attention-deficit hyperactivity disorder (ADHD) and other learning disorders, but few sites offer something for the kids themselves. At **LD Online**, a section for kids featuring a child artist and writer every day complements an exemplary collection of knowledge for parents.

Perhaps the most promising new addition to the online mental health scene is **afterdeployment.org**, a site for veterans and active servicemen and servicewomen who may be dealing with a host of problems, including post-traumatic stress disorder, anxiety and depression. The Department of Defense, along with an impressive lineup of psychiatrists and psychologists, created the site because of a congressional mandate. Launched in August, the sleek, interactive portal offers videos, self-check quizzes and online workshops, but one of its most important features is that it allows its users to remain anonymous. Many service members fear the stigmatization that therapy may bring in the culture of the armed forces—this site has the potential to help those people with its perfect use of the impersonal yet intimate nature of the Internet. —*Rachel Mahan*

Coming Soon

Why do some people hear the color blue? How do we learn to talk? What happens in the brain during orgasm? Take a whirlwind tour of our most complex organ with science writer Emily Anthes in the book *Instant Egghead Guide to the Mind* (St. Martin's Press, December 23, 2008), a product of SciAm.com's 60-Second Science. Although you may not become an expert, you will get an informative, fun introduction to the mind—and tons of tidbits to share at cocktail parties about everything from dreams to robotic limbs controlled by the brain. —*Rachel Mahan*

askthe**Brains**

Why am I sometimes awakened in the middle of the night by explosions going off in my head?

—Jade Peifer, Cypress, Fla.

Randolph W. Evans, professor of neurology at the Baylor College of Medicine, responds:

THERE MAY BE several reasons why you're experiencing these explosions erupting in your head. Perhaps you're in love, as the lyrics to Atreyu's "When Two Are One" suggest:

> Bang!
> Explosions in my head
> that just won't quit.
> A train has crashed into the
> wall around my heart …

Alternatively (and more likely), you have an uncommon sleep disorder, which in 1988 British neurologist John Pearce named "exploding head syndrome."

During an episode, a person feels a loud bang coming from inside his or her own head, often described as an explosion, a roar or waves crashing against rocks. Eruptions generally occur while people are falling asleep and less frequently when they are waking up. The explosions vary in frequency and happen most often in healthy individuals older than 50. In 10 percent of cases, people perceive a flash of light, and about 5 percent of patients report the sensation that they have stopped breathing and must make a deliberate effort to breathe again. Sufferers may be afraid or anxious in the aftermath of an attack.

Although the cause of the syndrome is unknown, some doctors speculate that it comes about when the brain stem reticular formation, an important regulator of sleep and wakefulness, fails to power down at the right moment. This area, which adjoins the spinal cord, may temporarily malfunction and cause hallucinations—but nobody knows exactly why the symptoms manifest as bangs or roars. Though loud, the noise is typically not painful or dangerous, and it usually is not indicative of any other neurological disorders. Stress or exhaustion may trigger episodes, which usually stop on their own over time and with reassurance that the phenomenon, though strange, is benign.

What is sleep paralysis, and is it rare?

—Mark Fischetti, Lenox, Mass.

Psychologist **Christopher French** of Goldsmiths College in London explains:

ATTACKS BY demons, ghostly visitations and alien abductions: some people are certain they have experienced such paranormal events. In reality, many of these victims probably had an episode of sleep paralysis.

Sleep paralysis, a momentary inability to move one's limbs, trunk and head despite being fully conscious, may occur when someone is either drifting off or, more rarely, waking up. During rapid-eye-movement (REM) sleep, the muscles of the body are paralyzed, presumably to prevent the dreamer from physically acting out the dream. Researchers are not sure why this normal paralysis happens during consciousness for victims of sleep paralysis, but psychophysiological studies have confirmed that attacks are particularly likely to occur if the person enters REM sleep quickly after hitting the pillow, bypassing the stages of non-REM sleep that usually happen first.

Other factors that make sleep paralysis more likely to occur include drifting off while lying on the back, feeling stressed or experiencing a disruption in normal sleep patterns, such as from shift work, jet lag, caffeine or alcohol.

During rapid-eye-movement sleep, the muscles of the body are paralyzed. Researchers are not sure why this normal paralysis happens during consciousness for victims of sleep paralysis.

