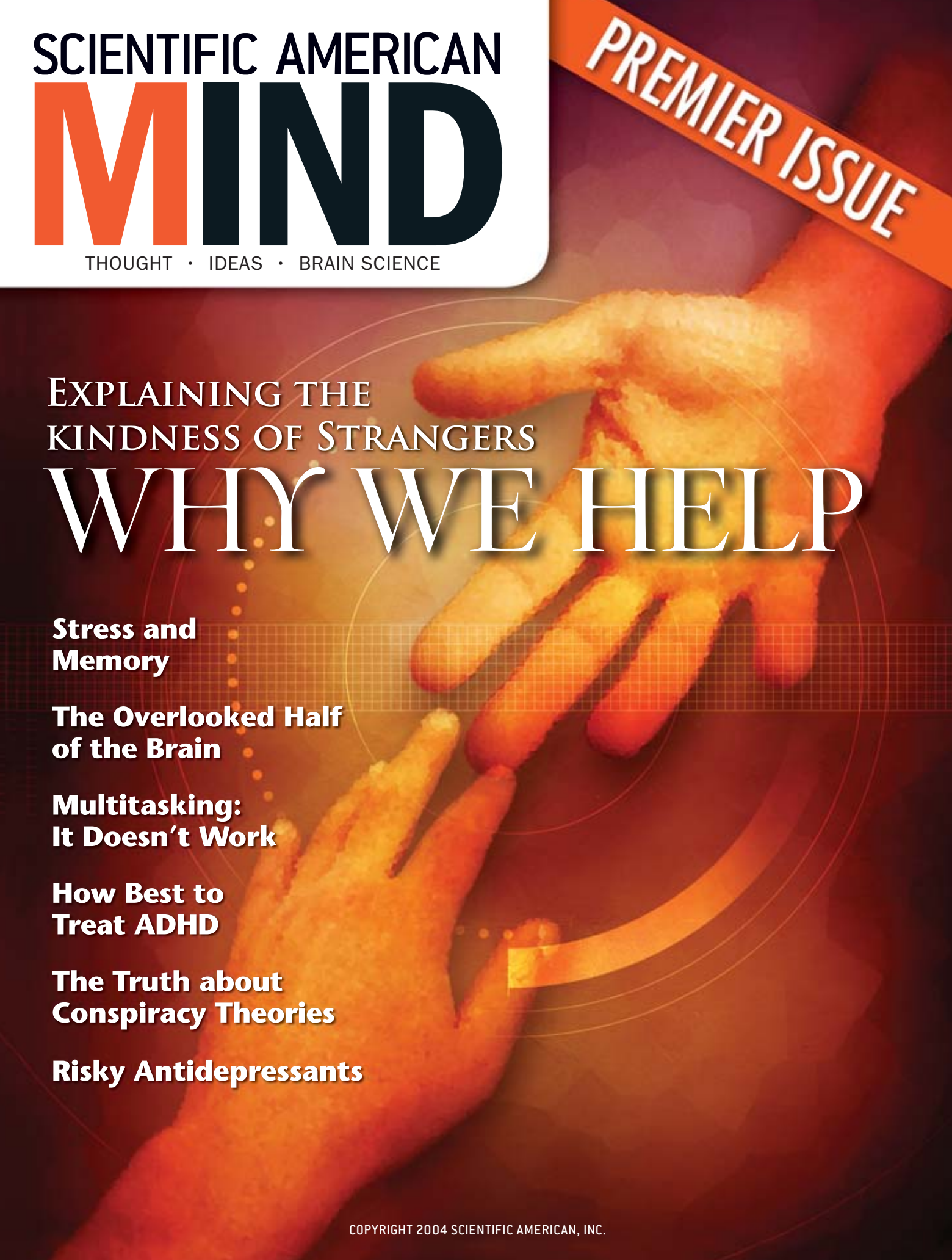
SCIENTIFIC AMERICAN
MIND
THOUGHT · IDEAS · BRAIN SCIENCE

PREMIER ISSUE



Explaining the kindness of Strangers

WHY WE HELP

Stress and Memory

The Overlooked Half of the Brain

Multitasking: It Doesn't Work

How Best to Treat ADHD

The Truth about Conspiracy Theories

Risky Antidepressants

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Volume 14, Number 5

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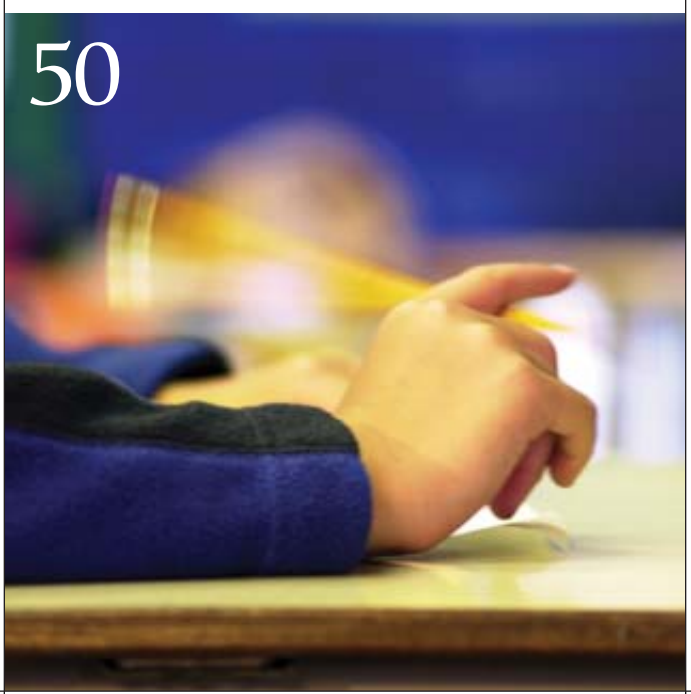

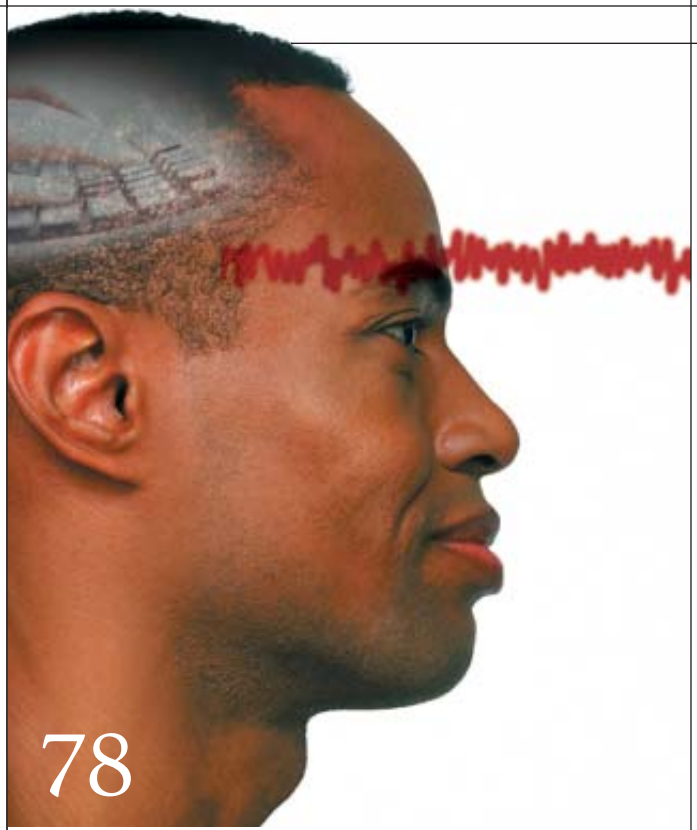

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Human Kind

Last night something happened for the first time in my 17 years of commuting by rail. As the train began rolling north, I concentrated on proofreading pages of the magazine that you now hold in your hands. Slowly, it dawned on me: "I left my purse in my office," I said to no one in particular. No ticket, no money, no ID—and no one I knew in sight to help me out. The conductor was headed down the aisle, and I wondered if I'd be tossed out at the next stop, leaving me miles from office or home. Then the woman across from me leaned forward. "Can I buy your ticket for you?" she asked. A man sitting two seats over from her added, "Do you need a ride home when we get to the station?"

Researchers have been puzzled about why such altruism, so frequently and generously offered, should exist at all. In a Darwinian world of "survival of the fittest," why do perfect strangers volunteer to help, even when such aid may come at a cost to themselves? Why purchase a ticket or expend gas and time driving a hapless commuter home? Seeking answers, scientists probe our behavior in experiments designed to reveal the roots of altruism. The cover story of this issue, "The Samaritan Paradox," by Ernst Fehr and Suzann-Viola Renninger, on page 14, describes how altruism emerges spontaneously even in anonymous exchanges among people, whereas animal altruism starts and ends with kin.

Mulling our surprisingly cooperative nature seems fitting in this, the premier edition of *Scientific American Mind*, a new quarterly publication. Each issue will explore similar mysteries about what makes us humans humane, heartless, helpless, hopeful—in short, why we are the way we are. Issue by issue, we aim to lift the veils, to reveal more about our own shared essence. Because we will be focusing on the workings of the mind and brain, we are naturally keen to hear what you think about the magazine as well.

Mariette DiChristina
Executive Editor
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(letters)

THE SPRING 2004 ISSUE of SCIENTIFIC AMERICAN Mind presented a sampling of the research that attempts to elucidate what makes us *us*. As readers learned, influences both internal and external create and shape the mind and brain. Researchers have explored the mystery of self through the study of concrete stimuli such as the effects of music and television, abstract issues (including the nature of free will and the power of persuasion) and even the effects of diseases such as autism and anxiety disorders. The editors invited readers to share their reactions to the issue and their resulting insights into the elusive human psyche. A selection of the reader responses appear on the following pages.

"MIND" MATTERS

Great job on your special issue. Your treatment of the material was very professional. I just wish it were a monthly edition!

Lt. Col. Jeff M. Ashley
Greenwood, S.C.

Forgive my being blunt, but your recent issue is just plain awful! Most of the articles I would not give a passing grade in a college intro-to-psych course. They are superficial, vague and dated.

Robert M. Sapolsky's essay, "Your Personal Pathology," is the exception. As usual, he presents solid and provocative information from the frontiers of research and pokes us with it to be sure that we see where it is leading.

Christopher J. Frederickson
Biomedical Engineering Center
University of Texas
Medical Branch, Galveston

WEIGHING THE OUTCOMES

I believe that the second experiment discussed in "Anguish and Ethics," by Hubertus Breuer, might have been flawed. Test participants were given a choice of throwing a large person in front of a train as a way to save the lives of a group. Despite the instructions, however, the subject might not, when forced to make a quick decision, consider one large person sufficient to stop a rushing train. If I am right, the brain images described in the article may have indicated that the participant was very busy balancing these probabilities, rather than exhibiting signs of a moral struggle.

David Pavlik
Norwalk, Conn.

Breuer replies: *Pavlik's point is a good one, but the researchers made it clear to the participants that sacrificing one life would definitely save the other five. It is possible, of course, that the participants could not accept the assumptions that they were given. It's also worth noting that the train and footbridge cases mentioned in the article are just two of the many scenarios that were used in this study.*

SURVIVAL OF THE FOCUSED

The idea that savants are produced by a compensation process after the brain is damaged, mentioned by Darold A. Treffert and Gregory L. Wallace in "Islands of Genius," must be wrong. Imagine the situation millions of years ago. We had only recently gained the bipedal ability that freed our hands to do clever things necessary for our survival. The brain was evolving in ways that presumably optimized our chance for survival, which would have included functioning after an injury had degraded its performance. Surely survival would not have been enhanced by suddenly being able to paint fabulous pictures or memorize unlimited cave drawings. I think there is a much more likely explanation.

The most important survival characteristic would have been the ability to concentrate on specific survival tasks such as spotting predators and chasing food. Seen in this light, the primary evolutionary function of the brain is focus. This is a startling idea because it downgrades the brain to a tool for filtering, with an underlying unlimited capability that we do not understand. Surely this ability must defy the category of mere compensation.

Henry Harris
via e-mail

Treffert replies: *There is indeed an emerging view that the right-brain compensation in response to left-hemisphere damage in many savants may be, instead of the development of "new" skills, rather a liberation from what some have termed the tyranny of the left (dominant) hemisphere, which keeps those skills more hidden. Methods and studies are under way to explore how such a freeing-up process, which if brought about noninjuriously, could expose special talents that perhaps already exist in each of us.*

These talents could be very extensive and unlimited as Harris suggests, possi-

MELISSA SZALKOWSKI

bly as an accumulation of vast ancestral or genetic memories, some with an evolutionary survival purpose. Some evidence also supports the suggestion that parts of the brain filter out such underlying, innate capabilities when focusing on some immediate higher-level tasks. Each of these ideas is worthy of further inquiry by researchers as we continue to search for the little Rain Man who, I am convinced, resides within us all.

HOOKED ON TV

All the articles were very interesting, to say the least, but the one I enjoyed best was "Television Addiction," by Robert Kubey and Mihaly Csikszentmihalyi. As a science and technology editor working for a major TV network in my country, I gained good insight into the nucleus of our job in television and how—without even intending to do so—we exploit people's lowest-level reactions and nervous systems to hook them on whatever we're broadcasting at the time.

Sotiris Damatopoulos
Athens, Greece

OFF KEY

Accuracy of music notation was evidently not checked as carefully as scientific diagrams and figures usually are in your articles ["Music in Your Head," by Eckart O. Altenmüller]. Two glaringly obvious errors appear in the otherwise clever skullcap notation of "Twinkle, Twinkle Little Star" on page 25 and in "Happy Birthday" on page 27. Any 10-year-old who has learned an instrument could spot the errors in a minute!

Otherwise this fascinating article corroborates much of the old-fashioned teaching of ear training and musicianship. The tactile and visual aid of using a real keyboard speeds up the development of hearing music notation. The mind's ear becomes more and more discriminating via many paths of musical experience and learning, not just a few. We seek to develop all of our students' senses in order to advance skilled musical understanding.

Frederick K. Gable
Department of Music
University of California, Riverside

The editors reply: *Gable is correct. In the photograph for "Twinkle, Twinkle Little Star," the tune is written in the key of C, and therefore the last note should be G. And "Happy Birthday" has one beat too many in the second full measure.*

GREG MILLER

MUSIC TEST: Can you spot the error in this photograph?

FLOWING CONSCIOUSNESS

In "Humbled by History," Robert-Benjamin Illing claims that "American psychologists such as William James and John B. Watson … concerned themselves almost entirely with the visible and measurable behaviors of an organism and considered mental processes and consciousness to be negligible in importance."

With regard to James, nothing could be further from the truth. James's landmark text "Principles of Psychology" reveals on nearly every page his view that consciousness, broadly defined, must be considered the core subject matter of psychology. Indeed, although German physiologist and psychologist Wilhelm Wundt and those who followed him argued that consciousness could be re-created through introspection, James cogently disposed of that view. He noted that one can never experience exactly the same consciousness twice, because each experience changes the brain in some way. In one of the most famous chapters, James compares consciousness to the flowing of a stream, in which different parts of the stream flow at different rates.

Perhaps the author of your article had in mind B. F. Skinner rather than James. Skinner followed Watson, who did in fact become a "radical" behaviorist who denied the existence of consciousness. Skinner incorporated many of Watson's ideas into his version of behaviorism.

Fairfid M. Caudle
Department of Psychology
College of Staten Island, C.U.N.Y.

ERRATUM Studies examining spatial-attention abilities, described in "Learning from Switched-Off Brains," by Claus C. Hilgetag, were performed by the author while he was a postdoctoral fellow at the Boston University School of Medicine, working with colleagues at Harvard Medical School.

Dyslexia by Culture

Children who grow up learning alphabetic languages and who are dyslexic have trouble connecting the letters in a word with their sounds. But Chinese readers face a different challenge: their brains must connect the subtle arrangement of strokes in each character to its sound and meaning, a task more visual and spatial. Now Li Hai Tan of Hong Kong University has discovered that the problem for Chinese dyslexics lies in a different area of the brain than children raised on alphabet soup.

Researchers have understood for several years that impaired reading of alphabetic scripts is associated with reduced activity in the left temporoparietal brain region. This is where the brain converts "graphemes"—written symbols—into phonemes (the sounds of speech), then analyzes the phonemes. Most researchers also believed there was a universal biological origin for dyslexia among readers everywhere. "But they had never looked at Chinese children," Tan says.

Tan used functional magnetic resonance imaging (fMRI) to watch the brains of Chinese children as they read characters. Children who were dyslexic had reduced activity in the left middle frontal gyrus compared with regular Chinese readers. As for the left temporoparietal region so important to alphabet readers, "there was no difference in activity there between normal and dyslexic Chinese," Tan says.

Tan believes he is among the first to use imaging to study Chinese reading at the neuroanatomical level. His work suggests that "the neural and cognitive correlates of impaired reading are different for Chinese readers and English readers," he concludes, adding that "future studies into diagnosis and treatment of dyslexia will have to take these differences into account." —Jonathan Beard

Head Lines

The Pleasure of Revenge

Revenge actually is sweet: it stimulates the same types of reward centers in the brain that desserts, desire and drugs do. Ernst Fehr, an economist at the University of Zurich in Switzerland, and his colleagues have shown that the dorsal striatum—the part of the brain that processes rewards—lights up when we punish those who have betrayed our trust.

Fehr's study paired male subjects in a game. Each player began with 10 money units. If A gave his 10 to B, then B received an extra 30 from a bank. If B shared his windfall with A, both players came out ahead. During the experiment, Player A almost always gave up his 10, but Player B often kept the extra money. In those cases, the researchers told A he could punish B by taking two to 40 money units from B's pot. Fehr scanned the brains of the As as they decided whether to exact revenge.

In all cases, the decision to punish B activated A's dorsal striatum: the promise of revenge registered like a reward. But when Fehr compared the scans of the As who had taken the maximum, he found that some showed more activation than others. So he set up another scenario, in which A had to give up one money unit for every two he took back from B. Fehr was able to predict how much A would sacrifice to punish B, based on the activation in his prior scan. "The higher the expected satisfaction from punishment, the more they punished," Fehr says, adding, "It looks pretty rational."

Fehr also says the experiment sheds some light on altruistic punishment—the human tendency to discipline those who violate social norms—so a few bad apples don't undermine the general cooperative spirit that permeates human existence [see "The Samaritan Paradox," by Ernst Fehr and Suzann-Viola Renninger, on page 14]. —Aimee Cunningham

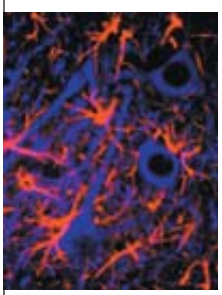
KEVIN R. MORRIS *Bohemian Nomad Picturemakers/Corbis (top)*; JOHN RITTER *(bottom)*

Refueling the Brain

Glucose is an important fuel for brain activity, but how do neurons actually use it? The traditional view is that neurons directly consume glucose to refill their energy supply. Now new evidence suggests that other brain cells, called astrocytes, are refueling the neurons.

Neuroscientists have long held that glial cells in the brain—of which astrocytes are one type—support neurons by protecting them from invaders and electrical interruption as well as "feeding" them in some unknown way. Modern research has indicated that astrocytes consume glucose and convert it to lactate during neural activity, but experts still thought neurons consumed glucose directly. To probe these mechanisms, Cornell University researchers used multiphoton microscopy to look at glucose metabolism in the cells of rat brain slices; illuminating the cells causes by-products of energy metabolism to fluoresce.

When the researchers stimulated the neurons to fire, the imaging showed that most glucose metabolism occurred in the astrocytes rather than in the neurons, supporting the notion that astrocytes function as the main neuron refuelers. Earlier studies had also suggested that neurons "prefer" the lactate made by astrocytes over glucose and that they may even rely solely on lactate. The Cornell results indicated that, indeed, nearby neurons took up lactate released by the astrocytes.



STAR-SHAPED CELLS (*red*) known as astrocytes may be largely responsible for refueling the brain's neurons (*blue*) after they fire.

The work adds to the growing body of literature demonstrating the importance of astrocytes and other glial cells in neuronal communication [see "The Forgotten Brain Emerges," on page 40]. The role glia play in glucose metabolism is also of great interest to doctors, because two diagnostic methods of brain imaging—positron emission tomography and functional magnetic resonance imaging—generate pictures based on glucose metabolism. The new information may allow researchers to better understand the molecular underpinnings of the cellular damage they see. *—Nicole Garbarini*

Drink Up, Girls

Teenage drinking among girls is rising faster than it is among boys, and magazine advertising may be a big reason why. Researchers at Georgetown University's Center on Alcohol Marketing and Youth in Washington, D.C., recently concluded a study of 103 national magazines. The group found that in 2002 the increase in ads for low-alcohol drinks seen by teenage females was more than four times higher than the rise in ads seen by teenage males.

The rise in drinking is documented by the 2002 National Household Survey on Drug Abuse. According to that study, teenage girls were more likely than their male peers to have imbibed alcohol in the month before filling out a survey. And previous studies have established that alcohol ads affect teens' drinking intentions and behavior. One study found that viewing ads activated brain areas associated with desire in adolescents who have alcohol-use disorders.

David H. Jernigan, a Georgetown health policy professor who led the advertising inquiry, considers the mounting evidence about teen drinking "a cause for concern." Alarmingly, his study found that girls between the ages of 12 and 20 were more likely to see magazine ads for alcohol than women between 21 and 34. He hopes recent changes in the voluntary advertising code of major alcohol trade associations may help limit teen exposure. *—Lisa DeKeukelaere*

Voters Fear Death

Thinking about death may have affected whether someone voted for George Bush or John Kerry for president. Last February nine psychologists put 74 students at Rutgers University through a mock exercise intended to unveil bias based on fear. Participants who had been asked to think about death or the events of September 11 were more likely to later respond favorably to a passage praising Bush's actions in the war against terrorism than those who responded after being asked to think about an upcoming school exam.

The findings support terror management theory, the idea that the conflict between one's biological instinct for survival and psychological realization of possible death makes one seek a source of immortality within society. Following this theory, the psychologists proposed that Bush might have been viewed favorably because the participants saw him as a leader who could be "a protective shield against death, armed with high-tech weaponry and patriotic rhetoric."

Bush might have curried favor because he was an incumbent—already in the highest position of national power. But a similar study showed that participants primed with thoughts of pain were more likely to favor John Kerry. Thus, incumbency "wouldn't explain why they liked Kerry more in control conditions," explains Sheldon Solomon, a psychology professor at Skidmore College who was involved with the work.

According to Solomon, previous research has shown that voters who are aware of trends such as these can control for them. "If you ask people to think rationally, then effects like these are minimized or completely eliminated," he says. Still, whether that realization ever comes up in real life, he notes, is an open question.

—Lisa DeKeukelaere

MICHAEL KRASOWITZ *Taxi/Getty Images (girl)*; K. KASISCHKE, P. FISHER *Cornell University (astrocytes)*; CRAIG LASSIG *EPA/Landov (Bush)*; GARY KASKEY *EPA/Landov (Kerry)*

Working Better on Drugs

Want to boost your performance at the office? On a test? Take a drug. Just make sure your doctor has diagnosed you with a mild version of a standard psychiatric disorder.

Since the 1988 introduction of the antidepression medication Prozac, the number of mood-enhancing drugs on the market, and the number of people with prescriptions for them, has risen dramatically. The trends are forcing an ethical issue: How should doctors respond to patients who seek pharmaceutical cures for mild mood disorders?

The medical community does not have a ready answer. Indeed, prominent mental health experts who spoke at a New York Academy of Sciences meeting in July said more study is needed. Most fundamental is how to assess the safety and risk-benefit ratio of chemical mood enhancement for mild disorders and how to gauge the overall effects of such drug use on society—including the possibility that widening usage could drive many more people to seek medications that enhance performance.

The ethical quandary exists in part because of the nature of certain drugs. For example, antidepressants and drugs for attention deficit disorder (ADD) produce effects that society views as positive, such as mental focus, elevated mood and decreased social anxiety. The problem is that mood-disorder drugs prompt the same effects in healthy people who take them. At the academy meeting, Brian D. Knutson, assistant professor of psychiatry at Stanford University, quoted a U.C.L.A. study indicating that healthy people who take the selective serotonin reuptake inhibitor Paxil experience fewer negative emotions and are more willing to work with others. Furthermore, these effects are proportional to the amount of drug a person takes. Other studies indicate that an increasing number of college students are abusing the ADD stimulant Ritalin in attempts to pump up their performance during exam times.

Demand on doctors to prescribe such drugs is increasing, although most of it is subtle. Peter D. Kramer, psychiatrist and author of the best-seller *Listening to Prozac* (Viking, 1993), says that in his clinical practice people are not asking for prescriptions outright, and most are appropriately wary of medications. Yet he does see an increase in "cosmetic psychopharmacology" for individuals who "want to move from a normal state that is less socially desired to a normal state that is more socially desired."

More clinical research is needed to inform the medical community's response to such trends. Viewing mood disorders as disease states is relatively new, and defining what would constitute actual disease is difficult, says Steven E. Hyman, provost of Harvard University and former director of the National Institute of Mental Health. For example, Hyman observes, depression could be weighed on a continuum, like cholesterol levels are. Just as doctors have recently reset the definition of "bad" cholesterol levels, mental health experts must define at what point depression presents a health risk serious enough to warrant medication. Answers such as this, Hyman notes, are needed if the medical community is to provide sound advice in favor of drugs to fight mood disorders and against drugs that are simply providing a social edge.

—Nicole Garbarini

Toying with Creativity

Imagine your boss asking you to play with toy Lego blocks to spark your creative juices. That's been happening at companies such as Orange and Nokia for years. But what is it about the process that actually sparks fresh thinking, if it does at all? A team led by social psychology professor Patrick Humphreys hopes to find out.

Humphreys will analyze executives who come to Box, a new center launched this December by technology services giant EDS. Box sits on the London School of Economics campus, where Humphreys works. EDS will send personnel to Box where facilitators will run them through Lego Serious Play, a kit of toy bricks and licensed exercises. As the executives fiddle, Humphreys will analyze them using video footage, interviews and other means to see which exercises seem to improve creativity. What will make Box different from other companies will be academic research, says Cliff Dennett, Box creative director and an experienced Lego facilitator.

Lego Serious Play was created by Johan Roos and Bart Victor when they were management professors at the International Institute for Management Development in Lausanne, Switzerland. The program was inspired in part by Swiss psychologist Jean Piaget. In a classic experiment, Piaget poured equal amounts of water in a tall, narrow glass and a short, wide one, only to have children claim the taller one had more. Yet later experiments by others found that if a child poured the water herself, she was more likely to understand the two glasses were equal, suggesting that physical manipulation helps thinking.

Humphreys says he is especially interested in how the Lego play translates from Box sessions back into the real world. Play is how we wire our brains as children, says Lewis Pinault, Box managing director, but as adults we tend too much to pave the cowpaths. By inviting Humphrey's analysis, Pinault hopes to gain insight for developing Lego Serious Play further.

—Karla Adam

CORBIS (*water bottle*) AND GETTY IMAGES (*pills*); CORBIS (*Legos*)

Cocaine Vaccine

Several drugs help to wean cocaine addicts from their physical dependency, but the compounds are limited in effectiveness. Researchers have dabbled with another approach—triggering the body's immune system to neutralize the narcotic—and new tests are under way.

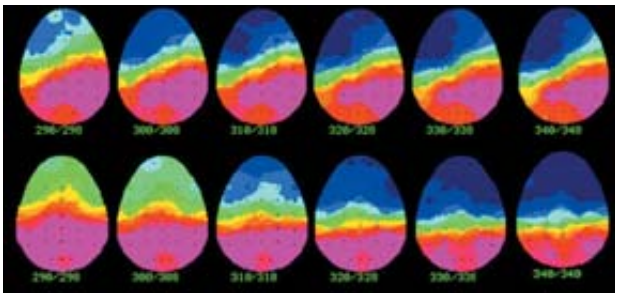
One notable clinical trial involves a cocaine vaccine developed by Xenova Group. Cocaine molecules are coupled to an inactivated cholera toxin and are injected like a regular vaccine. The immune system produces antibodies to the toxin and the cocaine attached to it. Later, if a person uses cocaine, antibodies bind to it in the bloodstream, acting like a sponge, so it doesn't reach the brain's addiction and reward centers.

In early Phase II clinical trials, patients were given five vaccinations at various intervals. More than half of the drug users in the trials who produced high levels of antibodies in response to the treatment stopped using the drug by the third vaccination. Thomas Kosten, professor of psychiatry at the Yale University School of Medicine who is involved in the trials, says the vaccine could help rehabilitate cocaine abusers. But he notes that such vaccines are not a magic bullet for curing addiction. Cocaine antibody levels persist for only a matter of months, so patients must return for booster shots. More problematic is that the medication does not address the psychological and behavioral aspects of addiction. "You have to want to quit," Kosten points out.

The vaccine approach can be applied to other addictive substances; clinical trials of nicotine vaccines are under way in the U.S. and Europe. Various drug actions are also being examined. For example, Kim Janda's group at the Scripps Research Institute—active in developing antibody-based drug therapies for more than a decade—is pursuing a virus-based vaccine against cocaine. In animal tests, the vaccine has produced antibodies in the brain, which could more directly prevent cocaine from binding to neurons in reward centers or be used in combination with therapies that act in the bloodstream. —Nicole Garbarini

CHRISTINE WEBER-FOX (*brain scans*); MALCOLM PIERS *The Image Bank/Getty Images* (*cocaine*); DONNA DAY STONE *Getty Images* (*TV*)

A Reason to Stutter



IN A SILENT RHYMING TASK, neural activity (blue) in the left hemisphere of children who stutter (bottom row) occurred later than it did for fluent speakers (top row).

People who stutter may seem tongue-tied, but at least part of their problem lies in their brains. A Purdue University study of fluent speakers and stutterers whose neural activity was monitored with electrodes found that the brains of those who stutter take a fraction of a second longer to process a complex language task. And only brains were involved: the test subjects were silent throughout their exercises.

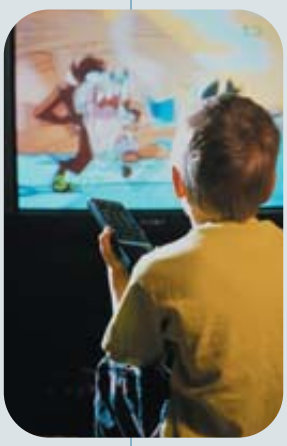
Subjects were asked to press computer buttons when asked questions about certain word pairs. One exercise involved pairs that looked alike and rhymed, such as "thrown and own." Another had pairs that looked different but rhymed (cone and own). In a third trial, the words neither looked similar nor rhymed (cake and own). All 22 subjects had about the same accuracy and response times.

But a fourth exercise used pairs that looked similar but did not rhyme, like "gown and own." The response time averaged 910 milliseconds for the fluent speakers but 1,040 milliseconds for those who stutter, according to Christine Weber-Fox, a Purdue neuroscientist who conducted the research with speech expert Anne Smith. "Although this difference seems small, in the world of neural activity it can be a significant delay," Weber-Fox says.

The added complexity of the fourth test, Weber-Fox states, "appears to put more load on the system." She hopes her study and others "will help us develop the best therapies for people who stutter." About 5 percent of American children stutter, and the condition persists in up to 1 percent of adults. —*Jonathan Beard*

TV Weakens Attention

When Dimitri Christakis noticed his three-month-old son's enchantment with television, he wondered how the exposure might affect a child's developing mind. So Christakis, associate professor of pediatrics at the University of Washington and Children's Hospital in Seattle, and his colleagues designed a study to find out.



The researchers asked parents of 1,345 children how much television their kids had watched at the ages of one and three and how well the children were able to pay attention (based on questions from a hyperactivity behavioral profile) at age seven. Christakis discovered that with each additional hour of television a child watched a day before age four, a child's risk of having attention problems at age seven increased by 9 percent.

Christakis hypothesizes that the mechanism damaging attention could be television's pacing. In contrast to real life's more leisurely rhythms, television displays rapidly shifting images and scenes. Exposure to such frenetic input during the first few years of a child's life—a critical time for brain development—"might condition the mind to expect that level of stimulation," he says. The study does not claim a connection between TV viewing and the clinical diagnosis of attention-deficit hyperactivity disorder, but Christakis notes that the core symptoms behind the reported attention problems are consistent with ADHD. —Aimee Cunningham

A scandal over hidden data about adolescent suicide lights a dark corner of our drug approval system

BY DAVID DOBBS

Antidepressants: Good Drugs or Good Marketing?

JACQUELINE LARMA *AP Photo*

Pallbearers carry the coffin of Traci Johnson, a 19-year-old from Bensalem, Pa., who committed suicide this past February in an Eli Lilly research lab where she was a volunteer testing a new antidepressant, duloxetine.

DISCUSSION ABOUT the use of antidepressants by children, always a hot topic, boiled over in September when hearings revealed that both the drug industry and the Food and Drug Administration had hidden evidence about dangers associated with the most widely prescribed drugs, a class known as selective serotonin reuptake inhibitors. The analysis, which pharmaceutical companies failed to release to the public and which the FDA sat on for a year, indicated that these SSRIs double the suicide risk in depressed juveniles yet help no more children in trials than placebos do.

The high-profile congressional and FDA hearings were made all the more dramatic as parents recounted how their children had moved from moderate depression to suicide within days of starting SSRIs. Some of their children died during the year of delayed FDA action. Congressional subcommittee chair Representative Joe Barton of Texas lambasted the drug companies for withholding information and said the FDA's connivance suggested its initials stood for "foot-dragging and alibis." Even John Hayes, product team leader for Eli Lilly (whose Prozac was the one SSRI found both effective and safe) acknowledged the crisis with marked understatement, saying, "These hearings

Results withheld by drugmakers and ignored by the FDA found that **SSRIs in juveniles provided only a placebo-level benefit** yet doubled suicidal tendencies.

are evidence … there is a great deal of mistrust."

Given the stellar rise of SSRI antidepressants such as Prozac, Zoloft and Paxil, perhaps a fall was due. Since Prozac's introduction in 1988, SSRIs had been hailed for being as effective as earlier classes of antidepressants yet having fewer and less serious side effects. As more and more published studies confirmed this assessment, SSRI use skyrocketed in both adults and children. Prescriptions for U.S. minors grew annually at double-digit rates through 2003, when 2.4 percent of all American minors—about two million kids—were taking the drugs.

This rise occurred even though no SSRI won FDA approval for use in children until Prozac did in 2003. Once a drug is approved for general use (based on testing in adults), doctors can also prescribe it for children unless a specific ban forbids it. Such "off label" practice is common, legal and, given due care, generally safe. To obtain specific approval for use in children, a pharmaceutical company must run additional trials in pediatric patients.

It was the data from such trials that came to light this summer. In both the U.K. and the U.S., government epidemiologists who ran meta-analyses on the published, positive numbers as well as results from less flattering, previously withheld trials found that overall, SSRIs helped about the same percentage of youths as placebos did, usually a third to a half, depending on the study. Yet the drugs doubled the incidence of suicidal thoughts and tendencies. This reversed the positive benefit-risk balance the companies had shown in their selected studies.

The U.K. responded by banning pediatric use of all SSRIs except Prozac. But when the FDA's epidemiologist, Andrew Mosholder, recommended similarly strong action, the agency deemed his findings inconclusive, ordered another study, forbade him from publishing and blocked him from testifying at FDA hearings on the issue this past February.

Truth wins out, at least sometimes, and the tale of Mosholder's suppressed findings leaked to the press soon after the FDA hearings. A month later the *Journal of the Canadian Medical Association* published a leaked 1998 GlaxoSmithKline memo urging its staff to suppress findings showing that its SSRI, Paxil, worked no better than placebos. Headlines and talk of cover-ups started to fly.

By June, New York State Attorney General Eliot Spitzer had sued Glaxo for consumer fraud, and Glaxo and other companies soon faced both individual and class-action lawsuits from families of children taking SSRIs who had attempted or committed suicide. Finally, September brought that unmistakable certification of scandal, the congressional hearing, where under bright lights both the drug industry and the FDA had to face bipartisan thrashing and wrenching testimony from parents of suicide victims.

The entire episode, as the British medical journal the *Lancet* put it, was "a story of confusion, manipulation, and institutional failure." Fortunately, the publicity seems likely to spur a much needed revision of warnings and protocols for pediatric antidepressant use. On the second day of its own September meeting, an FDA advisory committee voted to recommend a "black box" warning for SSRIs—the strongest measure short of a ban. This would require every SSRI container to display a prominent, black-bordered warning about suicide risk on its label and to be dispensed

Pharmaceutical companies have cherry-picked data for decades; only 50 percent of all drug trials over the past half a century were reported or published.

MATT DETRICH *Indianapolis Star/AP Photo*

Prozac prescriptions for children rose for a decade, even though the FDA did not approve this use until 2003.

with a pamphlet describing the risk and urging close monitoring.

The warning would also appear in all ads. Most observers felt this was a good solution, because it would inspire more discretion among doctors, parents and patients while allowing use of SSRIs when needed. Few dispute that the drugs help some patients, sometimes profoundly. And although their use may create suicidal tendencies in some patients, they may prevent needless death in many more. As this story went to press, it was unclear whether the FDA would accept these recommendations, although it usually follows the advice of its advisory committees. Most observers thought the highly publicized recommendations would leave the agency no choice, but others noted that the FDA's chief counsel, Daniel Troy, is a former drug industry lawyer who has often intervened on drug companies' behalf since joining the FDA in 2001.

Terri Williams of Wetumpka, Ala. (*left*), and friend Rhonda Thrower prepare to speak during an FDA public hearing in February. Williams's son Jacob (*button, photo*) committed suicide at age 14 while taking antidepressants.

EVAN VUCCI *AP Photo*

Hiding Negative Results

If instituted, a black-box warning will almost surely affect SSRI use. The extended controversy may have contributed to a decline in pediatric antidepressant prescriptions in the past year. Although doctors worry that wariness will prevent some needy patients from taking the drugs, the warnings should slow what many researchers felt was an overreadiness to prescribe these drugs.

Unfortunately, the deeper problem—a drug approval system that allows industry to highlight flattering results and hide negative ones—will be harder to fix. Drugmakers have cherry-picked their trial data for FDA consideration for decades, defending the practice in the name of protecting proprietary information; only about 50 percent of all drug trials over the past half a century were reported or published, according to a 2003 study of clinical trials in the *Journal of the American Medical Association* (*JAMA*). As a result, the FDA routinely approves drugs based on partial and often highly unrepresentative data—thereby forcing physicians to rely on the same skewed information.

Given the vast and growing role that medications play in our medical system, critics say that more lives could be in jeopardy. At issue is whether the "science" underlying much of our health care deserves that name. As University of California at San Francisco School of Medicine professor and *JAMA* deputy editor Drummond Rennie puts it, "If a company does 10 trials on a drug, and two show it helps but eight show it works no better than Rice Krispies, I'm not exactly getting a scientific view if they publish only the two positive studies. And this affects me as a patient. I've got a good doctor, and I watch his prescribing hand closely. We like to think we're sophisticated. But how can we practice sophisticated medicine if the drug companies are hiding their results? That's not science. That's marketing."

The solution, Rennie and other expert ob-

> The only fix is to **mandate registration of all drug trials** in a central, public database and to impose heavy fines on companies that do not comply.

servers say, lies in establishing a system that makes all drug trials, not just successful ones, part of the public record. The recent pledges by drug companies to publish their studies in an industry database will not answer the call. Making trial registration voluntary, as the industry wants, still allows the same types of selective publication.

More constructive was the September announcement by 11 major medical journals, including *JAMA*, the *New England Journal of Medicine* and the *Lancet*, that beginning next July, they will require drugmakers to have registered clinical trials at their outset if the companies want the option to eventually publish the results—a move designed to prevent them from hiding studies that don't pan out. Yet this system still allows manipulation unless all the hundreds of existing medical journals observe the policy.

Most doctors and patient advocates say the only sure fix will be to require registration of all drug trials *at their inception* in a central, publicly accessible database that includes a single, unique identifier for each drug, the intended therapeutic use in each trial, and each trial's protocols, outcomes and results. Advocates want a nonprofit or FDA government registry, perhaps building on the existing, voluntary register (available at www.clinicaltrials.gov) that already lists several thousand trials.

If mandatory, such a registry would enable the FDA to easily consider all trial results—whether they are negative, neutral or positive—when weighing a drug's approval. It would also allow physicians and patients to review trial data by drug, and if sufficiently detailed it might allow independent researchers to do meta-analyses of data from multiple trials, providing the kind of vital perspective the British and U.S. government reviews of SSRIs did.

For a registry to work, advocates also say, Congress must not only make trial registrations mandatory but must give the FDA or the Department of Health and Human Services strong enforcement powers, such as extremely punitive fines, to ensure that the drug companies actually register every trial. They note that the one mandatory trial register already in existence, established in 1997 for drugs and devices aimed at life-threatening conditions, gets only 50 percent compliance from the industry. "Any law establishing a new database has to give the government a big stick," says Kay Dickersin, director of Brown University's Center for Clinical Trials and Evidence-Based Healthcare.

Will it happen? Representatives Edward Markey of Massachusetts and Henry Waxman of California proposed a mandatory trial registration bill in September, and the bipartisan outrage at the congressional hearings suggested its chances were good. But the pharmaceutical industry lobby, one of Washington's most powerful, has resisted this idea for years and will probably oppose the measure vigorously, hoping to satisfy Congress that a voluntary register will suffice. This current Congress is wary of overregulation, and the industry claims that providing all trial data jeopardizes proprietary information and competitiveness.

Much depends on the outcome. A well-enforced, mandatory database seems like the only step that can repair the present system's data quality and confidence problems. Anything less is likely to leave both science and confidence wanting.

To trial registration advocates such as *JAMA*'s Rennie and Brown University's Dickersin, there's a painful irony in all this. "We've been pushing trial registration for over two decades," Dickersin says. "But the drug companies have always fended it off by claiming it infringes on their proprietary interests. It's terrible that we had to get to something that involved children and death to make people see the seriousness of this issue. But perhaps this will finally get the job done."

> At issue is whether the "science" underlying much of our health care deserves that name. **More lives could be in jeopardy.**

DAVID DOBBS, author of the forthcoming ***Reef Madness: Charles Darwin, Alexander Agassiz, and the Meaning of Coral,*** writes from Montpelier, Vt.

(Further Reading)

- Andrew Mosholder's originally blocked report urging new curbs on SSRIs may be viewed at **www.ahrp.org/risks/SSRImosholder/**
- Suppression of Mosholder's findings and testimony is documented by Anna Wilde Mathews's article "In Debate over Antidepressants, FDA Weighed Risk of False Alarm Doubting Data on Suicide and Kids" in *Wall Street Journal;* May 25, 2004. Viewable at **www.ahrp.org/infomail/04/05/25.html**
- **Drug Company Experts Advised Staff to Withhold Data about SSRI Use in Children.** Wayne Kondro in *Canadian Medical Association Journal,* Vol. 170; No. 5; March 2, 2004. Available online at **www.cmaj.ca/cgi/content/full/170/5/783**

If we live in a dog-eat-dog world, then why are we frequently so good to each other?

The Samaritan Paradox

By Ernst Fehr and Suzann-Viola Renninger

Like many members of the animal kingdom, people will readily lend a hand to immediate family and relatives. But humans alone extend altruism beyond kin, frequently helping perfect strangers for no obvious personal gain. Whether we live in large or small groups, in the global network of the New Economy or in the most isolated Yanomami reservation along the border between Venezuela and Brazil, human cooperation in the absence of family ties is widespread across cultures.

On what is this largehearted behavior built? Does each of us possess an inner samaritan who is selfless and community-minded, as philosophers have sometimes proposed [*see box on page 17*]? Or—as many sociobiologists have suggested—are actions that are seemingly done for the benefit of others really motivated by veiled economic calculations and selfishness or by egoism, with an eye to the very long term?

Some of the most fundamental questions about our evolutionary beginnings, social relations and the origins of society are centered on such issues of altruism and selfishness. Recent experiments show that current gene-based evolutionary theories cannot adequately explain important patterns of human altruism, pointing toward the importance of theories of both cultural

BRIAN CRONIN

Whether we live in the New Economy or in an isolated reservation, human cooperation in the absence of family ties is widespread.

NAJLAH FEANNY *Corbis Saba*

FAST FACTS

THE ROOTS OF ALTRUISM

1» Many animals demonstrate forms of altruism toward kin. But only humans go beyond nepotism or tit-for-tat tactics, such as cooperating only when one can expect future benefits or when such actions improve social standing. In experiments, people will reward cooperators and punish those who defect—even when it is costly to do so.

2» Just why this is so has puzzled scientists, because such altruism doesn't provide immediate benefit or personal gain—seemingly reducing the altruist's chances of survival.

3» Recent experiments point the way toward a more nuanced theory of societal origins, combining genetic and cultural evolution.

evolution and the coevolution of genes and cultures.

The idea that selfishness can contribute to the rise and maintenance of a cooperative society is a long-standing topic of political philosophy. At the beginning of the 18th century, in an essay called "The Fable of the Bees," Dutch-born English doctor and philosopher Bernard Mandeville maintained that "private vice" rather than "virtue" was really at the root of all "publick benefit." Morality and the public welfare, he reasoned, were based purely on the egoism of the individual. Further, if each member of society pursued his own best interests consistently, the greatest possible good would result. Mandeville concluded that government would collapse if egoism ceased to motivate our actions.

In an era when ecclesiastical authority imposed religious values, philosophers vociferously rejected Mandeville's ideas. But similar notions were put forth over the subsequent three centuries.

Waxing Philosophical about Human Nature

Why are people altruistic? The question has been a topic of philosophy from its beginnings. Greek philosopher Aristotle, for example, believed that all humans were inherently good but that potential could be realized only within society. He therefore called our species *zoon politikon,* the political animal.

Christianity introduced a view of humans as more flawed. Despite being created in God's image, humans were marred by the failure of sin. Only faith redeemed humans before God—but it did not by any means make them good.

Seventeenth-century English philosopher Thomas Hobbes considered ours to be a species of wild animals that constantly oppress our own kind. Our instinct for self-preservation expressed itself in an unquenchable lust for power, which would inevitably result in a battle of all against all if not for the presence of a king, who made possible social cohesion within a state.

Enlightenment thinkers of the 18th century took a rosier view, believing that goodness and altruism were part of human nature. In his novel *Emile,* French-Swiss philosopher Jean-Jacques Rousseau proposed that the key to happiness for everyone was the free development of each child's personality. By allowing children's naturally good tendencies to unfold, adults would prepare the way for a harmonious society. English philosopher Anthony Ashley Cooper, third earl of Shaftesbury, said that our inborn enthusiasm for the good, the true and the beautiful rendered us so virtuous and decent that a social order might be possible in which, ideally, we could even forgo the sanctions that ensured good behavior. *—E.F. and S.-V.R.*

Charles Darwin's 1859 *On the Origin of Species* posited that any organism that is less than completely engaged in the struggle for food, sex and territory lessens its chances of passing on its characteristics to offspring. In 1874 Darwin wrote that a tribe that collaborated "would be victorious over most other tribes; and this would be natural selection." Nineteenth-century economists and social scientists constructed a theory of *Homo economicus,* according to which *Homo sapiens* strive exclusively to maximize their own advantage.

In 1976 British evolutionary biologist Richard Dawkins reopened the public discussion dramatically with his best-seller *The Selfish Gene*. He argued that molecular genetic material uses its host—whether it is an amoeba, hippopotamus or human—as a "vehicle" to maximize its own propagation. "We are survival machines—robot vehicles blindly programmed to preserve the selfish molecules known as genes," Dawkins wrote.

Following those precepts, altruism becomes a form of disguised egoism. Philanthropy is less the expression of a love of humankind than of the cool calculation of the entrepreneur who seeks to ensure future profit by clever public relations. For example, according to the sociobiology theory of reciprocal altruism, people are most likely to help one another if frequent contact is expected in the future: "I'll scratch your back if you scratch mine." The giver assumes that his generosity will be reciprocated at a later date. Reputation theory, which explains another form of altruism that results in personal gain, proceeds from the assumption that it is generally advantageous to establish a reputation for benevolence and impartiality through the use of well-targeted good deeds. The result is to enhance one's image and improve the potential for long-term profits. *Homo geneticus* is closely allied with *Homo economicus*.

Rising above Nature

But can we simply explain away loving, selfless behavior with such an all-encompassing model? Aren't there countless examples of people coming to the aid of others—even when it is to their personal disadvantage? What about volunteers who risk their lives to help perfect strangers after an earthquake or other disaster? Such self-sacrifice does not follow the rules of evolutionary biology. If the immediate family does not profit and if neither reciprocal aid nor aid aimed at improving reputation promise future advantage, then selflessness gains nothing. Worse, it is costly in terms of resources, health or money. By this logic, there really should not be any good samaritans. Yet they clearly exist.

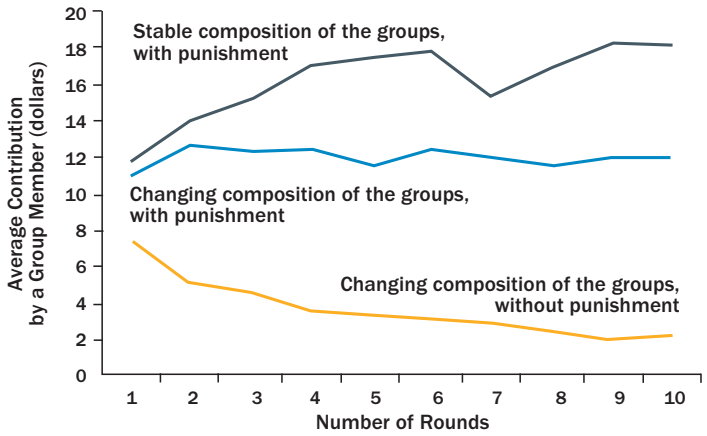
Humans appear to be a special case among animals—a finding supported by a significant number of laboratory experiments conducted by economists and social scientists over the past several years. The experiments come from a relatively new branch of research called experimental economics. The field uses methods such as "punishment"

(The Authors)

ERNST FEHR and SUZANN-VIOLA RENNINGER cooperated in the writing of this article. Fehr is director of the Institute for Empirical Economic Research at the University of Zurich in Switzerland. Renninger, a biologist, has a Ph.D. in philosophy and works as a journalist in Zurich.