Although sleep paralysis is a symptom of narcolepsy, it is also common in healthy people. Surveys from different countries show a wide range of estimates: 20 to 60 percent of the normal adult population has experienced sleep paralysis at least once. Around 5 percent of the population has experienced one or more of other disturbing symptoms associated with the disorder. The most common effects include visual hallucinations, such as shadows and light or a human or animal figure in the room, and auditory hallucinations, such as hearing voices or footsteps. A person often also feels pressure on his or her chest and has difficulty breathing.

The reason sleep paralysis may explain tales of ghosts and aliens is the strong sense of a presence, usually harmful, that victims commonly feel during an attack. They also report unusual kinesthetic sensations, such as feelings of being dragged out of bed, vibrating, flying or falling. These episodes can sometimes lead to full-blown out-of-body experiences. Sleep paralysis may be frightening, but it is never dangerous, and thankfully, episodes usually last only a few seconds. M

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

COURTESY OF RANDOLPH W. EVANS AND CHRISTOPHER FRENCH

Head Games

Match wits with the Mensa puzzlers

1 NUMEROLOGY

Find this six-digit number: it has no repeated digits, and none of its digits is zero; the first digit is half the second; the fourth digit is the square root of the two-digit number formed by reading the second and third digits together; and the last digit is the sum of the first, third and fifth digits and is not a prime number.

2 WORD MORPH

How many straight lines must be added to these letters to transform them into a word that means "parody"?

B U P I F S O U L

3 UNUSUAL ANALOGY

What word completes the following analogy?

SIGHT is to SLINGSHOT as _____ is to THESAURUS

4 WHO'S THERE?

Spell out 4 four-letter men's names by choosing one letter in each row from top to bottom. Every letter will be used only once.

A	**C**	**E**	**S**
H	**E**	**L**	**M**
M	**O**	**T**	**E**
S	**H**	**O**	**T**

5 BUDGETING ACE

At a tennis club, every can of tennis balls comes with a promotional sticker. You can trade in every four stickers you collect for a free can, which also contains a sticker. If each can costs $3, how many total cans of tennis balls can you acquire by spending $84?

6 ROLL CALL

Thirty-one students take music or art class (but nobody takes both); 14 are boys. Nineteen students take music, and eight girls take art. How many boys take music?

7 AVIANAGRAM

Delete two adjacent letters within each of the words below, then rearrange the remaining letters to spell out the name of a bird. Hint: never delete the first or last letter.

a) SCROOGE **b) CHIFFON** **c) AVENGER**
d) PROPHESY **e) FLAMENCO** **f) ORTHOTICS**

8 MISSING PIECES

Fill in the blanks according to the clues.

a)	**_ _ _ C U _ E**	**Buy**
b)	**C _ U _ E**	**It may have an effect**
c)	**C _ _ _ U _ E**	**It may be popular**
d)	**_ _ _ C U E**	**Free from danger**
e)	**C U _ _ E _**	**Nonlinear**
f)	**C U _ _ _ _ E**	**Type of work space**
g)	**C _ U_ _ E _**	**4 P.M. food choice**
h)	**_ _ _ _ _ C U _ E**	**Tiny**
i)	**_ _ _ _ C U _ E**	**Toenail treatment**

Answers

1. 364829. Suppose the digits are ABCDEF. When read as one unit, BC forms a two-digit square number, so it must be 16, 25, 36, 49, 64 or 81. B must be even because A is half of B, so 16 and 36 are eliminated as choices for BC. Attaching A (which is half of B) and D (which is the square root of BC) to each remaining choice for BC results in four options. Eliminate 1255 immediately because it has a repeated digit. The sum of A + C + E must equal F, a single digit, so 2497 is eliminated because A + C = 2 + 9 = 11. With 3648 and 4819 remaining, creating every possible combination for EF under the restriction A + C + E = F (with F not prime) results in five possible cases, of which only 364829 has no repeated digits.

2. Add six lines to make the word "BURLESQUE."

3. TEARS. SIGHT is hidden in every other letter of SLINGSHOT. TEARS is hidden in every other letter of THESAURUS.

4. Amos, Chet, Elmo, Seth.

5. 37 cans.

6. Ten boys take music class.

The information is summarized here:

	M	A	
B	10	4	14
G	9	8	17
	19	12	31

7. a) goose (SEROOGE)
b) finch (CHIFFON)
c) raven (AVENGER)
d) osprey (PROPHESY)
e) falcon (FLAMENCO)
f) ostrich (ORTHOTICS)

8. a) PROCURE b) CAUSE
c) CULTURE d) RESCUE
e) CURVED f) CUBICLE
g) CRUMPET h) MINUSCULE
i) PEDICURE

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