Altruism is costly in terms of resources, health or money. By this logic, there really should not be any good samaritans. Yet they clearly exist.

Trust but Verify



In an experiment, groups of four participants could invest portions of their initial individual capital of $20 in a project for the public good. If the players were permitted to punish noncontributors with fines, the level of cooperation was consistently higher—even when the groups were shuffled and the punishers and those punished did not play together in subsequent rounds.

games, which show that many people—even when facing high monetary stakes—are willing to penalize others at a cost to themselves to prevent unfair outcomes or to sanction unfair behavior.

We conducted one such experiment with 240 male and female students at the University of Zurich. Each person sat at a computer terminal in a sort of compartment isolated visually and acoustically from everyone else. Network connections linked groups of four, who played the game together. None of the players knew with whom they were playing, because their various partners were identified only by numbers on a computer display. After each of six rounds, the approximately 60 groups were randomly reconstituted.

A Free Ride?

At the beginning of a round, all participants received a virtual sum equivalent to $20 as start-up capital; they would be able to convert their virtual currency into real money at the end, so they were motivated to consider carefully how they played the game. The players in each quartet could choose to invest all or part of their money in a common project that consisted of some public good. Economists define a public good as any social institution or service from which everybody profits, even if everyone does not contribute to it. In the experiment we never told the participants exactly what constituted the public good; they were to infer this from what ensued.

After every round, the chief investigator increased the total sum pooled by each group of four by 60 percent and distributed the proceeds evenly among all four members, regardless of the amount of each individual's contributions. In the best-case scenario, all four players invested their entire initial capital, and each then received $32 ($12 profit plus the initial capital) for the round. If the test subjects contributed a total of only $40 to the public good, this amount was then increased to $64, and each participant got back $16. In this case, a person who paid nothing, called a free rider, received the same $16 profit as everyone else. A player who invested $10 netted $6. Someone who invested his entire wad of $20 ended up an exploited dupe; he lost $4.

For the individual selfish actor behaving rationally, it would be unwise to invest so much as a single cent under these conditions, because each dollar invested in the public good returns a mere 40 cents, a net loss of 60 cents. In other words, a player who invests nothing is guaranteed at least her initial $20, plus her share of the proceeds (assuming, of course, that the other players are willing to cooperate and trust in the process). The dilemma for the test subject was that if no one else invested in the project, she took home only her initial capital.

Up to this point, the setup is similar to the classic public-good experiments that economists have done for close to 20 years. But our trial went one crucial step further. After each of the four members had made their investment decisions, we told them how much the other three players had paid in, and we gave them the option of punishing free riders by reducing their profits as much as they deemed just. If a player decided to penalize the free riders, the chief investigator reduced his assets. Applying a fine of $3 cost the punisher $1; a docking of $6 cost $2, and so on.

The results will surprise proponents of the *Homo economicus* model: far more than 80 percent of participants penalized another player at

least once during the six rounds, even though doing so cost them and they gained no immediate advantage. More than 30 percent meted out punishment during each round. The free riders suffered the most. The less they contributed to the common project, the higher the penalty they received. And participants who invested more than an average amount in the public good were far more likely to penalize others.

To get a better understanding of the effects of such sanctions, we carried out a variant of the experiment. The procedure was identical, except we gave no provision for punishment. Almost 95 percent of the participants invested considerably less than we had observed in the earlier game. In fact, during the last round, 60 percent contributed nothing to the public good, compared with three quarters of the players who ponied up $15 or more when a penalty was at stake [*see box on opposite page*].

How can we explain such results? It is clear that in the first version of the experiment, the threat of penalty was not the only reason for the surprisingly high level of cooperation. The actual penalty was important as well: castigated free riders invested an average of $1.50 more in the public-good project during the next round. Rebuke for unfair behavior thus led to improved cooperation in subsequent rounds.

The only players who derived no advantage were those meting out the punishment. They got nothing from correcting the behavior of the free riders, because they were not in the same quartet during the next round. The punishment benefited some other, unknown players. In other words, those who made cooperation possible by threatening sanctions acted altruistically and apparently without considering personal advantage. Sociobiologists call this behavior strong or true altruism to differentiate it from the weak or false altruism of nepotism or actions that anticipate later payback. The strong altruist is one who does good out of motives other than mere nepotism or strategic gain.

Evolutionary theorists have sometimes argued that strong altruism is maladaptive, a kind of evolutionary carelessness. At its core, this argument states that an altruistic behavior that may have been appropriate and successful at one time has become disadvantageous in changed circumstances. The forebears of *Homo sapiens* lived in small, largely isolated groups and were extremely dependent on one another. Uncooperative group members who behaved unfairly would have been excluded from rewarding group activities or even punished. In this situation, free riding did not pay. Encounters with outsiders, which are typical in modern societies, were rare. As a result, there was little evolutionary pressure to differentiate between these two social situations. According to the maladaptation argument, a person living in today's world who demonstrates true altruism in an experiment may in fact be unable to make this crucial differentiation.

The members of the colonies of naked mole rats forgo reproduction in favor of their queen and spend their lives toiling on her behalf. Only humans cooperate with strangers and act with no prospect of reward.

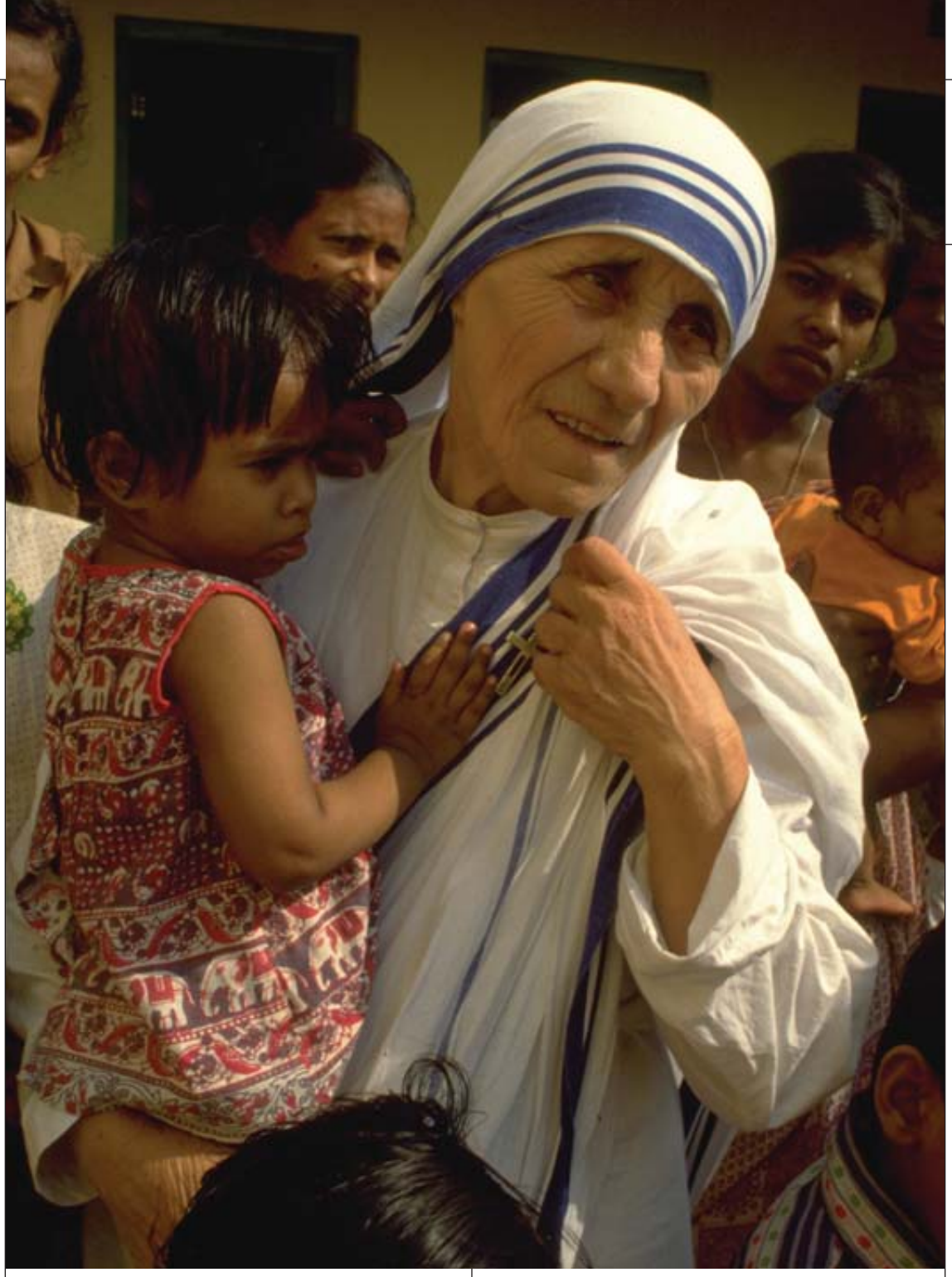
Seen from this perspective, strong altruism is merely a kind of habit—the experiments' participants had not internalized the fact that the members of their quartet would be shuffled after each round. As a result, they behaved as if they would always be dealing with the same people. Their altruism was based on considerations that, though apparently inappropriate to the situation, were nonetheless strategically plausible for survival—that is, they were selfish.

To test this hypothesis, our team conducted a third experiment, in which the composition of the groups remained unchanged for 10 rounds. If the maladaptation argument were correct, the test subjects should have acted exactly the same as when the groups were changed after each round.

But the results did not support this hypothesis. In the groups in which the players got to know one another, payments to the common project rapidly increased after the first round by an average of 50 percent more than those in the groups whose members were shuffled after each round.

Rise of Altruism

Now that we know that a body of evidence supports the notion that *Homo sapiens* is the only species capable of strong altruism, the question becomes, How did this characteristic arise? Natural scientists always consider the possible genetic basis for altruistic behavior. In so doing, however, they quickly find themselves contradicting the selfish-gene theory. In the final analysis, if genes caused their "vehicle" to engage in disadvantageous be-



Mother Teresa, for many people, exemplified charity. Exactly what drives people to selfless behavior is the subject of research in various disciplines.

CORBIS SYGMA

havior, that vehicle would soon self-destruct. And then the egoists would have the world to themselves.

A possible way out of this dilemma might have been that altruists exclusively populated some early communities. Such communities could have flourished because the altruists would not have been exploited by free riders. An aspect of evolutionary theory called group selection could support such an idea, and therefore also the development of altruistic behavior. In this model, groups compete for resources just as individuals do and are equally subject to selection. If one band is more successful than another because of some special characteristics of its members—such as a greater capacity for selfless cooperation—then it seems reasonable that their chance of long-term survival should be greater.

But group selection has been anathema to sociobiologists for the past 40 years, because the conditions under which it might operate are almost never met empirically. The biggest problem for group selection favoring altruistic societies is

> An egoist in a group inhabited by altruists was probably punished by altruists who did not care whether they derived personal advantage.

posed by the infiltration of egoists. As soon as any egoists gain entry, their chance of survival becomes much greater than that of the altruists, because they do not bear the costs of the public goods whose benefits they enjoy just the same. This means that they would tend to have the opportunity to reproduce more abundantly than their altruistic neighbors and thus would increasingly push them to the margins. After some time, communities that had previously been dominated by altruists would no longer differ from others, and group selection would no longer be effective.

Cultural Evolution

Anthropologists Robert Boyd of the University of California at Los Angeles and Peter Richerson of the University of California at Davis propose another hypothesis, which may support differences between groups during the early stages of human development. This idea is based on the theory of coevolution, in which nature and culture intertwine and interact in the formation of genetic and *cultural* characteristics. The capacity of human beings to learn is crucial for such a hypothesis to take hold. As they put it in "Cultural Evolution of Human Cooperation," a chapter in *Genetic and Cultural Evolution of Cooperation,* edited by Peter Hammerstein (MIT Press, 2003): "We believe that the human capacity to live in larger-scale forms of tribal social organization evolved through a coevolutionary ratchet generated by the interaction of genes and culture. Rudimentary cooperative institutions favored genotypes that were better able to live in more cooperative groups. Those individuals best able to avoid punishment and acquire the locally relevant norms [of behavior] were more likely to survive."

When an egoist immigrated to a group inhabited by altruists, he was probably punished for his actions by the altruists who did not care whether they derived personal advantage from their action. As a result, the egoist's behavior brought him only disadvantage, and in all likelihood he sooner or later began to imitate the predominant selfless behavior. This effectively put a stop to the damaging infiltration of the society by egoists, enabling the group to prosper. No well-established analytical or population genetic models yet support this hypothesis. But using computer simulations, Boyd and his colleagues have demonstrated that such a scenario is plausible. Some combination of cultural and genetic factors may preserve and perpetuate these altruistic tendencies through the subsequent generations.

PHOTODISC/GETTY IMAGES

Business deals largely depend on reciprocity. Selflessness is something else.

Richard Dawkins once challenged readers "to teach generosity and altruism, because we are all born selfish." We argue that this well intended advice can now be reframed. We still should promote tolerance, generosity and altruism, but educators will find encouragement in current research that suggests not only are we capable of altruism, it is possible that our genes even guide us toward such behavior. Perhaps we are born with the potential to be *selfless*.

In an age of enlightenment and secularization, scientists such as Charles Darwin shocked contemporaries when they questioned the special status of human beings and attempted to classify them on a continuum with all other species. Humans were stripped of all that was godlike. Today biology is restoring to them something of that former exalted position. Our species is apparently the only one with a genetic makeup that promotes selflessness and true altruistic behavior.

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HOW GROUP-THINK MAKES KILLERS

Lost in a crowd, average individuals can become exceptionally virtuous or deadly. Their behavior depends on how they believe they are expected to act

BY BERND SIMON

The prison cell is small and dirty. Three men in bleached garments are cowering on the bare floor. Silent, they wince at every noise from down the corridor. Suddenly, two men in uniforms and sunglasses appear at the cell door, smacking their batons into their hands. Violence is imminent.

Six days earlier both the inmates and the guards had been regular college kids. It was 1971, and they were about to start living a two-week experiment designed by psychologist Philip G. Zimbardo. The Stanford University researcher randomly divided a group of mentally healthy students into "guards" and "inmates" who would inhabit a simulated prison on campus. Zimbardo had to stop the experiment prematurely after only six days, because the guards had become sadistic, abusing the inmates physically and mentally.

How could peaceful young men change so horribly and so quickly? At the time, Zimbardo had a simplistic answer: Hidden in the anonymity of a crowd, humans lose all restraints and flout ethical norms. People in a mob are lawless herd animals without control or pity.

Today Zimbardo's classic, disturbing study is often cited to support the idea of the "evil collective." But is this view justified? Recent research suggests that although groups do sway their members into behaviors they would not exhibit during normal daily life, those actions are just as likely to be positive as negative. In late 2001, when British psychologists Stephen D. Reicher and S. Alexander Haslam repeated the inmate experiment for what was to become a reality-TV show aired by the British Broadcasting Corporation (BBC), the guards acted rather insecurely.

Given the contradictory results, Haslam and Reicher concluded that the behavior of a group depends on the members' expectations of the social role they should play. If they believe they are expected to exhibit authoritarian conduct, abuse is likely. Zimbardo, for example, encouraged the guards to behave threateningly. The key to which way a group's individuals will go is their preconditioned beliefs about what they ought to do.

Although psychologists may disagree over whether individuals in a given crowd might turn angelic or ugly, they do agree on one fundamental point: lost in a collective, the individual outgrows himself, for good or bad.

Giving Up "I" for "We"

Group dynamics and mass movements are fascinating because of the extremes to which they can push people. An individual in one team of volunteers risks his life to save a child from slipping under rapidly rising floodwaters, whereas another willingly sacrifices himself as a suicide bomber for the sake of a "higher" collective goal. Such exhibitions have occurred throughout history, from the mob calling for the crucifixion of Jesus to global goodwill during the most recent Olympic Games in Greece.

Often people's fears of mob mentalities lead them to expect groups to wield dark traits, even though history shows, for example, that positive social change is often impossible without mass movements. The rise of human rights, the fall of the Berlin Wall, environmental protection—many recent advances have resulted from the massive engagement of people who campaigned for a common good, putting their personal interests behind

After only six days, Stanford University psychologists had to stop a study in which students assumed the roles of prison guards and inmates in a makeshift prison. The guards were abusing the prisoners, believing they should act that way. Here a dramatization of one confrontation in the 2001 German movie *Das Experiment.*

DEFD

The rise of human rights and the fall of the Berlin Wall resulted from **people who put their personal interests second** to goals of the common good.

FLIP SCHULKE *Corbis*

Individuals are emboldened to oppose authority when campaigning together for a group's common goal, such as these civil-rights activists at a rally before a voting-rights march from Selma to Montgomery, Ala., in March 1965.

what was needed to achieve it. The BBC experiment further demolishes the widespread negative view that in a crowd, an individual's identity dissolves and the person is carried away to commit immoral, irrational deeds.

By now, social psychologists have largely demystified collective behavior, showing that normal, scientifically explainable psychological actions are taking place. The psychology of the collective is not pathological. But certainly an individual's identity is to some degree depersonalized when he or she joins a social group, whether it is a political action committee, sportsman's club or symphony orchestra.

But is that enough to allow someone to lose all sense of morality and commit harm? The complex interaction between "I" and "we" has been confounding scientists for a century. In his 1895 book *Psychologie des Foules* (*Psychology of the Masses*), French physician and sociologist Gustave Le Bon maintained that individuals in a group lose their identity and thus self-control. Guided only by emotions and instincts, they operate under a primitive force, which he called the "racial unconscious."

Fanatical Norms

Other researchers claimed that the collective had an independent mental consciousness. British-born psychologist William McDougall, who formulated the so-called group-mind hypothesis at the beginning of the 20th century, said that whoever joins a crowd gives up his identity in favor of a "collective soul."

Le Bon's and McDougall's theories later met with skepticism; in particular, the idea of a mass with its own mental perception was deemed to be too metaphysical. But the notion of an individual's loss of identity survives. After Zimbardo's work, the notion was further bolstered in the 1970s by studies of so-called minimal groups. In these experiments, participants were randomly assigned to groups according to trivial criteria, such as clothing choices. Even though the assignment was arbitrary, in most cases it created a strong group sense and analogous behavior.

Based on these trials, psychologists Henri Tajfel of the University of Bristol in England and John C. Turner, now at the Australian National University in Canberra, formulated in the early 1980s the "so-

In close quarters, opposing groups can turn on one another or unite against outsiders who threaten both groups, such as these Sampdoria soccer fans who battled riot police during a January 2004 match against AS Roma in Rome.

cial identity theory." It stated that belonging to a group created a "we feeling" in an individual, a sense of a "collective self." The more a person engages in a collective, the stronger he identifies with it and the more he accepts the group's values and norms. The norms can range from willing self-destruction, akin to that exhibited by cults such as the Branch Davidians in Waco, Tex., to utopian socialism on collectives such as the kibbutz in Israel. In contrast to Le Bon's and McDougall's models, social identity theory holds that individuals are not swept away by group-think but choose to perceive, feel, think and act in common ways.

Nevertheless, group motives can arise and merge with each person's own—sometimes so completely that the purpose of the group stands above everything else. The individual may then make great personal sacrifices for the supposed common good. Suicidal terrorist bomb attacks are dire testimony to how far such actions may go. Aggressive behavior is more likely to erupt if the collective self gains control over an individual's perception and actions. The person then no longer distinguishes between "I" and "you" but only between "we" and "the others."

This dynamic can also arise sporadically in those who carry on regular lives, such as the nice neighborhood man who mutates every Saturday into a rowdy soccer fan, loudly cursing the other team's fans. For him, this position is a logical outcome of his deep loyalty to the "we" of his beloved

Inhibitions are easily lost when Individuals are cloaked in the anonymity of a supportive crowd.

club. In the best case, this fan will ignore the "alien" group—the others—but he can just as easily become degrading and hostile toward them. This transformation is not so much a manifestation of a mysterious mass psyche but more a rational collective act that conforms to established rules. The soccer fan lets loose his battle cries at the stadium to help the team win.

If the game is lost and the fan's frustration turns into violence, it is not indiscriminate; it is directed against the alien group, recognizable by their in-

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PATRICK HERZOG *AFP/Getty Images (top)*; FIRSTLIGHT/IMAGESTATE *(bottom)*

An individual who knows how to persuade can lead a group astray. In April 1993 David Koresh led more than 70 followers to a fiery death at the Branch Davidian compound in Waco, Tex. Here a woman recalls the tragedy at a Waco memorial service three years later.

ERIC GAY *AP Photo*

signias and scarves. Yet sometimes the border between "we" and "they" can shift surprisingly. Warring fans can suddenly turn together against riot police. In socially tumultuous neighborhoods, members of antagonistic ethnic groups may find themselves united in fighting what they perceive to be unjust police crackdowns. Uncooperative social groups can even come together nationwide, as happened in the U.S. after the September 11 terrorist attacks.

Casting the First Stone

These situations do not explain, however, how a peaceful demonstration can suddenly turn into a

A suicidal terrorist's consciousness has become fully engulfed by the collective. Sacrificial death becomes the highest form of self-realization.

stone-throwing mob. The crucial factor seems to be that isolated actions by individuals can catalyze the group. If the first stone thrower is unambiguously recognizable as a member of the collective, for instance, by his attire or slogans, his action ends any uncertainties the others may have had about the role they are expected to play. They quickly emulate the role model's behavior.

Such infectious actions can erupt particularly easily within a group that does not have a strong leader or a firmly established code of behavior. Without clear direction, the participants gratefully emulate any putative role model. Mobs and riots follow their own impromptu norms.

But why should an individual in an anonymous crowd follow any rules? Hidden in anonymity, he or she should easily escape the laws of the collective without fearing any sanctions. But several studies show that anonymity actually increases a person's willingness to join in unusual behavior.

Unfortunately, sporadic conformity can prompt people to disregard behavioral rules learned during healthy socialization, such as "Be polite to other people." In civilized society, most humans do not want to harm others. But as Zimbardo's experiment showed, situation-specific norms can arise, and adherence to them can be reinforced by anonymity. To some degree, people in a group are emboldened because they think that others in the crowd are more likely to support their behavior. If test subjects assume the role of prison guards, aggression may well become the norm for that situation; everyone "knows" from movies and from hearsay that prison guards must discipline inmates and typically with force.

Leading the Masses

But what makes people in real life unite and engage in clubs, organizations or demonstrations? In the past, sociologists thought that an individual who joined a mass movement was a concealed egoist. Whether and how intensely he engaged in a group depended on his personal "cost-benefit analysis"—what he stood to gain or lose for himself. Today we know that most members are driven by their collective self-image.

Anyone who knows how to influence that collective self-understanding can lead the masses to great heights, such as Martin Luther King, Jr., but also can lead them astray. This ability underlies the charisma of sect leaders and revolutionaries. Their psyches, however, have evolved even further from normal. If a war hero or terrorist sacrifices his life for a collective, he does not necessarily make a flawed cost-benefit analysis. Basically, he no longer calculates his personal well-being against possible pain or death. His consciousness has become fully engulfed by the collective. Sacrificial death becomes the highest form of self-realization.

Our new-won knowledge about mass psychology may help us resist the seduction of demagogues in the future. Meanwhile it allows us to appreciate the creative forces of the collectives and social movements that continue to make many social advances possible.

KYODO/LANDOV

A freedom fighter, soldier or terrorist may sacrifice his life for a collective because his consciousness has become fully subsumed in the group's goal.

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Stressed-Out Memories

A little stress sharpens memory. But after prolonged stress, the mental picture isn't pretty

By Robert M. Sapolsky

Your first kiss. Your wedding ceremony. The time the car spun out of control and just missed the oncoming truck. Where you were when the earthquake hit, when Kennedy was shot, on 9/11. Each detail of such life-changing events is etched forever in your mind, even though you may not recall the slightest thing about the 24 hours beforehand. Arousing, exciting, momentous occasions, including stressful ones, get filed away very readily. Stress can enhance memory.

We've all had the opposite experience when under stress as well. The first time I met my future wife's family, I was nervous as hell; during a frantically competitive word game after dinner, I blew the lead of the team consisting of my future mother-in-law and me by my utter inability at one critical juncture to remember the word "casserole." Some instances of failed memory revolve around infinitely greater traumas: the combat veteran who went through some unspeakable battle catastrophe, the survivor of childhood sexual abuse—for whom the details are lost in an amnesic fog. Stress can disrupt memory.

For researchers like me who study stress, this dichotomy is quite familiar. Stress enhances some function under one circumstance and disrupts it under another. Recent research shows just how short-term stressors of mild to moderate severity enhance cognition and memory, whereas major or prolonged stressors disrupt them.

Memory Basics

To understand how stress affects memory requires some background on how memories are formed (consolidated), how they are retrieved and how they can fail.

Memory is not monolithic but comes in different flavors. One particularly important di-

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chotomy distinguishes short-term versus long-term memories. With the former, you look up a phone number, sprint across the room before you forget it, then punch in the digits. And then the number is gone forever. In contrast, long-term memory refers to recalling what you had for dinner last night, how many grandchildren you have, where you went to college.

Another important distinction is that between explicit (also known as declarative) and implicit (which includes an important subtype called procedural) memory. Explicit memory concerns facts and events, along with your conscious awareness of knowing them: I am a mammal, today is Monday, my dentist has thick eyebrows. In contrast, implicit procedural memories are about skills and habits, about knowing how to *do* things, even without having to think consciously about them: shifting the gears on a car, riding a bicycle, doing the fox trot. Given enough practice, such memories can be transferred between explicit and implicit forms of storage.

Just as there are different types of memory, different areas of the brain are involved in information storage and retrieval. One critical site is the cortex, the vast and convoluted surface of the brain. Another is a region tucked just underneath part of the cortex, called the hippocampus. If you want a totally simplistic computer metaphor, think of the cortex as your hard drive, where memories are stored, and your hippocampus as the keyboard, the means by which you place and access memories in the cortex. Last, brain structures that regulate body movements, such as the cerebellum, are involved with implicit procedural memory.

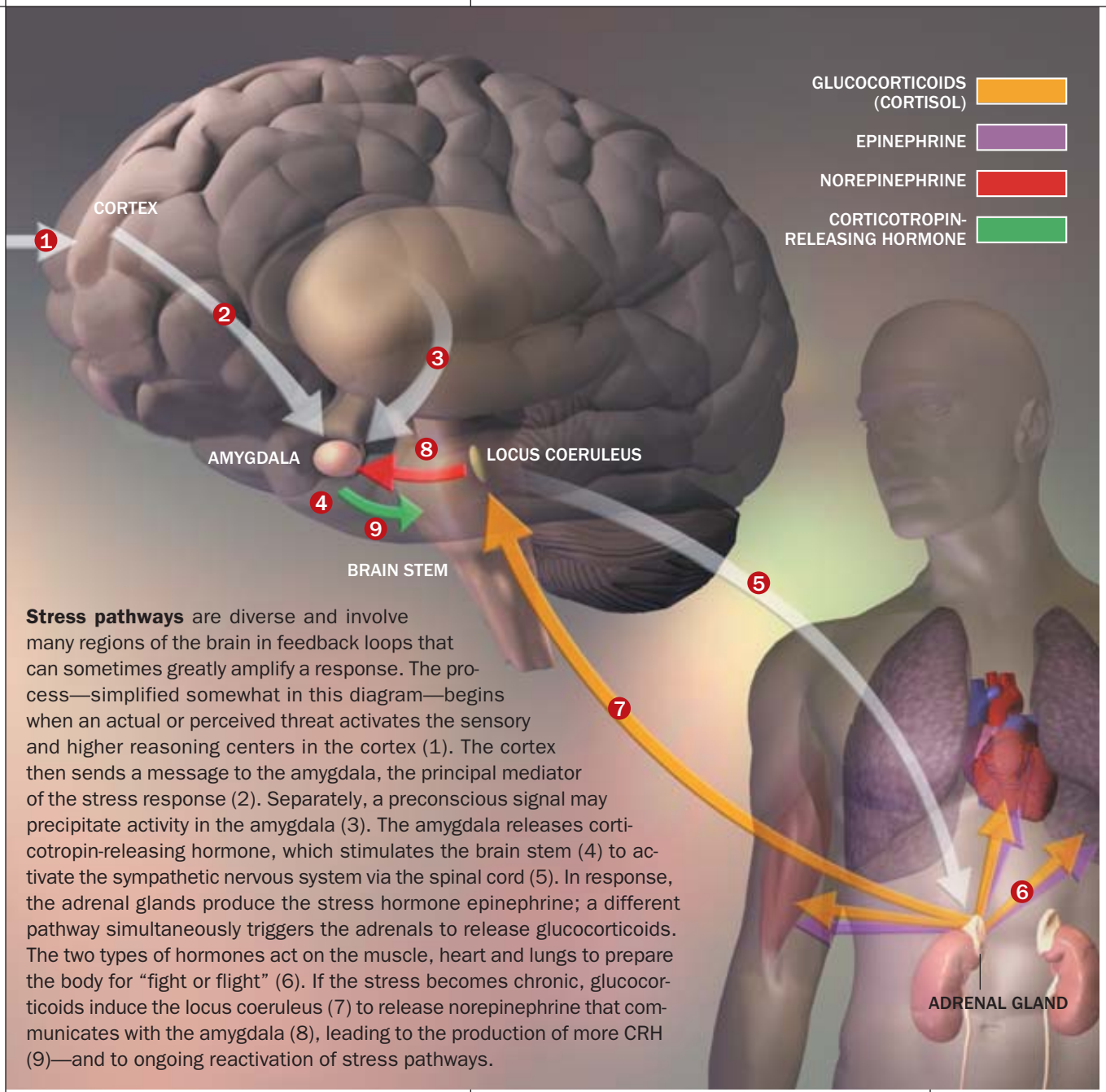
Now let us shift to the next magnification to examine what goes on at the level of clusters of neurons within the cortex and hippocampus. Knowledge is stored in the patterns of excitation of vast arrays of neurons—in trendy jargon, in neuronal "networks." We take advantage of such convergent networks whenever we are trying to grasp a memory that is almost, almost there. Suppose you are trying to remember the name of a painter, that guy, what's his name? "He was that short guy with a beard [activating your "short guy" and your "bearded guy" networks]. He painted all those Parisian dancers; it wasn't Degas [two more networks pulled in]. Wow, remember that time I was at the museum and there was that really cute person I tried to talk to in front of one of his paintings … oh, what was the stupid pun about that guy's name, about the train tracks being too loose?" With enough nets working, you finally stumble into the one fact at the intersection of all of them: Toulouse-Lautrec.

Neuroscientists have come to think of both learning and storing of memories as involving the "strengthening" of some network branches rather than others. To see how that occurs, we switch to a final level of magnification, to consider the tiny gaps between the thready branches of two neurons, called synapses. When a neuron wants to pass on some fabulous gossip, when a wave of electrical excitation sweeps over that brain cell, this wave triggers the release of chemical messengers—neurotransmitters—that float across the synapse and excite the next neuron. Dozens, probably hundreds, of kinds of neurotransmitters exist, and synapses in the hippocampus and cortex disproportionately make use of what is probably the most excitatory neurotransmitter, called glutamate.

"Glutamatergic" synapses have two properties critical to memory. First, they are nonlinear in their function. In a run-of-the-mill synapse, a little bit of neurotransmitter from the first neuron causes the second to get a little excited; if a smidgen more neurotransmitter becomes available, a smidgen more excitation occurs and so on. With glutamatergic synapses, some glutamate is released, and nothing happens. A larger amount is released, and still nothing happens. But when a certain threshold is passed, all hell breaks loose in the second neuron, and a massive wave of excitation follows. And this wave is what learning is about.

The second feature is even more important. Under the right conditions, when a synapse has had a sufficient number of superexcitatory glutamate-driven experiences, it becomes persistently more excitable. That synapse just learned something; that is, it was "potentiated," or strengthened. From then on, it takes less of a signal to recall a memory. We can now see what happens when the system reacts to stress.

Each detail of life-changing events is etched forever in your mind, even though you may not recall the slightest thing about the 24 hours beforehand.



Stress pathways are diverse and involve many regions of the brain in feedback loops that can sometimes greatly amplify a response. The process—simplified somewhat in this diagram—begins when an actual or perceived threat activates the sensory and higher reasoning centers in the cortex (1). The cortex then sends a message to the amygdala, the principal mediator of the stress response (2). Separately, a preconscious signal may precipitate activity in the amygdala (3). The amygdala releases corticotropin-releasing hormone, which stimulates the brain stem (4) to activate the sympathetic nervous system via the spinal cord (5). In response, the adrenal glands produce the stress hormone epinephrine; a different pathway simultaneously triggers the adrenals to release glucocorticoids. The two types of hormones act on the muscle, heart and lungs to prepare the body for "fight or flight" (6). If the stress becomes chronic, glucocorticoids induce the locus coeruleus (7) to release norepinephrine that communicates with the amygdala (8), leading to the production of more CRH (9)—and to ongoing reactivation of stress pathways.

ALFRED T. KAMAJIAN

Add a Little Stress . . .

The first point, of course, is that mild to moderate short-term stressors enhance memory. This is the sort of optimal stress that we would call "stimulation"—it makes us feel alert and focused. Larry Cahill and James McGaugh of the University of California at Irvine carried out one particularly elegant study in this realm. Test subjects who heard a tale with an exciting passage remembered the emotional components better than subjects who heard a uniformly dull story. The study also indicated how this effect on memory works. Hear a stressful story, and a stress response is initiated [*For more on stress pathways, see illustration above*]. The sympathetic nervous system kicks into gear, pouring epinephrine and norepinephrine into the bloodstream. Sympathetic stimulation appears to be critical, because when Cahill and McGaugh gave subjects a drug (the beta blocker propranolol, the same medication used to lower blood pressure)

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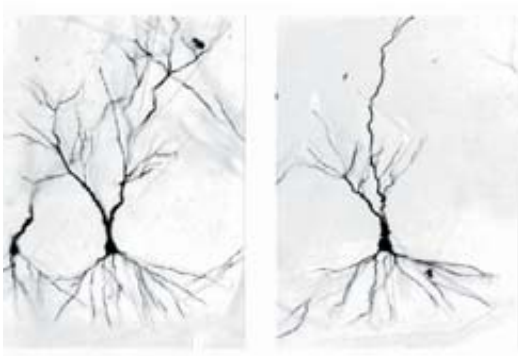
to stall the system's activation, the experimental group did not remember the livelier story any better than the controls remembered theirs. It's not that propranolol obstructs memory formation. Rather the drug disrupts stress-enhanced memory formation. In other words, the experimental subjects did as well as the controls on the boring parts of the story but didn't get the boost in memory for the emotional section.

The sympathetic nervous system indirectly arouses the hippocampus into a more alert, activated state, which in turn facilitates memory consolidation. This involves an area of the brain that is also central to understanding anxiety, the amygdala. The sympathetic nervous system also helps the energy needs of potentiating neurons to be met by mobilizing glucose into the bloodstream and increasing the force with which blood is pumped into the brain. An important class of hormones released in response to stress are glucocorticoids. Secreted by the adrenal gland, they often act in ways similar to their more famous cousin, epinephrine (also known as adrenalin). Epinephrine acts within seconds; glucocorticoids back up this activity over the course of minutes or hours.



Healthy neurons of the hippocampus of a rat (left) shrink after prolonged stress (right).

As it happens, a mild elevation in glucocorticoid levels smoothes the progress by which synapses in the neocortex and hippocampus become more sensitive to glutamate signals, the long-term potentiation that is the building block of learning.

A mild elevation in glucocorticoid levels smoothes the progress of long-term potentiation in the hippocampus as well. Finally, there are some obscure mechanisms by which moderate, short-term stress makes sensory receptors more sensitive. Taste buds, olfactory receptors, the cochlear cells in the ears all require less stimulation under moderate stress to get excited and pass on the information to the brain.

Too Much of a Good Thing

We can now look at how memory formation and retrieval go awry when stressors become too big or prolonged. Numerous studies with lab rats—using an array of stressors, including restraint, shock, exposure to the odor of a cat—have shown a resulting decline in explicit memory. A similar deficit appears when high doses of glucocorticoids are administered to rats. Other aspects of brain function, such as implicit memory, remain fine.

The picture is much the same in humans. Problems with explicit memory appear in patients who suffer from a disorder called Cushing's syndrome, in which tumors cause the secretion of tons of glucocorticoids. Prolonged treatment with synthetic glucocorticoids, which are often administered to people to control autoimmune or inflammatory disorders, results in explicit memory problems as well. As the clearest evidence, just a few days of high doses of synthetic glucocorticoids impairs explicit memory in healthy volunteers.

How does prolonged stress disrupt hippocampus-dependent memory? A hierarchy of effects has been shown in laboratory animals.

First, hippocampal neurons exposed to high glucocorticoid levels no longer work as well. Stress can disrupt long-term potentiation in that brain region even in the absence of glucocorticoids (as in a rat whose adrenal glands have been removed). Extreme arousal of the sympathetic nervous system seems responsible for this effect.

In the mid-1980s Ron de Kloet of the University of Utrecht in the Netherlands discovered the mechanisms behind the disruption caused by exposure to high glucocorticoid levels. The hippocampus has large amounts of two types of glucocorticoid receptors. Notably, the hormone is about 10 times better at binding to one kind (a "high-affinity" receptor) than the other. If glucocorticoid levels rise only a little bit, most of the hormone effect in the hippocampus is mediated by that high-affinity receptor. In contrast, the hormone released during a major stressor activates a lot of the low-affinity receptor. And, logically, it turns out that activation of the high-affinity receptor enhances long-term potentiation, whereas the low-affinity one does the opposite.

In the second of the hierarchy of effects, during major stressors the amygdala sends a large, influential neuronal projection to the hippocampus. Activation of this pathway seems to be a prerequisite for stress to disrupt hippocampal function. Destroy a rat's amygdala or sever its connection to the hippocampus, and stress no longer impairs the kind of memory that the hippocampus mediates, even amid high glucocorticoid levels.

Third, neural networks in the hippocampus start to become disconnected. Bruce S. McEwen of

BRUCE S. McEWEN AND ANA MARIA MAGARIÑOS *Rockefeller University*

the Rockefeller University has shown that in a rat, after as little as a few weeks of stress or exposure to excessive glucocorticoids, cellular communication cables known as dendrites begin to shrivel, atrophy and retract [*see illustration on opposite page*]. Fortunately, it seems that at the end of the stressful period the neurons can dust themselves off and regrow those connections. Memories are not lost, just harder to access.

Fourth, prolonged stress inhibits the birth of new neurons in the hippocampus, which was recently discovered to be one of only two sites in the adult brain where new neurons can arise. When the stress stops, does neurogenesis recover and, if so, how fast? No one knows. Also, does it matter that stress hinders adult neurogenesis? Intrinsic in this question is the larger issue of what adult neurogenesis is good for. The jury is still out on this one, too.

Fifth, if hippocampal neurons experience an insult (such as from a stroke or seizure), stress makes them more susceptible to dying. By about 30 minutes into a continuous stressor, glucose delivery is no longer enhanced and has returned to normal levels. If the stressor continues, the delivery of glucose to the brain becomes inhibited. My lab and others have shown that the relatively mild energy problem caused by that inhibition makes it harder for a neuron to contain the eleventy things that go wrong during neurological insults.

Finally, some studies appear to suggest that glucocorticoids and stress may even kill neurons outright, although the results are preliminary and controversial.

These findings have some disturbing implications. About 16 million prescriptions are written annually in the U.S. for glucocorticoids. Much of the use is benign—a little hydrocortisone cream for some poison ivy, a hydrocortisone injection for a swollen knee, steroid inhalants for asthma. But hundreds of thousands of people take high doses of glucocorticoids to suppress the inappropriate immune responses in autoimmune diseases (such as AIDS, lupus, multiple sclerosis or rheumatoid arthritis). So should you avoid taking glucocorticoids for your autoimmune disease to avoid the possibility of accelerated hippocampal aging down the line? Almost certainly not: these are often devastating diseases, and glucocorticoids are often highly effective treatments. Potentially, the memory problems are a particularly grim and unavoidable side effect.

Neurologists also use synthetic versions of glucocorticoids (such as hydrocortisone, dexamethasone or prednisone) to reduce brain swelling after a person has had a stroke. Glucocorticoids do wonders to block the edema that occurs after something like a brain tumor, but it turns out that they don't do much for poststroke edema. Worse, there is increasing evidence that these famously anti-inflammatory compounds can actually be pro-inflammatory in certain types of injured brains. An even more troubling implication of these findings is that what we think of as typical amounts of brain damage after a stroke or seizure are actually worsened by the natural release of glucocorticoids as part of the stress responses our bodies have at such times.

> There simply has not been much **evolutionary pressure to make the body's response** to massive neurological injury more logical.

Consider how bizarre and maladaptive this is. Lion chases you, and you secrete glucocorticoids whose primary effects on metabolism throughout the body are to divert energy to your thigh muscles for sprinting: great move. Go on a blind date, get nervous and you secrete glucocorticoids to divert energy to your thigh muscles: probably irrelevant. Have a grand mal seizure, secrete glucocorticoids to divert energy to your thigh muscles—and your brain damage becomes more severe.

How did such maladaptive responses arise? The most likely explanation is that the body simply has not evolved the tendency *not* to secrete glucocorticoids during a neurological crisis. Stress-induced glucocorticoid secretion works roughly the same in all mammals, birds and fish, and only in the past half a century have Westernized versions of just one of those species had much of a chance of surviving something like a stroke. There simply has not been much evolutionary pressure to make the body's response to massive neurological injury more logical.

We are now 50, 60, years into thinking about ulcers, blood pressure and aspects of our sex lives as being sensitive to stress. We also now recognize the ways in which stress can interfere with how we learn and remember. The noted neuroscientist Woody Allen once said, "My brain is my second-favorite organ." My guess is that most of us would rank our brains even higher up on the list.

DIGITAL VISION/GETTY IMAGES

Treating Depression: Pills or Talk

Medication has reduced depression for decades, but newer forms of psychotherapy are proving their worth

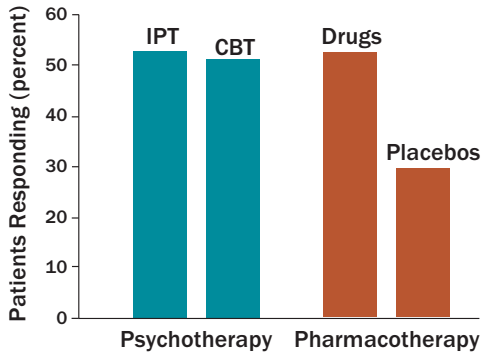
BY STEVEN D. HOLLON, MICHAEL E. THASE AND JOHN C. MARKOWITZ

For decades, the public and most mental health professionals have felt that antidepressant medications are a magic bullet for depression. Beginning in the late 1950s, antidepressants ushered in an era of safe, reliable and reasonably affordable treatment that often produced better results than the psychotherapies of the day. As the compounds rose in popularity, many physicians came to view psychotherapy alone as ineffective and as little more than a minor adjunct when combined with medication.

This is no longer the case, if it was ever true. Contrary to prevailing wisdom, recent research suggests that several focused forms of psychotherapy may be as effective as medication, even when treating more severe depressions. Moreover, the newer psychotherapies may provide advantages beyond what antidepressants alone can achieve. Nevertheless, pharmaceutical therapy remains the current standard of treatment, and effective new options are being added all the time.

These trends are important to examine because depression exacts a significant toll on society as well as individuals. Depression is one of the most common psychiatric disorders and is a leading cause of disability worldwide. The impact of mood disorders on quality of life and economic productivity matches that of heart disease. Depression also accounts for at least half of all suicides.

The efficacy of antidepressants has been established in thousands of placebo-controlled trials. The newer ones are safer and have fewer noxious side effects than earlier compounds. About 50 percent of all patients will respond to any given medication, and many of those who do not will be helped by another agent or a combination of them.



Meta-analysis indicates depression patients respond about equally well to medication or to psychotherapy (interpersonal psychotherapy—IPT—or cognitive and behavioral therapies—CBT).

Not everyone responds, however, and many who do would prefer not to have to take the pills. Quietly over the years, newer psychotherapeutic techniques have been introduced that may be just as good at alleviating acute distress in all but the most severely depressed patients. And some of the therapies provide advantages over medication alone, such as improving the quality of relationships or reducing the risk that symptoms will return after treatment is over.

This last revelation is significant because many people who recover from depression are prone to succumb again. The illness is often chronic, comparable to diabetes or hypertension, and patients treated with medication alone may have to remain on it for years, if not for life, to prevent symptoms from returning. Moreover, combining treatments—prescriptions to reduce acute symptoms quickly and psychotherapy to broaden their effects and to prevent symptoms from returning after treatment terminates—may offer the best chance for a full recovery without recurring problems.

Remission or Relapse

Our conclusions refer mainly to the condition termed unipolar disorder. Depression comes in two basic forms: The unipolar type involves the occurrence of negative moods or loss of interest in daily activities. In the bipolar form, commonly known as manic-depression, patients also experience manic states that may involve euphoria, sleeplessness, grandiosity or recklessness that can lead to everything from buying sprees to impulsive sexual adventures that later bring regret.

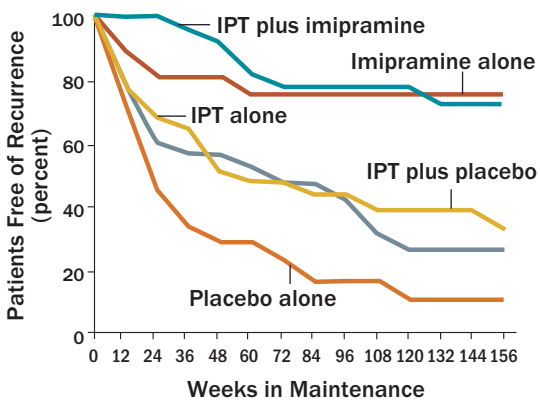
Bipolar disorder shows up in only 1 to 2 percent of the population and is usually treated with mood-stabilizing medication such as lithium. In contrast, about 20 percent of women and 10 percent of men suffer from unipolar depression at some time in their lives.

The treatment of unipolar depression typically progresses through three phases, determined by changes in the patient's intensity of symptoms. These are usually measured by clinical ratings such as the Hamilton Rating Scale for Depression. Seriously depressed patients in the acute phase often report feeling down much of the time. They have lost interest in formerly pleasurable activities, and they may have difficulty sleeping, changed appetite, and diminished libido. They may feel fatigued or worthless, and they may entertain recurrent thoughts of death or suicide. The goal of treatment is to relieve symptoms. "Remission" is reached when someone is fully well.

Even when in remission, however, patients may still have an elevated risk for the return of symptoms. It is common practice to encourage patients to stay on medication for at least six months following the initial remission. The return of symptoms soon after remission is called a relapse. In this sense, treating depression with drugs may be like treating an infection with antibiotics; a patient must take the medication beyond the point of first feeling better, to fully prevent the original problem from coming back. This effort to forestall relapse is called continuation treatment and typically lasts at least six to nine months beyond the point of remission.

Those who pass the point at which the treated episode is likely to return are said to have recovered. But even then, they might experience a new episode; people with a history of depression are three to five times more likely to have an episode than those with no such history. A new episode is considered a recurrence. To protect against recurrence, many patients are kept in ongoing maintenance treatment, typically medication but sometimes with psychotherapy. But once patients are off medication, having been on it does nothing to reduce subsequent risk for recurrence. Therefore, patients with a history of multiple episodes are usually advised to stay on medication indefinitely.

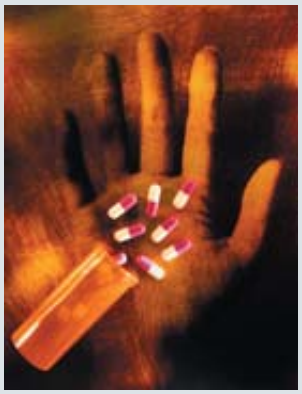
Although the scope of depression can vary widely, there are only a few prevailing treatments. Most of the leading antidepressants fall into three main



Recovered patients are least likely to suffer new depression if they continue on IPT and imipramine together (blue), rather than either treatment alone, according to one study.

SOURCES: STEVEN HOLLON ET AL. IN *PSYCHOLOGICAL SCIENCE IN THE PUBLIC INTEREST*, VOL. 3, NO. 2; NOVEMBER 2002 (*top*); E. FRANK ET AL. IN *ARCHIVES OF GENERAL PSYCHIATRY*, VOL. 47; 1990 (*bottom*)

The Antidepressants



MAOI. Monoamine oxidase inhibitors were the first widely used antidepressants. They curtail the action of an enzyme that breaks down brain neurotransmitters. They are rarely prescribed as a first-line treatment because they require a special diet to avoid potentially dangerous though rare interactions with certain common foods. But they are still a medication of last resort.

TCA. Tricyclic antidepressants inhibit the reuptake of the neurotransmitters norepinephrine and serotonin. TCAs have unpleasant side effects that can include fainting, dry mouth and blurred vision; about 30 percent of patients stop taking the medication because of these problems. TCAs are also potentially lethal in an overdose. But they may still be the medication of choice for those with certain kinds of depression.

SSRI. Selective serotonin reuptake inhibitors, such as Prozac and Paxil, block the reuptake of serotonin back into presynaptic neurons. They have replaced TCAs as the primary medication because they have fewer side effects and are less likely to prove fatal in an overdose. Nevertheless, side effects such as gastrointestinal and sexual problems can be disconcerting. Indications that SSRIs may increase suicidal thoughts and actions in children and teenagers have led to mandatory warnings for these age groups in the U.S. and a ban for minors in Great Britain.

Newer medications. More doctors are trying new drugs that affect multiple neurotransmitter systems or make use of mechanisms other than blocking reuptake. Examples include bupropion, venlafaxine, nefazodone and mirtazapine. *—S.H., M.T., J.M.*

classes: monoamine oxidase inhibitors (MAOIs), tricyclic antidepressants (TCAs), and selective serotonin reuptake inhibitors (SSRIs), such as Prozac and Paxil [*see box above*]. Each class has a slightly different action and different side effects and is prescribed based on a patient's history, the likelihood of certain complications, and cost. Although about equally effective in a general population, some medications are more efficacious than others for specific types of depression. In general, the older MAOIs and TCAs carry greater risk of side effects than the SSRIs. But the SSRIs do not always work, especially for more severely depressed patients, and they are more expensive.

Despite the widespread use of antidepressants, their actions are not fully understood. They work in part by affecting the neurotransmitters (signaling molecules in the brain) norepinephrine, serotonin and dopamine, which are involved in regulating mood, primarily by blocking the reuptake of these neurotransmitters into the neurons that secrete them. Yet this action cannot fully explain the effects, and it is quite likely that the compounds drive a subsequent cascade of biochemical events. Many people who do not respond to one antidepressant will respond to another or to a combination.

New psychotherapy methods have proved as effective as medication, although they are still not as extensively tested [*see box on next page*]. The programs include interpersonal psychotherapy (IPT), which focuses on problems in relationships and helps patients lift the self-blame common in depression. Developed in the 1970s, IPT has performed well in trials but has only begun to enter clinical practice. Studies do show, however, that when IPT is paired with medication, patients receive the best of both worlds: the quick results of pharmaceutical intervention and greater breadth in improving the quality of their interpersonal lives.

Cognitive and behavioral therapies, collectively known as CBT, also compare well with medication in all but the most severely depressed patients—and they can benefit even those people if they are administered by experienced therapists. Most exciting is that CBT appears to have an enduring effect that reduces risk of relapse and perhaps recurrence. Even the most effective of the other treatments rarely have this type of long-lasting benefit. Cognitive therapy is perhaps the most well established CBT approach. It teaches patients to examine the validity of their dysfunctional depressive beliefs and to alter how they process information about themselves. Behavioral therapy had lost favor to the cognitive approaches, but it, too, has done well in recent trials and is undergoing a revival.

(The Authors)

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CORBIS

Psychotherapies for Depression

Interpersonal psychotherapy (IPT) focuses on problems in relationships. Therapists help patients to understand life events that may have started their depression and to find ways to combat such episodes as well as reverse cycles of social withdrawal, fatigue and poor concentration. IPT emphasizes that symptoms are the result of a mood disorder and not an outgrowth of personal failure, which lifts the guilt and self-blame common in depression.

Cognitive and behavior therapies hold that mood disorders are caused or exacerbated by learned beliefs and behaviors—which can be unlearned or modified through experience. The more cognitively based methods emphasize the role of a patient's aberrant beliefs and dysfunctional information processing, whereas the more behavioral approaches focus on how external circumstances shape patient responses. Most therapies blend cognitive and behavioral strategies and are often referred to as CBT. The goal is not to "think happy thoughts" but to become more accurate in one's self-assessments and more effective in one's behaviors. Recent variants such as mindfulness-based cognitive therapy incorporate strategies based on mediation and acceptance; others such as well-being therapy try to enhance life skills and a sense of happiness in addition to reducing distress. And still others integrate cognitive and behavioral approaches with so-called dynamic and interpersonal strategies.

More purely **behavioral therapies** akin to behavioral activation maintain that depression results from too little positive reinforcement, brought on by problems in a person's environment or a lack of social skills or a propensity to avoid challenging situations. These approaches are drawing renewed attention. *—S.H., M.T., J.M.*

Which Way to Turn

It is not possible to simply say whether medication or psychotherapy is "better" for depressed patients. But many studies have reached interesting conclusions about the approaches when they are applied across the illness's three phases: the acute symptoms at onset, the months of continuation treatment to forestall relapse, and the maintenance of health for years to come.

Among patients who take antidepressants during treatment for acute symptoms, about half show a 50 percent drop in symptom scores on rating tests over the first four to eight weeks. About one third of those patients become fully well (remission). Not all the improvement can be attributed to pharmacology, however. In pill-placebo control experiments, placebos can achieve up to 80 percent of the success rate of active medication, probably by instilling in patients hope and the expectation for change. The placebo effect does tend to be less stable over time and smaller in magnitude in more severe or chronic depressions. A major problem with acute-phase therapy, however, is that many stop taking their medication—primarily because of side effects—before therapists can clearly tell if the agents are working. Attrition rates from clinical trials are often 30 percent or higher for older medications such as the TCAs and around 15 percent for newer options such as the SSRIs.

The newer psychotherapies appear to do as well as medication during the acute depression phase, although the number of studies is fewer and the findings are not always consistent. One typical study found that IPT alone was about as effective as medication alone (with each better than a control condition) and that the combination was better still. In general, medication relieved symptoms more quickly, but IPT produced more improvement in social functioning and quality of relationships. The combined treatment retained the independent benefits of each.

IPT also fared well in the 1989 National Institute of Mental Health Treatment of Depression Collaborative Research Program. The TDCRP, as it is known, is perhaps the most influential study to date that compared medication and psychotherapy. In that trial, patients with major depression were randomly assigned to 16 weeks of IPT, CBT or the TCA imipramine, combined with meetings with a psychiatrist or a placebo plus meetings. Patients with less severe depression improved equally across conditions. Among more severely depressed patients, imipramine worked faster than IPT, but both were comparable by the end of treatment and both were superior to a placebo.

As for CBT, most of the published trials have found it to be as effective as medication in the acute phase. The most notable exception—the TDCRP—did find that cognitive therapy was less efficacious than either medication or IPT (and no better than a placebo) in the treatment of more severely depressed patients. Because the study was large and was the first major comparison to include a pill-placebo control, its results considerably dampened

GETTY IMAGES

enthusiasm for cognitive therapy, even though no other study had produced such a negative finding.

Today this conclusion appears to have been premature. More recent studies have found that CBT is superior to pill-placebos and is as good as an SSRI for more severely depressed outpatients. These studies suggest that cognitive therapy's success depends greatly on the level of a therapist's training and experience with it, especially for patients with more serious or complicated symptoms.

Continuing the Fight

The best treatments for reducing acute distress also seem to work as well for reducing relapse when they are carried into the continuation phase. Antidepressants appear to reduce the risk for relapse by at least half. It is unclear exactly how long patients must keep taking medication to pass from remission into full recovery, but current convention is to go for at least six to nine months.

IPT during the continuation phase appears to prevent relapse nearly as well as medication, although studies in this regard are few. Recent investigations also suggest that if cognitive therapy is continued past the point of remission, it can reduce the risk for relapse. To date, no studies have compared continuation CBT to continuation IPT or medication.

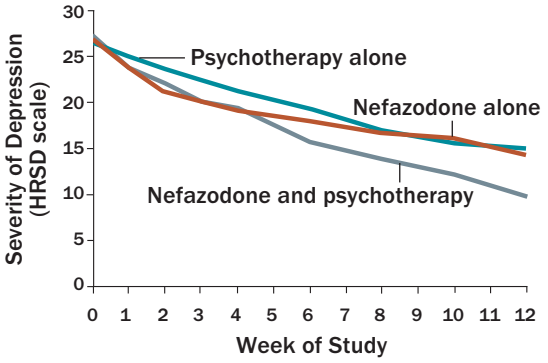
During the maintenance phase, medication is usually recommended for high-risk patients, especially those with multiple prior episodes. Therapy can go on for years. It does protect against recurrence. Even among recovered patients, though, the risk of recurrence off medication is at least two to three times greater. Given that there is no evidence that prior medication use does anything to reduce subsequent risk for recurrence, most physicians will encourage their high-risk patients to stay on medication indefinitely.

Studies of maintenance IPT are few, but they generally support the notion that it, too, reduces risk of recurrence. It has not been as efficacious as keeping people on medication, but the handful of studies have typically cut back the frequency of IPT to monthly sessions while maintaining medication at full, acute-treatment dosages. It would be interesting to see how maintenance IPT compares when the psychotherapy sessions are also kept at "full strength."

Several studies have shown that CBT has an enduring protective benefit that extends beyond the end of treatment. Patients treated to remission with CBT were only about half as likely to relapse after treatment termination as patients treated to remission with medication, and the CBT patients were no more likely to relapse than patients who continued on the prescriptions. CBT appears to produce this enduring effect regardless of whether it is provided alone or in combination with medication during acute treatment and even if it is added only after medication has reduced acute symptoms. Further, indications are that this enduring effect may even prevent wholly new episodes (recurrence), although findings are still far from conclusive.

Given these trends, CBT may ultimately prove more cost-effective than medication. Psychotherapy usually costs at least twice as much as medication over the first several months, but if the enduring effect of CBT truly extends over time, it may prove less costly for patients to learn the skills involved and discontinue treatment than to stay on medication indefinitely. It remains unclear whether other interventions such as IPT have an enduring effect, but this possibility should certainly be explored.

Our review of the treatment literature indicates that some forms of psychotherapy can work as well as medication in alleviating acute distress. IPT may enhance the breadth of response, and CBT may enhance its stability. Combined treatment, though more costly, appears to retain the advantages of each approach. Good medical care can be hard to find, and the psychotherapies that have garnered the most empirical support are still not widely practiced. Nevertheless, some kind of treatment is almost always better than none for a person facing depression. The real tragedy is that even as alternatives expand, too few people seek help.



Combining medication (nefazodone) and psychotherapy (gray) reduced the intensity of symptoms furthest among chronically depressed patients in a 2000 study.

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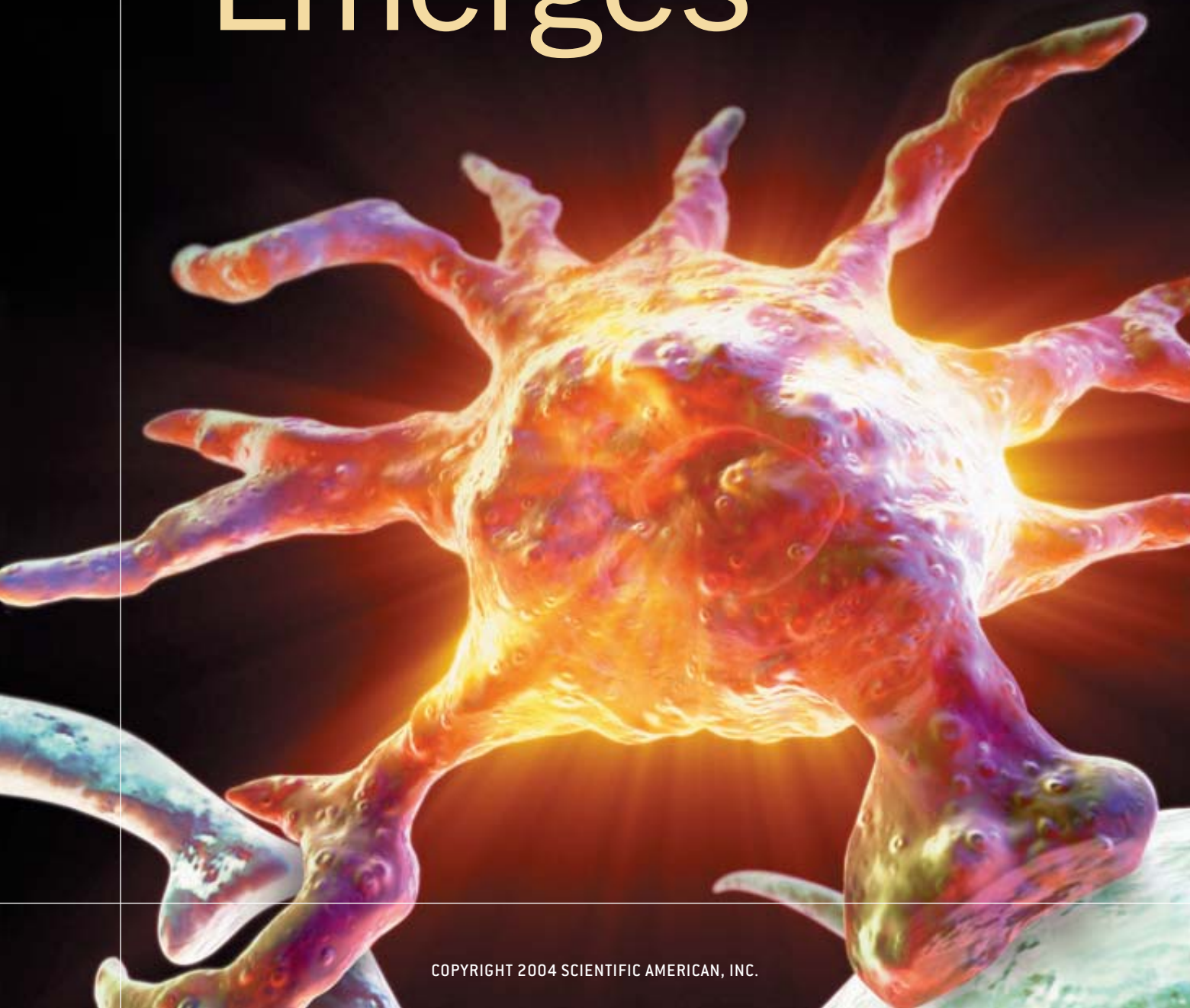
SOURCE: M. B. KELLER ET AL. IN *NEW ENGLAND JOURNAL OF MEDICINE*, VOL. 342; 2000

The **Forgotten Brain** Emerges



After disregarding them for decades, neuroscientists now say glial cells may be nearly as important to thinking as neurons are

BY CLAUDIA KREBS, KERSTIN HÜTTMANN AND CHRISTIAN STEINHÄUSER

The brain consists mainly of neurons, right? Wrong. There are nine times as many glial cells in our gray matter as there are neurons. For 50 years, neuroscientists have maintained that glia merely provide support services to neurons: warding off pathogens, maintaining a healthy ion balance around the neurons and insulating them from electrical interference.

But recent work indicates that glia are intimately involved in all aspects of our brain's information processing. Not only do glia talk with neurons, they communicate among themselves, aiding and abetting how our brains react, learn and remember. Understanding more about how glia function may greatly alter our model of how the brain and mind work.

Always Talking

Glial cells are of three different types. Microglia in the brain act like immune system cells elsewhere in the body by protecting neurons from intruders. Oligodendrocytes form insulating myelin sheaths around the outstretched axons that carry a neuron's signals to neighboring neurons. Astrocytes surround neurons, especially at the synaptic gap where signaling molecules cross the tiny gulf between the end of one neuron's axon and the next neuron's dendrite. The latest research demonstrates that astrocytes—the most numerous of all glia—perform many different functions.

Among other supportive jobs, astrocytes supply neurons with nutrients from blood vessels, they absorb neurotransmitters when needed to help shut down the neurons that are sending them, and they ensure that ion concentrations remain constant in intracellular spaces in the brain. But it has become increasingly clear that astrocytes also listen in on the signals passing from neuron to neuron and communicate with those neurons. Astrocytes talk with one another, too, along networks that parallel neural networks, using the same neurotransmitters that neurons use. Clearly, glia affect how neurons communicate—in other words, how we think and how our brains perform.

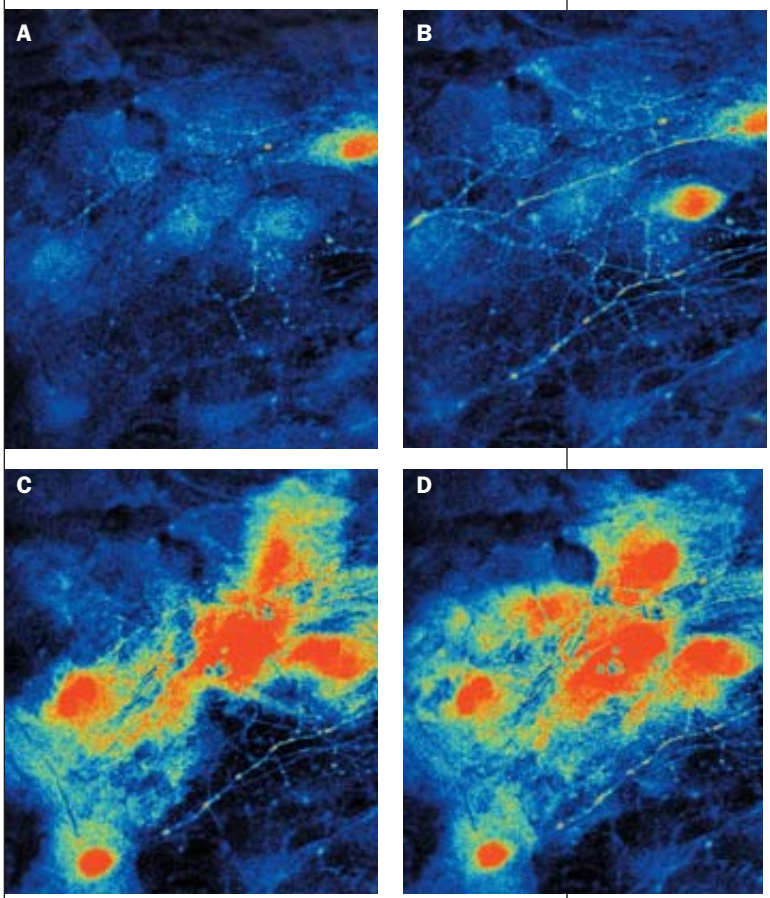
And yet neurons and glia differ markedly in how they conduct information. Neurons send rapid electrical impulses, known as action potentials. Astrocytes use chemical messages, which are controlled by rising and falling concentrations of calcium ions. An increased concentration spreads throughout the cell like a human wave propagating through the stands at a baseball game—and often spills over to neighboring astrocytes through channels between the cells. Although they are dissimilar, the two types of cells sometimes use the same types of messenger molecules. Recently our neurobiology group in Bonn, working with Andrea Volterra of the University of Lausanne in Switzerland, demonstrated that astrocytes, when activated by the chemical messenger glutamate, release the same neurotransmitters that neurons release, using a similar molecular mechanism.

By affecting how neurotransmitters carry signals across synaptic gaps among neurons and by releasing the same neurotransmitters to neurons and to one another, glia directly influence infor-

JEFF JOHNSON *Hybrid Medical Animation*

Glial cells outnumber neurons in the brain (opposite page). Could they outthink neurons as well?

Future research into pathological brain problems will have to consider not just neuronal activity but glial activity, too.



Astrocytes (*a*) and neurons (*not shown*) were mixed with calcium ions. After a neuron was stimulated to fire (*b, shown by bright lines*), astrocytes began to light up, indicating they were sensing the message by absorbing calcium. After 10 and 12.5 seconds (*c* and *d*), waves of calcium ions were carrying signals among many astrocytes.

mation transfer in the brain. Astrocytes affect the signaling between adjacent neurons along a chain and, using their own network, also affect how neurons are triggered in distant parts of the brain. Researchers now think astrocytes coordinate the activity of nerve cells in various brain regions at the same time, through the propagation of calcium ion waves.

Clues from Epilepsy

One way to examine how glia communicate is to analyze what happens during epileptic seizures. This condition manifests itself as occasional sudden disturbances of consciousness or uncontrollable convulsions or spasms. In these episodes, neurons in one region of the brain fire suddenly and in complete synchrony. In some cases, only a few cells misfire. In others, the discharge spreads to large areas of the cerebral cortex. The firing can be very intense. These electrical storms temporarily bring the affected brain region to a standstill. But how?

To look for an answer, we studied tissue from the hippocampus of epileptic patients. The hippocampus is heavily involved in the onset and spread of seizures, and in patients who have severe epilepsy it can be surgically removed as a treatment of last resort. By experimenting on thin sections of removed hippocampus, we were able to track ion streams flowing through the cell membranes of individual astrocytes and thus measure the activity of individual ion channels and neurotransmitter receptors.

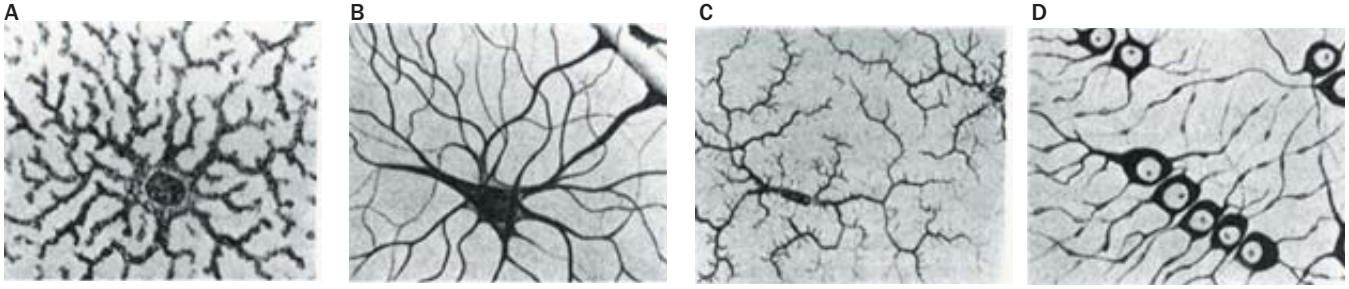
In a nonepileptic brain there are normally two different types of astrocytes: gluT cells and gluR cells. But we have found that in one widespread form of temporal lobe epilepsy, called sclerosis of the hippocampus, gluT cells are completely lacking in the hippocampus. In healthy brains these astrocytes absorb glutamate released by neurons and thereby inhibit prolonged stimulation of the neurons. The gluT cells also have potassium channels in their cell membrane that can remove potassium ions from the intracellular space, again shutting down neurons so they do not run wild.

It turns out that gluT astrocytes are connected together in long networks comprising hundreds of gap junctions—a particular type of regulated channel between cells. Functioning collectively as a large network, gluT cells can remove molecules and ions from many neurons simultaneously by

(The Authors)

CLAUDIA KREBS, KERSTIN HÜTTMANN and CHRISTIAN STEINHÄUSER study glial cells. Krebs and Hüttmann are researchers in the experimental neurobiology department at the University of Bonn's Clinic for Neurosurgery. Steinhäuser is professor of neurobiology at the university.

R. DOUGLAS FIELDS *University of Maryland*



The basic classification of glial cells in the brain—protoplasmic astrocytes (*a*), fibrous astrocytes (*b*), microglial cells (*c*) and oligodendrocytes (*d*)—traces back to Spanish anatomist Pío del Río Hortega. Hortega made these drawings in 1920 with the help of a microscope's camera lucida.

shunting them to blood vessels where they are carried away, shutting down overactive transmission in a brain region. The loss of gluT cells in the hippocampus, however, prevents the rapid removal of messenger molecules and ions. Instead the substances collect around neurons, overstimulating them for too long and raising the probability of excessive firing.

An Ocean of Einsteins

In 1955 pathologist Thomas Harvey performed an autopsy on Albert Einstein, then took the Nobel laureate's brain home and kept it for 40 years, occasionally doling out tiny slices for study. Marian C. Diamond of the University of California at Berkeley was one lucky recipient. In the mid-1980s Diamond discovered that Einstein had an unusual number of glial cells in brain regions responsible for higher thought.

Since then, researchers have found that the average human cerebral cortex has approximately two glial cells for every neuron (other brain regions have up to 10 times as many). That's a glia index of 2.0. The index in comparable regions in rodents is 0.4, in worms 0.17. The work supports the theory that a high concentration of glia may actually boost the ability to think. So here's something to think about: the glia index in the cerebral cortex of dolphins is 3.0. *—C.K., K.H., C.S.*

A further consequence of gluT cell loss is that the neurons become energy-depleted. In healthy tissue, astrocytes absorb glucose from the blood and transform it into lactic acid, which the neurons use to generate energy. A lack of gluT astrocytes in patients with sclerosis of the hippocampus appears to considerably impair the supply of nutrients to neurons in that region. So it may be that vast complexes of neurons overstimulate at the onset of a seizure, then stop en masse, exhausted.

For their part, gluR astrocytes possess specialized receptors for a variety of messenger substances, including glutamate. The precise function of these cells is still largely unclear, however. Although they, like gluT astrocytes, have potassium channels in their membranes, they are not connected in a network and so cannot remove those ions. Patients with sclerosis of the hippocampus have gluR cells, but the density of the potassium channels in their cell membranes is significantly lower than in a healthy brain. In addition, the glutamate receptors in these cells operate more slowly. That fact may allow neurons to fire more easily, further increasing the risk of an epileptic seizure.

A New Pathology

Although we must pin down more details, our work on seizures thus far indicates a clear correlation between unusual astrocyte density and electrical storms in the brain. What we still do not know is whether the deficiency or changes in glial cells actually cause this form of epilepsy or are a consequence of it. Either way, we can conclude that glia and neurons cooperate closely.

Future research on pathological problems in the brain will have to consider not just neuronal activity, as has been the practice to date, but glial activity, too. To actually pinpoint the mechanisms underlying certain brain diseases and conditions, researchers must develop a new understanding of how glia—particularly astrocytes—contribute to information processing. Only then can effective treatments be developed.

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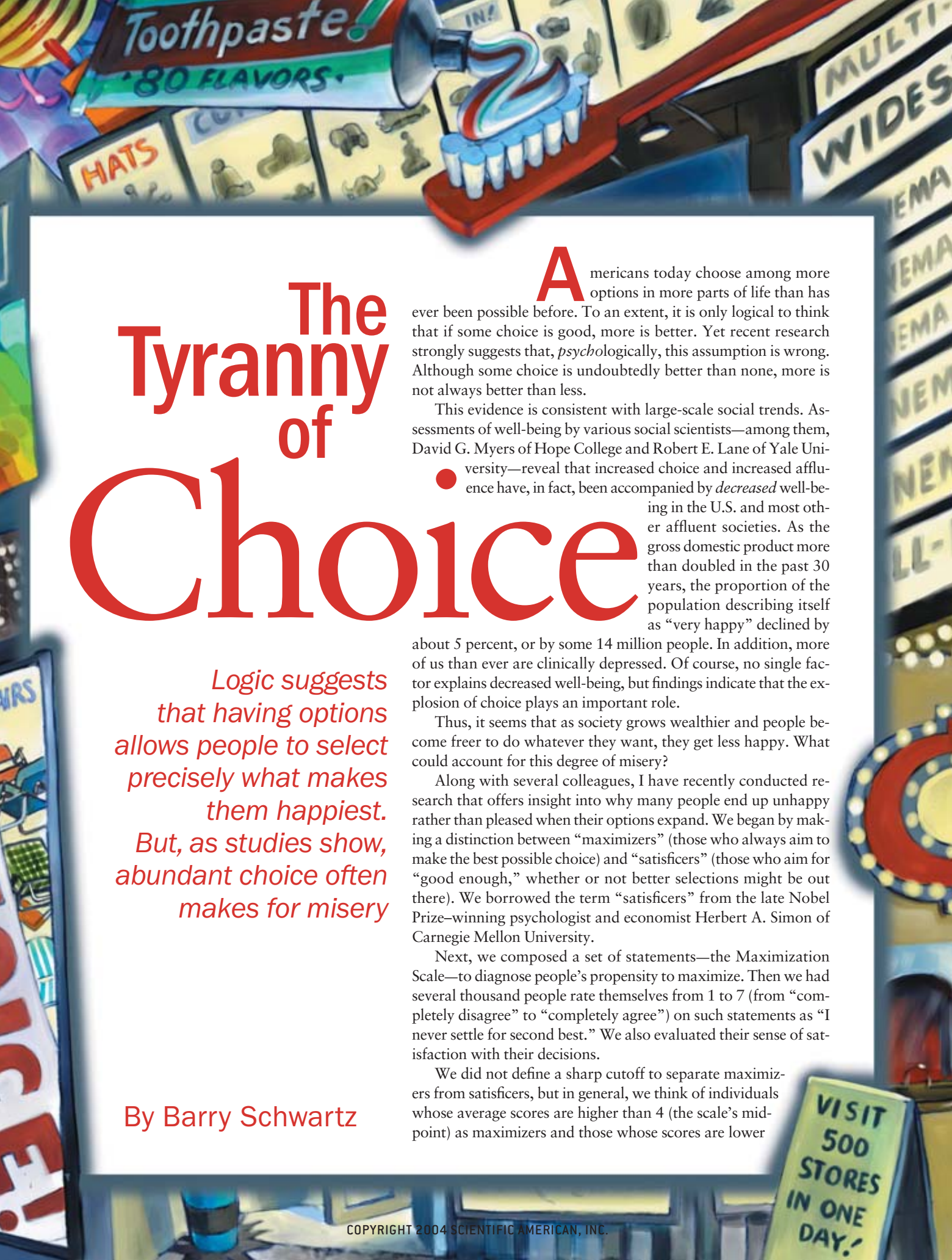


The Tyranny of Choice

Logic suggests that having options allows people to select precisely what makes them happiest. But, as studies show, abundant choice often makes for misery

By Barry Schwartz

Americans today choose among more options in more parts of life than has ever been possible before. To an extent, it is only logical to think that if some choice is good, more is better. Yet recent research strongly suggests that, *psycho*logically, this assumption is wrong. Although some choice is undoubtedly better than none, more is not always better than less.

This evidence is consistent with large-scale social trends. Assessments of well-being by various social scientists—among them, David G. Myers of Hope College and Robert E. Lane of Yale University—reveal that increased choice and increased affluence have, in fact, been accompanied by *decreased* well-being in the U.S. and most other affluent societies. As the gross domestic product more than doubled in the past 30 years, the proportion of the population describing itself as "very happy" declined by about 5 percent, or by some 14 million people. In addition, more of us than ever are clinically depressed. Of course, no single factor explains decreased well-being, but findings indicate that the explosion of choice plays an important role.

Thus, it seems that as society grows wealthier and people become freer to do whatever they want, they get less happy. What could account for this degree of misery?

Along with several colleagues, I have recently conducted research that offers insight into why many people end up unhappy rather than pleased when their options expand. We began by making a distinction between "maximizers" (those who always aim to make the best possible choice) and "satisficers" (those who aim for "good enough," whether or not better selections might be out there). We borrowed the term "satisficers" from the late Nobel Prize–winning psychologist and economist Herbert A. Simon of Carnegie Mellon University.

Next, we composed a set of statements—the Maximization Scale—to diagnose people's propensity to maximize. Then we had several thousand people rate themselves from 1 to 7 (from "completely disagree" to "completely agree") on such statements as "I never settle for second best." We also evaluated their sense of satisfaction with their decisions.

We did not define a sharp cutoff to separate maximizers from satisficers, but in general, we think of individuals whose average scores are higher than 4 (the scale's midpoint) as maximizers and those whose scores are lower

The Maximization Scale

The statements below distinguish maximizers from satisficers. Subjects rate themselves from 1 to 7, from "completely disagree" to "completely agree," on each statement. Analysts generally consider people whose average rating is higher than 4 to be maximizers. When we looked at averages from thousands of subjects, we found that about a third scored higher than 4.75 and a third lower than 3.25. Roughly 10 percent of subjects were extreme maximizers (averaging greater than 5.5), and 10 percent were extreme satisficers (averaging lower than 2.5). —*B.S.*

1. **Whenever I'm faced with a choice, I try to imagine what all the other possibilities are, even ones that aren't present at the moment.**
2. **No matter how satisfied I am with my job, it's only right for me to be on the lookout for better opportunities.**
3. **When I am in the car listening to the radio, I often check other stations to see if something better is playing, even if I am relatively satisfied with what I'm listening to.**
4. **When I watch TV, I channel surf, often scanning through the available options even while attempting to watch one program.**
5. **I treat relationships like clothing: I expect to try a lot on before finding the perfect fit.**
6. **I often find it difficult to shop for a gift for a friend.**
7. **Renting videos is really difficult. I'm always struggling to pick the best one.**
8. **When shopping, I have a hard time finding clothing that I really love.**
9. **I'm a big fan of lists that attempt to rank things (the best movies, the best singers, the best athletes, the best novels, etc.).**
10. **I find that writing is very difficult, even if it's just writing a letter to a friend, because it's so hard to word things just right. I often do several drafts of even simple things.**
11. **No matter what I do, I have the highest standards for myself.**
12. **I never settle for second best.**
13. **I often fantasize about living in ways that are quite different from my actual life.**

than the midpoint as satisficers. People who score highest on the test—the greatest maximizers—engage in more product comparisons than the lowest scorers, both before and after they make purchasing decisions, and they take longer to decide what to buy. When satisficers find an item that meets their standards, they stop looking. But maximizers exert enormous effort reading labels, checking out consumer magazines and trying new products. They also spend more time comparing their purchasing decisions with those of others.

Naturally, no one can check out every option, but maximizers strive toward that goal, and so making a decision becomes increasingly daunting as the number of choices rises. Worse, after making a selection, they are nagged by the alternatives they have not had time to investigate. In the end, they are more likely to make better objective choices than satisficers but get less satisfaction from them. When reality requires maximizers to compromise—to end a search and decide on something—apprehension about what might have been takes over.

We found as well that the greatest maximizers are the least happy with the fruits of their efforts. When they compare themselves with others, they get little pleasure from finding out that they did better and substantial dissatisfaction from finding out that they did worse. They are more prone to experiencing regret after a purchase, and if their acquisition disappoints them, their sense of well-being takes longer to recover. They also tend to brood or ruminate more than satisficers do. Working with Columbia University psychologists Rachael F. Elwork and Sheena S. Iyengar, I found that maximizing college seniors searching for jobs actually found positions with 20 percent higher starting salaries than satisficing job seekers. Yet the maximizers were less satisfied with the jobs they got, and with the entire search process, than the satisficers were.

Does it follow that maximizers are less happy in general than satisficers? I and other researchers tested this by having people fill out a variety of questionnaires known to be reliable indicators of well-being. As might be expected, individuals with high maximization scores experienced less satisfaction with life and were less happy, less optimistic and more depressed than people with low maximization scores. Indeed, those with extreme maximization ratings had depression scores that placed them in the borderline clinical range.

Recipe for Unhappiness

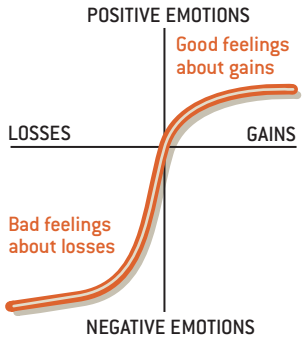
Several factors explain why more choice is not always better than less, especially for maximizers. High among these are "opportunity costs." The quality of any given option cannot be assessed in isolation from its alternatives. One of the "costs" of making a selection is losing the opportunities that a different option would have afforded. Thus, an opportunity cost of vacationing on the beach in Cape Cod might be missing the fabulous restaurants in the Napa Valley. If we assume that opportunity costs reduce the overall desirability of the most preferred choice, then the more alternatives there are, the deeper our sense of loss will be and the less satisfaction we will derive from our ultimate decision.

Lyle Brenner of the University of Florida and his

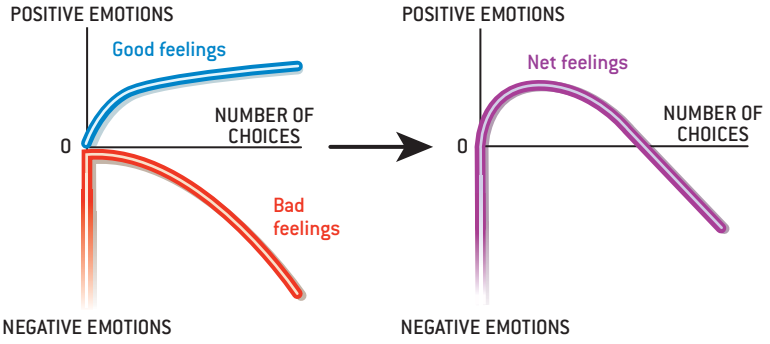
Feelings Evoked by Ever More Choices

Early research showed that people respond more strongly to losses than gains (*left graph*). Similarly, feelings of well-being initially rise as choice increases (*blue line in center graph*) but then level off quickly (good feelings satiate). Meanwhile, although zero choice (*at the* y *axis*) evokes virtually infinite unhappiness, bad feelings escalate (*red line*) as we go from having few choices to many. The net result (*purple line in right graph*) is that, at some point, added choice only decreases happiness. —*B.S.*

REACTIONS TO LOSSES AND GAINS



REACTIONS TO INCREASING CHOICE



collaborators demonstrated the effects of opportunity costs when they had subjects put a dollar value on subscriptions to magazines or flights from San Francisco. Some attached prices to a single magazine subscription or a single destination. Others attached prices to the same magazine or destination when it was part of a group containing three others. Prices were consistently lower when a given alternative was evaluated as part of a group than when it was evaluated in isolation.

Why might this be so? When you assign a value to, say, *Newsweek*, as part of a group that also contains *People* and *Us*, your tendency will be to compare the magazines. Each comparison that *Newsweek* wins will be a gain, but each comparison that it loses will be a loss, an opportunity cost. But we know from the research of Nobelist psychologist Daniel Kahneman of Princeton University and his late colleague Amos Tversky of Stanford that losses (in this case, opportunity costs) have a much greater psychological impact than gains. Losses make us hurt more than gains make us feel good.

Sometimes opportunity costs may create enough conflict to produce paralysis. The problem of opportunity costs will be worse for a maximizer than for a satisficer. The latter's "good enough" philosophy can survive thoughts about opportunity costs. The "good enough" standard also leads to much less searching and inspection of alternatives than the maximizer's "best" standard. With fewer choices under consideration, a person will have fewer opportunity costs to subtract.

Regret Adds to Costs

Just as people feel sorrow about the opportunities they have forgone, they may also suffer regret about the option they settle on. My colleagues and I devised a scale to measure proneness to feeling regret and found that people with high sensitivity to regret are less happy, less satisfied with life, less optimistic and more depressed than those with low sensitivity. Not surprisingly, we also found that people with high regret sensitivity tend to be maximizers. We think that worry over future regret is a major reason that individuals become maximizers. The only way to be sure you will not regret a decision is by making the best possible one.

Regret may be one reason for our aversion to losses. Have you ever bought an expensive pair of shoes only to discover that they are so uncomfortable that you cannot wear them for more than 10 minutes without hobbling? Did you toss them out, or are they still sitting in the back of your closet? Chances are you had a hard time throwing them away. Having bought the shoes, you incurred an actual, or "sunk," cost, and you are going to keep them around in the hope that eventually you will get your money's worth out of them. To give the shoes away or throw them out would force you to acknowledge a mistake—a loss.

In a classic demonstration of the power of sunk costs, people were offered season subscriptions to a local theater company. Some were offered the tickets at full price and others at a discount. Then the researchers timed how often the purchasers attended

BARRY SCHWARTZ

Lessons

Choose when to choose.
We can decide to restrict our options when the decision is not crucial. For example, make a rule to visit no more than two stores when shopping for clothing.

Learn to accept "good enough."
Settle for a choice that meets your core requirements rather than searching for the elusive "best." Then stop thinking about it.

Don't worry about what you're missing.
Consciously limit how much you ponder the seemingly attractive features of options you reject. Teach yourself to focus on the positive parts of the selection you make.

Control expectations.
"Don't expect too much, and you won't be disappointed" is a cliché but can help you be more satisfied with life. —*B.S.*

the plays. Full-price payers were more likely to show up than discount payers. The reason for this, the investigators argued, was that the full-price payers would experience more regret if they did not use the tickets because that would constitute a bigger loss.

Several studies have shown that two of the factors affecting regret are how much personal responsibility one feels for the result and how easy it is to imagine a better alternative. The availability of choice obviously exacerbates both these factors. When you have no options, what can you do? You will feel disappointment, maybe; regret, no. But with many options, the chances increase that a really good one is out there, and you may well feel that you ought to have been able to find it.

Adaptation Dulls Joy

A phenomenon called adaptation also contributes to the fallout we face from too many choices. Simply put, we get used to things, and as a result, very little in life turns out quite as good as we expect it to be. After much anguish, you might decide to buy a certain luxury car and then try to put all the attractions of other models out of your mind. But once you are driving your car, adaptation begins, and the experience falls just a little bit flat. You are hit with a double whammy—regret about what you did not choose and disappointment with what you did, even if your decision was not bad.

Because of adaptation, enthusiasm about positive experiences does not sustain itself. Daniel T. Gilbert of Harvard University and Timothy D. Wilson of the University of Virginia have shown that people consistently mispredict how long good experiences will make them feel good and how long bad experiences will make them feel bad. The waning of pleasure or enjoyment over time always seems to come as an unpleasant surprise.

And it may cause more disappointment in a world of many options. The opportunity costs associated with a decision and the time and effort that go into making it are "fixed costs" that we "pay" up front, and those costs then get "amortized" over the life of the decision. The more we invest in a decision, the more satisfaction we expect to realize from our investment. If the decision provides substantial satisfaction for a long time after it is made, the costs of making it recede into insignificance. But if the decision provides pleasure for only a short time, those costs loom large. Spending four months deciding what stereo to buy is not so bad if you really enjoy that stereo for 15 years. But if you are excited by it for six months and then adapt, you may feel like a fool for having put in all that effort.

The Curse of High Expectations

A surfeit of alternatives can cause distress in yet another way: by raising expectations. In the fall of 1999 the *New York Times* and CBS News asked teenagers to compare their experiences with those their parents had growing up. Fifty percent of children from affluent households said their lives were harder. When questioned further, these adolescents talked about high expectations, both their own and their parents'. They talked about "too muchness": too many activities, too many consumer choices, too much to learn. As one commentator put it, "Children feel the pressure … to be sure they don't slide back. Everything's about going forward.… Falling back is the American nightmare." So if your perch is high, you have much further to fall than if your perch is low.

The amount of choice we now have in most aspects of our lives contributes to high expectations. When I was on vacation a few years ago in a tiny seaside town on the Oregon coast, I went into the local grocery store to buy ingredients for dinner. The store offered about a dozen options for wine. What I got

MATT COLLINS

(The Author)

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was so-so, but I did not expect to be able to get something very good and, hence, was satisfied with what I had. If instead I had been shopping in a store that offered an abundance of choices, my expectations would have been a good deal higher and even a better wine might have left me sorely disappointed. When we say an experience was good, what we mean, in part, is that it was better than we expected it to be. High expectations almost guarantee that experiences will fall short, especially for maximizers and especially when regret, opportunity costs and adaptation do not factor into our expectations.

A Link to Depression?

The consequences of unlimited choice may go far beyond mild disappointment. Americans are showing a decrease in happiness and an increase in clinical depression. One important contributing factor is that when we make decisions, experience the consequences and find that they do not live up to expectations, we blame ourselves. Disappointing outcomes constitute personal failures.

The research that my colleagues and I have done suggests that maximizers are prime candidates for depression. With group after group of people, varying in age (including young adolescents), gender, educational level, geographic location, race and socioeconomic status, we have found a strong correlation between maximizing and measures of depression. If the experience of disappointment is relentless, if virtually every choice you make fails to live up to expectations and aspirations, and if you consistently take personal responsibility for the disappointments, then the trivial looms larger and larger, and the conclusion that you cannot do anything right becomes devastating. Although depression has many sources, and the relation among choice, maximizing and depression requires more study, there is good reason to believe that overwhelming choice at least contributes to the epidemic of unhappiness spreading through modern society.

What Can Be Done

The news I have reported is not good. Does it mean that we would all be better off if our choices were severely restricted, even eliminated? I do not think so. The relation between choice and well-being is complicated. Being able to choose has enormously important positive effects on us. But only up to a point. As the number of choices we face increases, the psychological benefits we derive start to level off. And some of the negative effects of choice accelerate. A quarter of a century ago the late Clyde H. Coombs of the University of Michigan at Ann Arbor and George S. Avrunin of the University of

MATT COLLINS

Massachusetts at Amherst noted that good feelings "satiate" and bad feelings "escalate." Much the same can be said of choice: what is good about choice "satiates" and what is bad about it "escalates." A point is reached at which increased choice brings increased misery. It appears that American society has long since passed that point.

Few Americans would favor passing laws to limit choices. But individuals can certainly take steps to mitigate choice-related distress. Such actions require practice, discipline and perhaps a new way of thinking, but each should bring its own rewards [*see box on opposite page*].

Beyond those individual strategies, our society would be well served to rethink its worship of choice. As I write this, public debate continues about privatization of Social Security (so people could select their retirement investments), privatization of Medicare and prescription drug benefits (so people could choose their own health plans), and choice in public education. And everyone seems to insist that having patients choose their treatments will make them better off. Software developers design their products so that users can customize them to their own specific needs and tastes, as if the resulting complexity and confusion are worth it. Manufacturers keep offering new versions of old products, as if we needed more variety. The lesson is that developments in each of these spheres may well rest on assumptions that are deeply mistaken.

(Further Reading)

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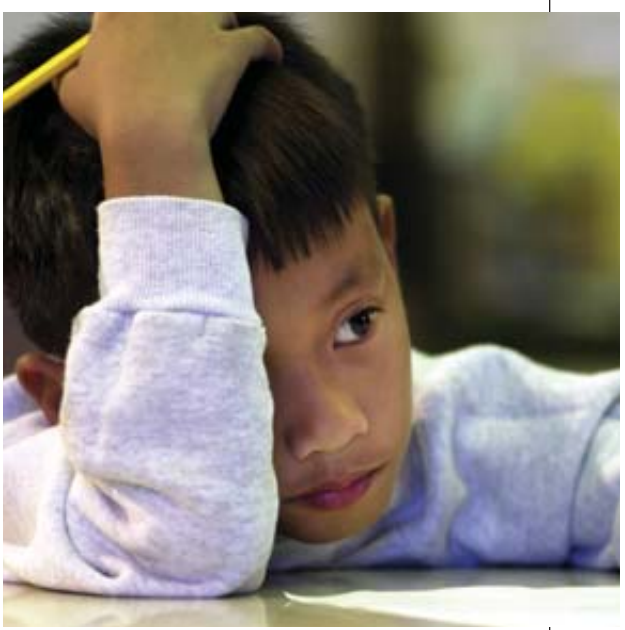
- **The Loss of Happiness in Market Democracies.** Robert E. Lane. Yale University Press, 2001.
- **Maximizing versus Satisficing: Happiness Is a Matter of Choice.** Barry Schwartz et al. in *Journal of Personality and Social Psychology,* Vol. 83, No. 5, pages 1178–1197; 2002.
- **The Paradox of Choice: Why More Is Less.** Barry Schwartz. Ecco/HarperCollins Publishers, 2004.

Informing the ADHD Debate

The latest neurological research has injected much needed objectivity into the disagreement over how best to treat children with attention-deficit disorders

By Aribert Rothenberger and Tobias Banaschewski



From the moment Julia entered first grade, she appeared to spend most of her time daydreaming. She needed more time to complete assignments than the other children did. As she moved through elementary school, her test scores deteriorated. She felt increasingly unable to do her homework or follow the teacher's instructions in class. She made few real friends and said her teachers got on her nerves. She complained that her parents pressured her all day long and that nothing she did was right.

Julia was actually very friendly and talkative, but a lack of self-control made others feel uneasy around her. By age 14, she found that concentrating on assignments seemed impossible. She constantly lost her belongings. Neuropsychological exams showed Julia was of average intelligence but repeatedly interrupted the tests. She was easily distracted and seemed to expect failure in every-

thing she did. So she just gave up. Ultimately Julia was diagnosed with attention-deficit hyperactivity disorder (ADHD) and was treated with methylphenidate, one of the standard drugs for her condition. The medication helped Julia organize her life and tackle her schoolwork more readily. She says she now feels better and is much more self-confident.

Julia's symptoms constitute just one profile of a child with ADHD. Other girls and boys exhibit similar yet varied traits, and whereas medication has helped in many cases, for just as many it provides no relief. With the number of cases increasing every year, debate over basic questions has heightened: Is ADHD overdiagnosed? Do drugs offer better treatment than behavior modification? Recent progress in understanding how brain activity differs in ADHD children is suggesting answers.

What Causes ADHD?

ADHD is diagnosed in 2 to 5 percent of children between the ages 6 and 16; approximately 80 percent are boys. The typical symptoms of distractibility, hyperactivity and agitation occur at all ages, even in adults who have the condition, but with considerable disparity. Children often seem forgetful or impatient, tend to disturb others and have a hard time observing limits. Poor impulse control manifests itself in rash decision making, silly antics and rapid mood swings. The child acts before thinking. And yet ADHD children often behave perfectly normally in new situations, particularly those of short duration that involve direct contact with individuals or are pleasurable or exciting, like watching TV or playing games.

THINKSTOCK/GETTY IMAGES

Precursor behaviors such as a difficult temperament or sleep and appetite disorders have often been found in children younger than three who were later diagnosed with ADHD, but no definitive diagnosis can be made in those first three years. Physical restlessness often diminishes in teenagers, but attention failure continues and can often become associated with aggressive or antisocial behavior and emotional problems, as well as a tendency toward drug abuse. Symptoms persist into adulthood in 30 to 50 percent of cases.

Longitudinal epidemiological studies demonstrate that ADHD is no more common today than in the past. The apparent statistical rise in the number of cases may be explained by increased public awareness and improved diagnosis. The condition can now be reliably identified according to a set of characteristics that differentiate it from age-appropriate behavior. Nevertheless, debates about overdiagnosis, as well as preferred treatments, are sharper than ever.

Neurologists are making headway in informing these debates. For starters, researchers using state-of-the-art imaging techniques have found differences in several brain regions of ADHD and non-ADHD children of similar ages. On average, both the frontal lobe and the cerebellum are smaller in ADHD brains, as are the parietal and temporal lobes. ADHD seems to be the result of abnormal information processing in these brain regions, which are responsible for emotion and control over impulses and movements.

Yet these variations do not indicate any basic mental deficiency. Currently physicians see the disorder as an extreme within the natural variability of human behavior. On neuropsychological tests such as letter-sequence recognition on a computer, ADHD children have varied but frequently slower reaction times. The reason, experts now believe, is that neural information processing—the foundation of experience and behavior—may break down, especially when many competing demands suddenly flood the brain. In this circumstance or when faced with tasks requiring speed, thoroughness or endurance, the performance of ADHD brains decreases dramatically compared with the brains of other children. A lack of stimulation, on the other hand, quickly leads to boredom.

The attention deficit is particularly evident whenever children are asked to control their behav-

ior—stopping an impulsive action or maintaining a high level of performance in a given task. The problem is not so much a lack of attention per se but a rapid drop in the ability to continually pay attention.

A different phenomenon, however, gives hyperactive children the uncontrollable urge to move. Together with the cerebellum, which coordinates movement, various control systems within and underneath the cerebral cortex are responsible for motor functions. This region is where the neurons of the motor cortex, the basal ganglia and the thalamus come together. The motor cortex represents the final stage of neural processing, after which motor impulses are sent to muscles. When activity in these regions is not balanced, children have difficulty preparing for, selecting and executing movements because they cannot adequately control or inhibit their motor system. Complex movements that require precise sequencing are initiated too early and then overshoot their target. Hyperactivity also often goes hand in hand with deficits in fine motor coordination and an inability of children to stop speech from bursting forth uncontrollably.

The performance problem is not so much a lack of attention per se but a rapid drop in the ability to continually pay attention.

In general, the underlying trait of impulsivity is linked to the development of the brain's so-called executive function: the ability to plan and to monitor working memory. Executive function develops over time as the brain matures. In children with ADHD, however, it tends to remain rudimentary. Anatomically, the executive function stems from neural networks in the prefrontal cortex—the so-called anterior attentional system. Together with the posterior attentional system, located largely in the parietal lobes, it tracks and regulates behavior.

While trying to navigate life without a strong ability to monitor and plan, ADHD children are often in constant battle with their emotions. They are barely able to control their feelings, and they do not endure frustration well. They easily become excited and impatient and tend toward hostility. They also find it hard to motivate themselves for certain tasks. And they are apt to grasp at the first reward that comes their way, no matter how small, rather than wait for a larger, more attractive payoff.

Dopamine plays an important role in the limbic system, which addresses emotional challenges, and ADHD children typically have low levels of this neurotransmitter. Normally, for example, dopamine release strengthens the neural connections that lead to a desired behavior when a reward stimulus is presented. But when dopamine is absent, rewards that are minor or presented at the wrong time have no effect.

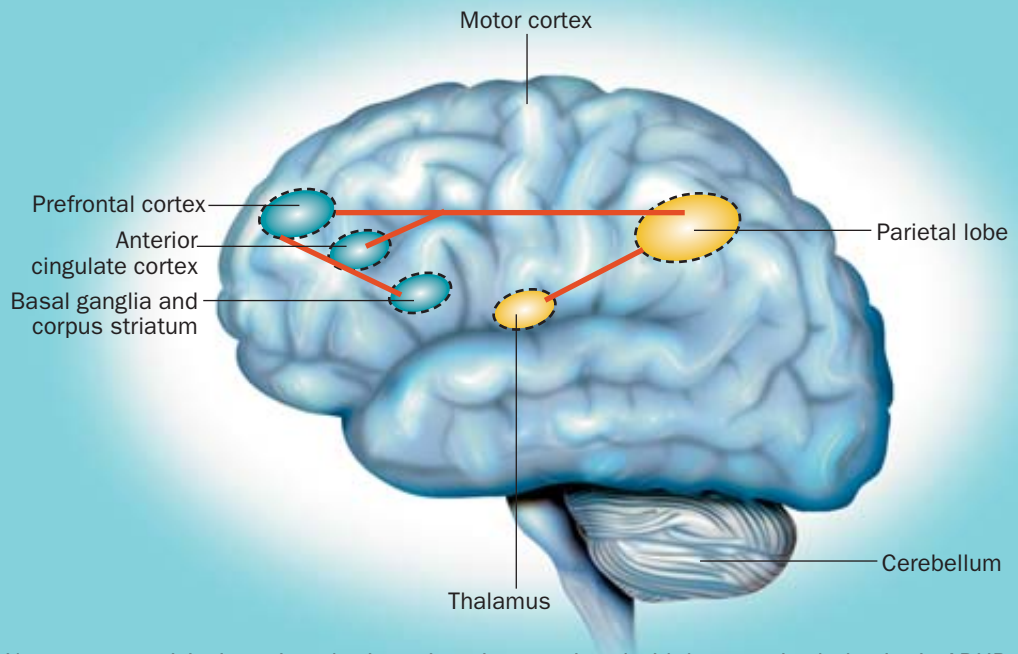
Genes or Environment

One question that arises from all these findings is why specific brain regions are smaller than others and why certain brain functions are weak or unbalanced. Genes may play a considerable role. Comprehensive metastudies of parents and children and identical and fraternal twins, such as those conducted by Anita Thapar, then at the University of Manchester in England, in 1999, Philip Asherson of King's College in London in 2001, and Susan Sprich of Massachusetts General Hospital in 2001, show that heredity greatly influences the occurrence of ADHD. For example, children of parents who have had ADHD are far more likely to suffer similar symptoms. The studies indicate that approximately 80 percent of ADHD cases can be traced to genetic factors.

As a result, researchers have been busily trying to identify which genes might be different in ADHD children. High on the suspect list are genes involved in transferring information between neurons. This group includes genes for proteins that influence the circulation of dopamine at the synapses between neurons—for example, proteins that clear away old messenger molecules so new ones can come through. So far researchers have found that receptor mediation of the dopamine signal is too weak in some patients, and dopamine reuptake is too rapid in others.

The genetics work seems to indicate that behavior problems are associated with insufficient regulation of dopamine metabolism, which derails neural information processing. The neurotransmitter norepinephrine may play a role, too. Although the genetic links between norepinephrine and its receptors and transporters are not as clearly understood as those for dopamine, medications such as atomoxetine that inhibit norepinephrine reuptake by neurons do improve symptoms.

When coupled, the neurotransmitter and brain-imaging evidence imply that the brains of ADHD children may be organized and function



Uncommon activity in various brain regions is associated with hyperactive behavior in ADHD children. Regions are typically part of the anterior attentional system (*green*) which depends on the neurotransmitter dopamine, or the posterior attentional system and norepinephrine (*yellow*).

differently from an early age. These organic disparities may actually be the cause of behavioral changes and not a consequence of them, as has sometimes been suggested. Another piece of evidence is that in some cases, as children mature, certain physiological peculiarities—such as the size of the corpus striatum—become normal, and ADHD fades.

Still, ADHD cannot yet be tied neatly to known physical, genetic factors. Experts believe that the gene loci discovered to date explain at most 5 percent of problematic behaviors. If more fundamental gene variations are at fault, they have not yet been found. The probability of developing a hyperactivity disorder depends on a combination of many different genes.

Furthermore, there is wide variability in the degree to which these genetic factors are expressed. That means environmental influences must certainly play a role. For example, alcohol and nicotine consumption by a mother during pregnancy tends to increase the risk of ADHD in offspring, in much the same way they contribute to extreme prematurity, low birth weight and food allergies.

On the other hand, it is also true that mothers with a genetic predisposition to ADHD have a propensity to smoke and drink during pregnancy. They tend to make basic child-rearing errors, too, such as failing to establish clear rules and effective limits. A chaotic household can strengthen biological ADHD tendencies, leading to a vicious cycle.

Other psychosocial factors, including a nonsupportive school environment, marital crises or psychological problems arising between parents, and poor parent-child attachment can also transform a latent tendency into a full-blown disorder.

Medication Dispute

Recent findings about deficits in brain function and neurotransmitters make it clear why certain drugs are likely treatments. And yet the role of environment suggests that behavioral therapy can also be effective. Today uncertainty surrounds both options, and the increasing use of medication has proved divisive. Opinion runs from euphoric endorsement to outright rejection.

The body of evidence suggests that neurotransmitter systems need to be targeted. Psychostimulants such as amphetamine sulfates and methylphenidate, marketed under such names as Ritalin, have had widespread success. Numerous clinical studies show that these medications can

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Latest Leap

Neurofeedback is the newest treatment alternative that therapists are exploring to combat ADHD. It is based on the finding that the electrical brain activity of ADHD children often differs from that of their peers. In this scheme, children play special computer games to learn how to consciously influence their brain waves—and therefore their behavior. For example, they can make themselves calmer and more attentive by strengthening certain electrical activity and decreasing other activity. Sounds, music or movie clips reward them when they can elicit a desired change.

In one game (*photograph*), a child wearing electrodes watches a cartoon of a pole-vaulting mouse. The mouse can only clear the bar when the pole turns red. This feat occurs when the child concentrates, but the pole turns blue when the child does not.

Children in neurofeedback therapy usually undergo three or four 30- to 40-minute sessions a week for six to 10 weeks. Attention, concentration, impulsivity and mild forms of hyperactivity frequently improve. A child's feelings of self-esteem also improve because he sees that he can control his own behavior. Many succeed in transferring the concentration skills they develop to their schoolwork. *—A.R. and T.B.*

decrease or eliminate behavioral disorders in 70 to 90 percent of patients.

Administering stimulants to hyperactive children might seem counterintuitive. Yet these substances fix the genetically based dopamine imbalance in the parts of the brain responsible for self-regulation, impulse control and perception. In effect, they prevent the overly rapid reuptake of dopamine at synapses. Other substances with similar modes of action, such as the norepinephrine reuptake inhibitor atomoxetine, work equally well.

Many parents are understandably nervous about subjecting their children to a long-term regimen of medication. News that Ritalin use may be implicated in Parkinson's disease, a dopamine deficiency illness, has added to the worry. Such a connection was suspected because rats that received methylphenidate before sexual maturity exhibited fewer than normal dopamine transporters in their striatum. But to date, not a single case of Parkinson's has been attributed to the use of Ritalin during childhood, and on average Parkinson's patients do not have a history of taking psychostimulants more frequently than other people. Nevertheless, many parents may fear that long-term treatment with psychoactive drugs could leave their child vulnerable to drug or medication abuse in the future.

Recently, however, Timothy E. Wilens and his colleagues at Harvard Medical School laid these concerns to rest with a large-scale metastudy. It turns out that the use of psychostimulants significantly *reduces* the risk of future abuse. In comparing ADHD adults with comparable symptoms, those who had not received ADHD medications as children were three times more likely to succumb to drug addiction later in life than those who had received medication.

Drugs Plus Behavior

This does not mean that physicians should prescribe drugs lightly. And under no circumstances should doctors, parents or patients rely exclusively on medication. Studies show that adding behavioral therapy greatly enhances improvements. It also can teach children how to overcome any kind of problematic behavior that might arise in their lifetime. Children learn how to observe and control themselves. Unless ADHD erupts in its most extreme form, behavioral therapy should be the initial treatment of choice. If a child shows no significant signs of improvement after several months, a drug regimen can then be considered.

ARIBERT ROTHENBERGER

For the youngest children—those of preschool age—psychostimulants should generally be avoided. Parents should instead try to work daily with their children on their behavior. Parents would also do well to draw on the expertise of preschool teachers, who see many different children with a wide range of challenges.

A comprehensive examination conducted in 2000 by the National Institute of Mental Health rated the effectiveness of medical and behavioral treatments of ADHD. Conducted over two years, the Multimodal Treatment Study of Children with ADHD included 579 ADHD children at six different university medical centers. The principal investigators divided the test subjects, all of whom were between the ages of seven and nine, into four groups that had different treatment plans. The results strongly suggest that a combination of drug and behavioral therapies leads to the highest success:

- Routine daily treatment with prescribed medication normalized behavior in 25 percent of children treated.
- Intensive behavioral therapy without medication ended with 34 percent of patients exhibiting no further remarkable symptoms.
- Carefully tailored medical treatment with accompanying counseling for the child and parents helped 56 percent of the children.
- A combination of medication and behavioral therapy resulted in a success rate of 68 percent.

Always Count to 10

These findings allow us to draw concrete conclusions about how parents and educators might best help ADHD children. With or without drugs, it is imperative that children be taught how to handle tasks with more organization and less impulsivity. One common tool, for example, is teaching them to count to 10 before carrying out an impulse, such as jumping up from a table at school. Wall posters or cards shaped like stop signs can remind children to use the various devices they have learned in the heat of a moment. Older children and teenagers can learn how to make detailed plans and how to follow through when complicated tasks threaten to shut them down—for example, when they must straighten a messy bedroom.

Parents also need aids for dealing with trying situations. They can receive guidance in parent training programs that focus on their child-rearing skills as well as their child's interactions within the family. One common recommendation is to set up written schedules with children so that getting ready for school, for example, does not turn into a contest every morning. Clear rules, specific expectations and known consequences as well as reward points for desired behaviors can all be effective. Particularly with teenagers, parents and even siblings should be included in family therapy.

Studies strongly suggest that a combination of drug and behavioral therapies leads to the highest success.

As neuroscience progresses, therapists continue to try to refine which mixes of drugs and behavioral therapy are best for which types of ADHD. More work is needed. Little is known, for example, about what occurs in the brains of ADHD children between birth and the time they enter school. One conclusion has become increasingly clear, however: the varying combinations of behaviors cannot be grouped into a picture of a single disorder. Researchers are now trying to define subgroups that are more coherent in terms of symptoms and neurological causes. To this end, they are looking at other disturbances that are often associated with attention deficit or hyperactivity; approximately 80 percent of ADHD children suffer from at least one other challenge, such as nervous tics, antisocial behavior, anxiety, or reading and spelling problems.

In the meantime, as parents and teachers do the best they can, they must remember that ADHD children possess many positive traits. They tend to be free-spirited, inquisitive, energetic and funny as well as intelligent and creative. Their behavior is often spontaneous, helpful and sensitive. Many ADHD children are talented multitaskers, last-minute specialists and improvisationalists. Parents and educators should encourage these strengths and let their children know whenever possible that these qualities are highly valued. That will help them feel less under attack, a relief that all by itself can help them begin to turn the corner.

(Further Reading)

- **Driven to Distraction: Recognizing and Coping with Attention Deficit Disorder from Childhood through Adulthood.** Reprint edition. Edward M. Hallowell and John J. Ratey. Touchstone, 1995.

Underappreciated yet vital, the sense of touch helps to complete an amazingly accurate mental picture of our surroundings and ourselves

Worlds of feeling

BY MARTIN GRUNWALD

FAST FACTS

Sense of Touch

1 » Our sense of touch refines our mental picture of the world around us; sight alone cannot tell our brains about aspects of objects such as weight or texture.

2 » Millions of touch sensors form an intricate sensory network in the body; exactly how they work together is still not well understood.

3 » Touch systems gone awry could be a contributing factor in mental disorders involving body image, such as anorexia nervosa.

At dawn the beeping of your alarm clock drills relentlessly into your consciousness. With eyes still closed, you reach for the nightstand. Your hand glides over your bedtime book, reading glasses and the cup of water, landing almost precisely on the noisy nuisance. After a short fumble, your fingers press down on a raised button to silence the alarm. With a sigh, you sink back into sleep. You do not dwell on what an impressive feat you have just performed. The sense of touch—which is absolutely necessary for us to perform our physical capabilities as well as for learning—is not something we waste time thinking about.

DIGITAL VISION/GETTY IMAGES

Perhaps that is because life without the ability to feel is scarcely imaginable. The complete absence of this sense never occurs in nature, and independent life would not be possible without it. Beyond giving us the ability to smack a blaring alarm clock, the luxurious provision of sensors on our hands, for instance, permits us to achieve quite a lot even with our eyes closed. Consider the seemingly simple act of writing with a ballpoint. This task demands a constant flow of detailed information from sensors to the brain, which report how our fingers are holding the pen and measure pressure changes on the skin and joints.

How touch works is extremely complex and poorly understood, although in recent years scientists have learned enough about its operation to at least grasp some of the fundamental aspects of this sensory system.

Our entire bodies are covered with a network of tactile sensors, perhaps six million to 10 million in all.

Researchers make a basic distinction between the passive and active acquisition of information through touch. Passive tactile awareness involves the sensing of external pressure or temperature acting on parts of the body. In addition to providing cues about our environment, being touched affects the early development of many creatures, including humans. When young rats are separated from their mother in the laboratory, they immediately secrete less growth hormone—unless researchers replace the missing maternal caresses by stroking the pups with a moist paintbrush. Moreover, if tactile stimulation is completely cut off for too long, the animal's brain and body will not develop normally. Heeding such studies, therapies for premature human infants include whole-body massage, which reduces stress hormone levels in premature babies and helps them sleep better and grow faster. Many researchers agree that early skin-to-skin contact affects later intelligence, as well as social and emotional growth.

Active touching, on the other hand, occurs when we explore our surroundings with our hands, feet or mouth. This form of touch helps our brains develop a comprehensive understanding of objects around us. Many material and spatial characteristics—how much things weigh or how hard, rough or stretchy they are—are difficult to gauge with our eyes alone. We begin acquiring such data soon after birth. As soon as infants can grab objects, they stick everything they can reach in their mouths to suck every bit of tactile information out of them. And when a two-year-old splashes again and again in water, he may be attempting to resolve the contradictory information he has from his senses: How can the solid-looking pool of water slide through his grasping fingers?

Complex Network

Fingers are not the only areas filled with touch-sensing equipment. Our entire bodies are covered with a network of tactile sensors, perhaps six million to 10 million in all. Exactly where these information gatherers are located is not known in great detail: obviously the skin, the erogenous zones and the area around the mouth are especially richly endowed. Touch sensors come in numerous types, including specialized receptors in our joints, tendons and muscles [*see illustration on opposite page*], which report to the brain on the position and motion of our limbs.

The largest tactile receptors are Vater-Pacini corpuscles, which can be up to four millimeters long. They reside in the lower layers of the skin, the muscles and the tendons and are sensitive to vibrations with frequencies between 40 and 1,000 hertz (cycles per second). They can tell you about the cell phone buzzing in your pocket or detect the familiar vibrations of a car you are driving—thus helping to warn you if the engine or tires are not working right. It is possible that our ancestors benefited from this warning function of the Vater-Pacini corpuscles: they are extremely sensitive to ground vibrations that could announce the footfalls of an approaching enemy.

Lower-pitched vibrations—those between 0.3 and three hertz—are the métier of Meissner corpuscles. These tiny receptors, forty-thousandths of a millimeter thick and about twice that long, lie just under the skin's surface throughout the body. They are especially densely packed in areas that help us discriminate among fine differences. The fingers of adults, for example, have 24 of them per square

(The Author)

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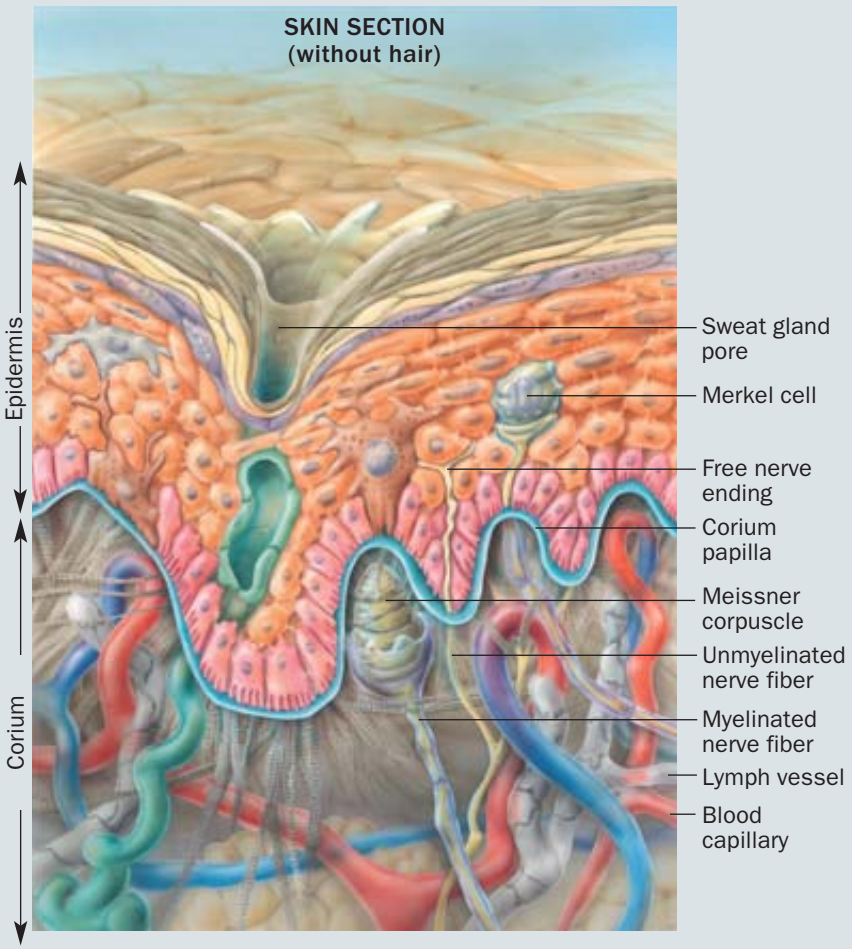
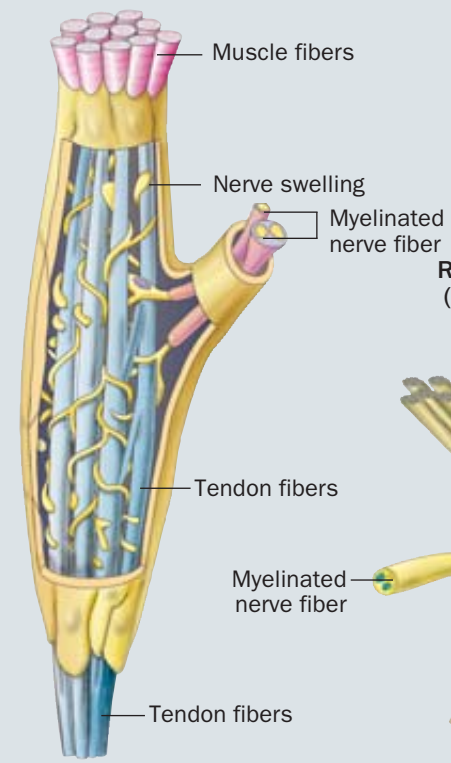
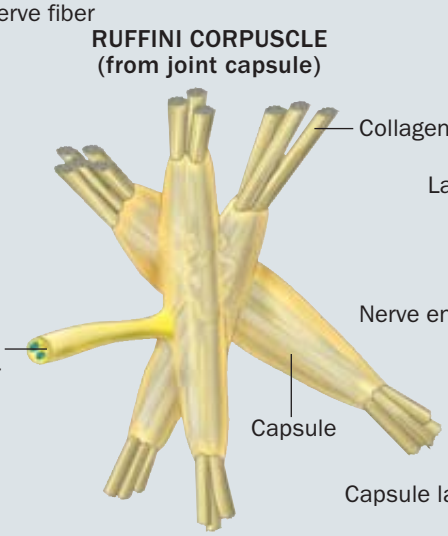
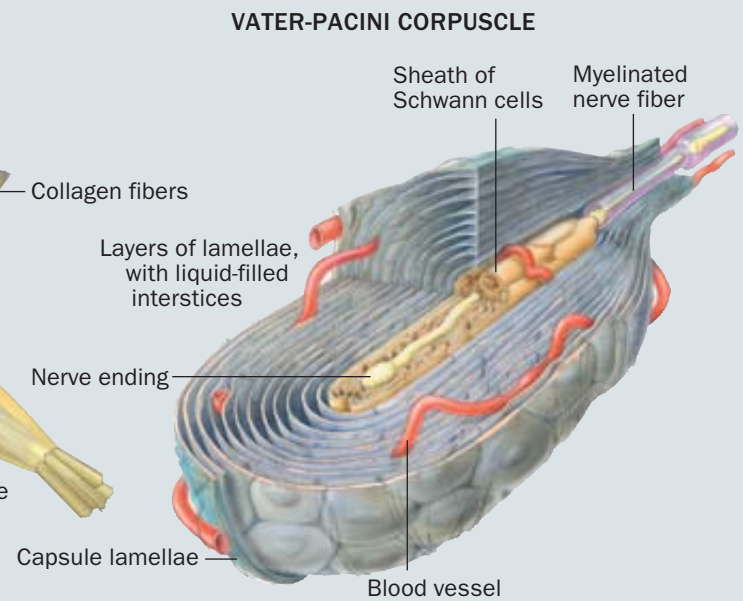
Sensors for Touch

The main field of action for tactile sensation is the skin. Just under its surface lie the Merkel cells, which permit the fingers to achieve spatial resolution down to 0.5 millimeter. While free nerve endings probably detect the very smallest movements, Meissner corpuscles are important for control when gripping objects. Ruffini corpuscles react especially sensitively to stretching of the skin and joints. In joints, together with other receptors, such as the Golgi tendon organs, they provide information to the brain about the locations of the extremities. Vater-Pacini corpuscles are found in many parts of the body, such as deep within the skin, in joints and in internal organs. They are especially adept at detecting vibrations from surroundings.





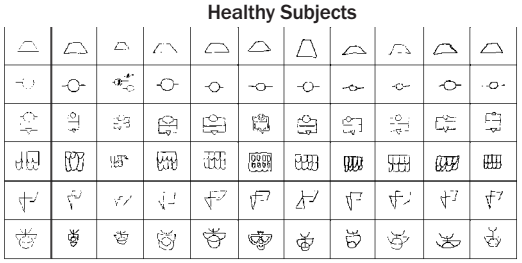




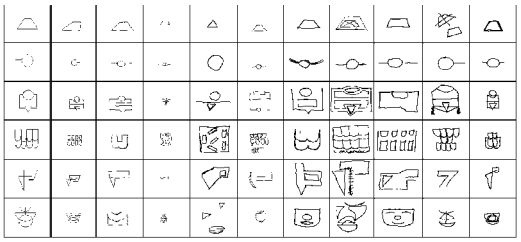
JULIUS ECKE N. KRSTIC (*Golgi tendon organ* and *Vater-Pacini corpuscle*); N. HALATA U. MUNGER (*Ruffini corpuscle*)

Touch and Body Image

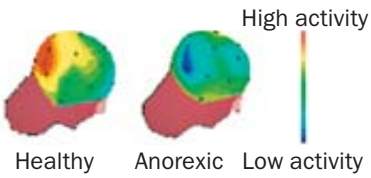
Healthy Subjects



Anorexic Patients



In an experiment, blindfolded healthy women and patients with anorexia nervosa felt designs in sunken relief (*top*) and then drew them on paper (*tables*). The patients had difficulty making accurate drawings, suggesting a deficit in the operation of sense of touch. Brain activity measurements taken while the patients felt the reliefs showed less activity in the right parietal cortex (*at right*). The author hypothesizes that flaws in tactile capabilities and in the integrative function of the parietal cortex could contribute to faulty body image in anorexics.



millimeter of skin. Standing and walking upright would also be impossible if Meissner corpuscles and other tactile sensors were not providing a constant stream of information from the deformation of the bottoms of the feet, allowing our brains to calculate the necessary movements to remain upright. Shoes with thick soles can thwart Meissner corpuscles, so the tactile system taps other sensors. Among them are Ruffini corpuscles, located in the connective tissue of the limbs and joints in addition to the skin. They help to give the brain precise information about the positions of our arms and legs. Ruffini corpuscles consist of three cylinders, which come together in the center to form a kind of knot. Bundles of fibers anchored to connective tissue, muscles and tendons run through these cylinders. Any motion of a joint compresses or stretches a fiber, which signals a change then picked up by these sensors.

Auxiliary equipment for keeping track of the environment includes the Golgi tendon organs—highly sensitive tension sensors in the tendons and muscle fibers. These fine bundles of fibers run through the muscles from end to end. Information from Golgi tendon organs helps the brain calculate the muscle strength and balance needed, for instance, to walk up or down stairs. They report any changes in length of or tension in the skeletal muscles to the brain. The degree of contraction needed to take the first step up serves as a basis for calculating every other. That is why climbing stairs with risers that differ in height by even just a few millimeters can be so treacherous: suddenly the calculated amount of muscle contraction needed does not correspond to reality, and we stumble.

The brain's impressively precise awareness of limb positions becomes clear in a simple experiment. Wearing a blindfold, a person moves the crank of an apparatus into a certain position. Then, still blindfolded, she tries to turn a second crank to the same angle. Most people do so well that the final alignments differ by an astonishingly small amount—usually less than three degrees.

Whether a person is writing, climbing stairs or turning a crank, all the flows of sensory and motor data meet up in the brain. The parietal cortex (a part of the brain's surface slightly behind the top of the skull) apparently plays the main role in integrating the signals. Our vision seems to be secondary here—people born blind have no trouble creating images that situate them or other things in space. If this region of the brain is damaged by a head injury—a condition called ostereognosis—a person can no longer locate an alarm clock and

Demonstrating the sensitivity and accuracy of our sense of touch, a blindfolded woman moves one crank to a given angle, then puts another one at almost the same angle.

MARTIN GRUNWALD (*photograph and table*)

Techno Touches

Various research projects aim to extend human touch to machines—and vice versa.

One example is simulated haptic sensation, where a person wears instrumented gloves that control movements of a mechanical "hand" located remotely. Tiny electric motors move the fingers. The technology lets a person perform a dangerous action from a safe distance. In another meeting of biological senses and mechanical sensors, surgeons using haptic interfaces such as CyberGlove can practice operations in virtual-reality simulators.

Other labs cut out the human altogether in favor of focusing on the robotics. Although no robot so far can duplicate the sensory network found in *Homo sapiens,* researchers seek to imitate the magnificent human body with humanoid machines. Using elaborate sensor feedback, Honda's Asimo robot, for instance, apes a human's ability to walk on two legs, and it even climbs stairs.

Truly endowing machines with the ability to feel and react as humans do will require developing an active sense of touch. One step in that direction is pressure-sensitive "skin" (*photograph*) developed by Takao Someya and his co-workers at the University of Tokyo. Each sensor is about three millimeters square; individual square patches of sensors can be linked up to cover larger areas simply by taping them together with their electrodes aligned. The units can be bent to a one-millimeter radius—good enough for encircling slender robot fingers. So far, however, the sensors' transistors' response degrades after only a few days and requires a high operating voltage, 40 volts, which researchers hope to lower to 10.

TAKAO SOMEYA *University of Tokyo*

push down the snooze button with his eyes closed.

Our sense of touch also enables us to take the measure of our body's size and position. The parietal cortex apparently combines millions of individual data points from the touch sensors in muscles, joints, tendons and skin to create an internal picture of ourselves. Normally, people are very good at estimating how tall, heavy and broad they are, allowing them to duck sufficiently for a low doorway or turn sideways to slip through a narrow passageway. Scientists call these internal ideas about the exterior dimensions of our bodies corporal representation, or body image.

Distorted Self-Image

For some people, however, body image is distorted. That is the case for almost all those afflicted with anorexia nervosa, a serious mental illness that ends fatally for up to 18 percent of patients. Victims, who starve themselves until they are emaciated, experience and describe their bodies as fat and bloated. Our work group hypothesizes that a disturbance to the integrative function of the parietal cortex could play a role in anorexia. If this is true, then patients should also have problems in tasks that require haptic (sense of touch) awareness, and we should see characteristic changes in electrical activity within the parietal cortex.

To test this theory, we blindfolded normal, healthy women and women suffering from anorexia and then asked them to feel sunken relief designs made from plastic with their hands. Afterward, with their eyes open, they drew the same designs on a sheet of paper, as exactly as possible. We monitored their brain activity as they worked.

Anorexic patients had difficulty with this test. In contrast to the drawings made by healthy women, those of anorexics were sometimes inaccurate. In addition, analysis of the electrical activity within the brain revealed that in the anorexic patients, the right parietal cortex was less active than in the healthy subjects [*see box on opposite page*]. Given our findings, we would like to develop therapeutic measures to help anorexics gain a more accurate body image. The first studies are under way.

Many puzzles still surround the exact operation of the body's tactile system, but one thing remains clear: from learning to everyday functioning to rare disease states, our haptic senses literally touch every part of our lives.

(Further Reading)

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The Limits of Multitasking

Reading e-mail, sorting data and talking on the phone at once—multitasking clearly saves time in a fast-paced world. Or does it?

BY KLAUS MANHART

You arrive at the office, review your 17-point to-do list and immediately start to feel butterflies in your stomach. You resolve to tackle the items as fast as possible. While you return calls, you sort e-mail and snail mail. You begin keying in slides for tomorrow's presentation. Then the boss comes in to demand an update on sales figures—ASAP, please. You've just opened the spreadsheet when one of your most important customers calls. With the receiver jammed between your shoulder and ear, you keep tabbing up the sales totals until, 15 minutes later, you are finally able to get rid of the client politely.

Anybody who expects to get ahead today better master the art of multitasking, right? A recent study of employees by the Families and Work Institute in New York City finds that some 45 percent of U.S. workers believe they are asked or expected to work on too many tasks at once.

Their bosses might be surprised to learn that they are actually wasting their workers' time. As it turns out, the human brain cannot truly ape the

ZEFA VISUAL MEDIA–GERMANY

Multitasking as extreme sport: in many fields juggling several tasks has long since become part of the job.

computer's knack of crunching data in the background while toggling among processing windows. Instead a growing number of studies show that trying to juggle jobs rather than completing them sequentially can take longer overall and leave multitaskers with a reduced ability to perform each task. In addition, the stress associated with multitasking may contribute to short-term memory difficulties. The combination results in inefficiency, sloppy thinking and mistakes—not to mention the possible dangers of divided attention for drivers, air traffic controllers and others who handle machinery. Recognizing the problem, New Jersey became the second state (after New York) this past July to ban drivers from using a cell phone without a headset.

How can a time-management strategy that has become part of the common wisdom actually be so off base? To explore that question requires a closer look at an area of consciousness research that examines how the brain focuses attention.

Interference in Your Brain

Walking and chewing gum may work out. But you can strain your brain—or, more precisely, your attention resources—when you try to combine a routine, automated task (such as reading) with one that demands conscious control. Called interference or the Stroop effect, the phenomenon was first reported by American psychologist John Ridley Stroop in the December 1935 *Journal of Experimental Psychology*.

To experience interference for yourself, say the colors of the Xs in the tables below out loud and as quickly as possible. Then name the colors of the words listed in the columns at the right. Remember, do not read the words themselves but rather call out the colors of the type you see.

Many people take longer to complete the second test and may trip over one or more of the colors. The Stroop effect thus demonstrates how two psychological processes, running in parallel, collide with each other. Naming the colors is the primary task, which demands concentration and must be consciously controlled. The second process, reading, has been so well learned that it runs automatically and can be suppressed only with effort. Solving the primary task is thus slowed and we notice a hesitation when we try to say that, for instance, the color of the word "red" is green.

XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX
XXXX	XXXX

blue	yellow
red	yellow
blue	red
yellow	blue
gray	red
red	green
blue	blue
green	yellow
yellow	green
green	red

Automatic Interference

One of the modern foundations of current knowledge about multitasking in the brain was laid in 1935. That was when American psychologist John Ridley Stroop reported that processing the information for one task can cause "interference" with another. Stroop noticed that when study participants were asked to name the color of a word, such as "green," printed in an incompatible color—say, red—they experienced difficulty saying the color. Now known as the Stroop effect, the phenomenon is thought to occur when two tasks get tangled: the brain must suppress one that has been learned so well that it has become automatic (reading) to attend to a second that requires concentration (naming the color). The brain performs automated processes quickly and unconsciously—and sometimes we have trouble suppressing them when we want to. As soon as we see a word, we decipher it unconsciously. If the word's meaning contradicts other information provided simultaneously, interference results. [*To take the test yourself, see box above.*]

During the past couple of decades, psychologists have probed more deeply into the nature and limitations of multitasking in the brain. Part of the ability to juggle depends on the types of the tasks. In the absence of the contradictory cues that cause interference, automated tasks (walking, for instance) are fairly easy to blend with harder ones (such as carrying on a conversation). It is also possible to combine two relatively complicated tasks, as long as they are not too similar. Pianists, for example, can play a new piece fairly quickly, sight-

Up to a point, people can improve their multitasking skills with practice—at least those that can become routine.

RUBBERBALL PRODUCTIONS/GETTY IMAGES

reading it, while at the same time repeating back a text that is being read to them at the rate of 150 words per minute. The pianists receive the information via different input channels (eyes and ears), use the music- and speech-processing regions of their brains, respectively, and in the end carry out these tasks in one case by speaking and in the other by using their hand and arm muscles.

Up to a point, people can improve their multitasking skills with practice—at least those that can become routine. In one study, scientists gave a group of students texts to read, while at the same time dictating words for them to write down. In the beginning, the participants found it extremely challenging to do both tasks, and they were forced to read much more slowly than usual. But after six weeks of practice, they could read at their normal speed. The researchers, psychologists Elizabeth S. Spelke, now at Harvard University, William Hirst, now at the New School University in New York and Ulric Neisser of Cornell University, were surprised to discover that the subjects no longer were aware of what they were jotting down. Their brains had automated the writing.

Switching Channels

By-rote tasks require fewer mental resources, but they cannot be fobbed off entirely. And switching tasks comes at a mental cost: reduced ability to focus on the matter at hand, lost time during "resetting" for different jobs and even memory problems.

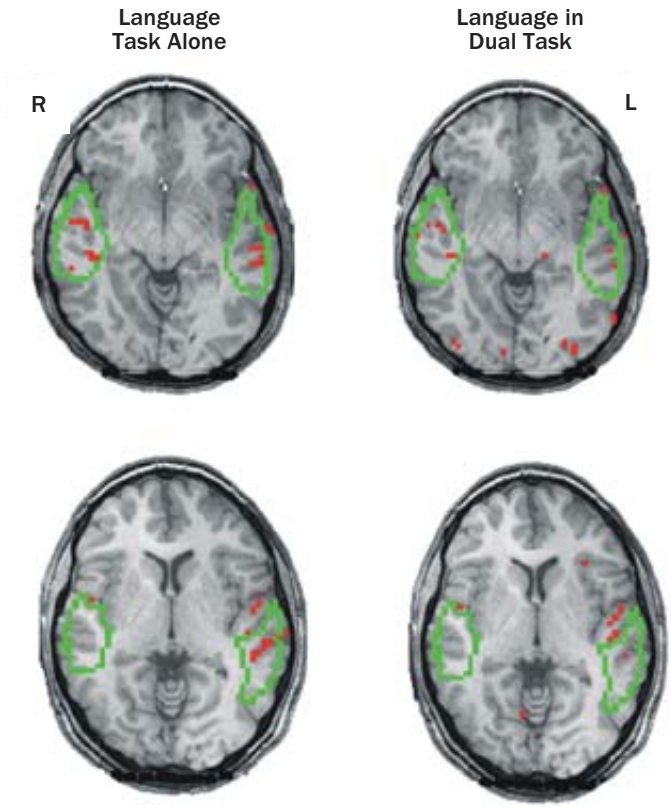
Psychologist and brain researcher Ernst Pöppel of the Institute for Medical Psychology at the Ludwig Maximilian University in Munich believes that it is impossible to carry out two or three different tasks simultaneously with the same degree of concentration. He says that seemingly simultaneous awareness and processing of information actually takes place in "three-second windows."

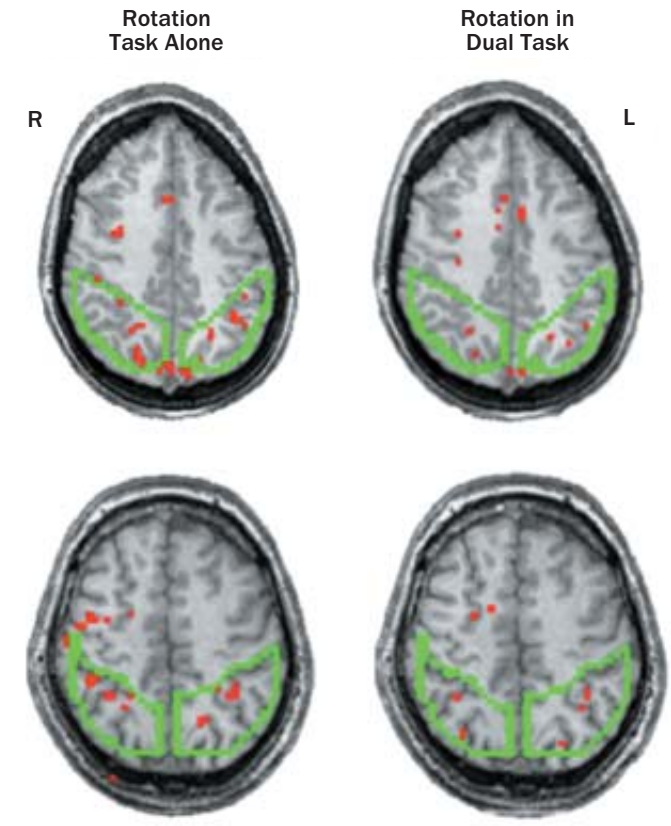
In these three-second increments, the brain takes in all the data about the environment streaming in from the sensory systems as a block; subsequent events are then processed in the next window. What appears to be multitasking is thus more akin to channel surfing among different television stations. A person can concentrate on a conversation for three seconds, then for three seconds on a crying child and three on a computer screen. While one subject at a time occupies the foreground of consciousness, the others stay in the background until they, in turn, are given access to the central processor. [*For more on how scientists explain the limits of attention, see box on page 67.*]

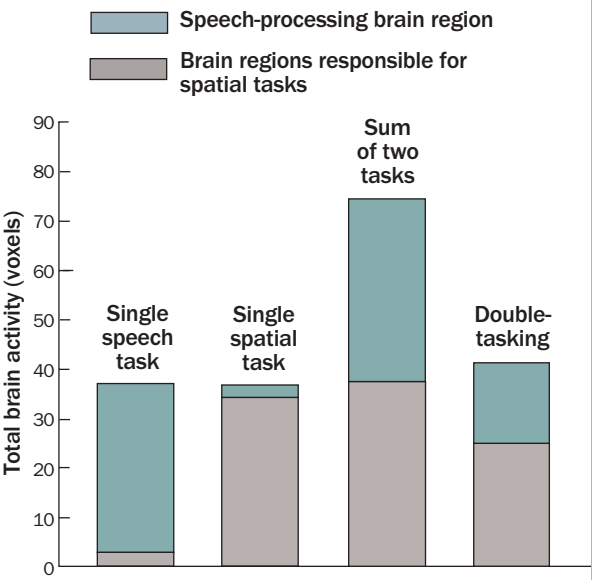
This effect seems to be confirmed by the results from research teams at the Center for Cognitive Brain Imaging at Carnegie Mellon University. The scientists used an MRI (magnetic resonance imaging) machine to measure brain activity as subjects listened to sentences being read to them while at the same time mentally rotating two three-dimensional figures. First, the investigators established with tomographic images that there was minimal "task similarity." The activated regions of the brain barely overlapped, so the two tasks presumably ought to have been easy to combine. When the subjects tried to perform both simultaneously, however, they struggled. They could manage to do both but not as quickly and not as well as doing either by itself.

(The Author)

KLAUS MANHART has a degree in the philosophy of science and works as a social scientist as well as freelance writer in Munich, Germany.







If two thought problems must be solved simultaneously rather than sequentially, the brain must drastically cut the resources allocated to each (*above*). Images of two people's brains show neural activity decreases when neurons juggle two tasks at once as compared with focusing on one task alone (*left*).

MARCEL JUST *Carnegie Mellon University*

What was striking was how brain activity *dropped* while the subjects tried to perform the two tasks: it was less than two thirds as much as the total devoted to each task when processed independently [*see illustrations on this page*]. "The human brain cannot simply double its efforts when there are two problems to solve at the same time," concludes Marcel Just, leader of the study.

Another experiment, by psychologist David E. Meyer of the University of Michigan at Ann Arbor and his colleagues, quantified just how much time we can lose when we shuttle among tasks. The researchers asked test participants to write a report and check their e-mail at the same time. Those individuals who constantly jumped back and forth between the tasks took about one and a half times as long to finish as those who completed one job before turning to another.

In another trial, the scientists asked subjects to switch between solving math problems and classifying geometric figures. They found that the more difficult the problems and the more complex the rules used in sorting, the more time the subjects lost in switching. Each switchover from one task to the next meant rethinking and thus involved ad-

Multiple Multitasking Models

Cognitive psychologists have developed three models to account for apparent multitasking in humans.

One Channel, or Bottleneck, Theories. These hold that the brain has a single data-processing channel, analogous to serial processing in a computer; true parallel processing of several tasks is fundamentally impossible. Combining tasks is only possible if we rapidly jump back and forth among them. What looks like multitasking is explained by "redundancy." For example, one does not have to focus on every word to read and understand a text. The brain can devote attention during those spare moments to another task.

Theories of Central Capacity. These posit that the brain has limited, or finite, attention resources that can be flexibly allocated among different tasks. The quality of performance in doing two tasks depends on the level of cognitive resources that the two require; if the sum exceeds attention resources, performance declines.

Modular Theories. Based on the idea that brains work like a computer—one with rich networks created from specialized subsystems. The decisive factor for multitasking for this model is similarity of tasks. When performance declines, we can conclude that two tasks are using the same resources or subsystems. Cognitive neuropsychologists currently favor modular theories over the alternatives.

By its nature, multitasking is stressful, and the area in the brain most involved with multitasking is also most affected by the resulting stress.

ditional neuronal resources. In effect, the brain needs time to shut off the rules for one task and to turn on the rules for another. "Multitasking saves time only when it is a matter of relaxed, routine tasks," Meyer says.

It also takes the brain longer to change gears when switching back to an interrupted task rapidly, as many multitaskers do, rather than waiting longer before switching back. A fall 2002 study from the National Institute of Mental Health found that the brain has to overcome "inhibitions" it imposed on itself to stop doing the original task in the first place.

Stressing Memory

By its nature, multitasking is stressful, and the area in the brain most involved with multitasking is also most affected by the resulting stress. Located right behind the forehead, the prefrontal cortex, which neuroscientists call the "executive" part of the brain, helps us assess tasks, prioritize them and assign mental resources. It also "marks" the spot at which a task has been interrupted, so we can return to it later. This area is affected by prolonged stress. Such stress can also affect brain cells in another region, the hippocampus, which is important for forming new memories and accessing existing ones [see "Stressed-Out Memories," by Robert M. Sapolsky, on page 28]. That damage makes it difficult for a person to acquire new skills and facts.

Pöppel does not recommend mental channel surfing. During such disjointed thinking, connections are lost, and as a result no lasting neuronal representation is created from the information so processed. "In this way, the brain is very conservative and protects itself," the scientist warns.

Psychiatrists Edward Hallowell and John Ratey of Harvard say that multitasking can cause "pseudo-ADD," which is different from ADD, attention-deficit disorder [see "Informing the ADHD Debate," by Aribert Rothenberger and Tobias Banaschewski, on page 50]. Those affected by pseudo-ADD constantly seek new information and have difficulties in concentrating on its content.

So let the e-mail sit while you work on that presentation. After all, a certain satisfaction comes from a job well done.

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Secret Powers EVERYWH

Conspiracy theories offer attractively simple explanations for a chaotic world. But be careful about what you believe

By Thomas Grüter

President John F. Kennedy wasn't assassinated by Lee Harvey Oswald; he was actually murdered by the CIA because he opposed the agency's unauthorized operations. Princess Diana didn't simply die in a car crash because the driver was fleeing from paparazzi; the royal family played a role because they didn't want Diana to inherit power or wealth. And when you see high-flying jet fighters leaving contrails in their wake, that's not just a physical effect of hot emissions in cold, humid air; the aircraft are spraying fine droplets—chemtrails—over the public, sometimes experimental infections or poisons, perhaps vaccines.

Conspiracy theories have thrived for centuries, and the Internet has accelerated their dissemination. Chemtrail believers have posted several Web sites to warn people of current threats. And the British Broadcasting Corporation has identified more than 36,000 sites providing myths and legends about Lady Di's fatal accident in 1997.

Why do people go to great lengths to try to prove that secret powers are orchestrating everything from the spread of diseases to the death of famous people? And do those who believe the theories merely have overactive imaginations, or is something else going on in their heads?

Borderline Sanity

Most individuals who revel in tales of conspiracies are sane, even if they border on delusional. Psychiatrists label someone delusional when he has a false view of reality and holds onto that view with subjective certainty. Arguments and clear evidence against the delusion will not shake the person. This steadfastness can take several forms. In relational delusions, an individual sees all the people, events and objects around him as connected to him. He believes the window display in the store on the corner is sending him a message or that a certain newspaper article was meant for him alone. In persecution delusions, the individual thinks others are eavesdropping on him, watching him, chasing him.

Whatever the delusion, therapists often cannot tell if an apparently crazy idea is or is not based in reality. And to some degree, it doesn't matter.

HERE

Accepted: a crazed Lee Harvey Oswald assassinated John F. Kennedy in 1963. Conspiracy: the CIA had Kennedy killed because he was about to expose the agency's secret attempt to control the country.

Accepted: Princess Diana died in a 1997 car crash while fleeing from paparazzi. Conspiracy: the royal family played a role because they did not want Diana, who might have had an affair with a commoner, to wield power or gain her inheritance.

A diagnosis of delusional disorder is made primarily on the way a patient presents the idea and his absolute certainty about events that will fall out from it. Still, therapists must be cautious. It is possible, after all, that a patient is really being harassed at work, that her spouse is cheating on her, or that her business partner is defrauding her.

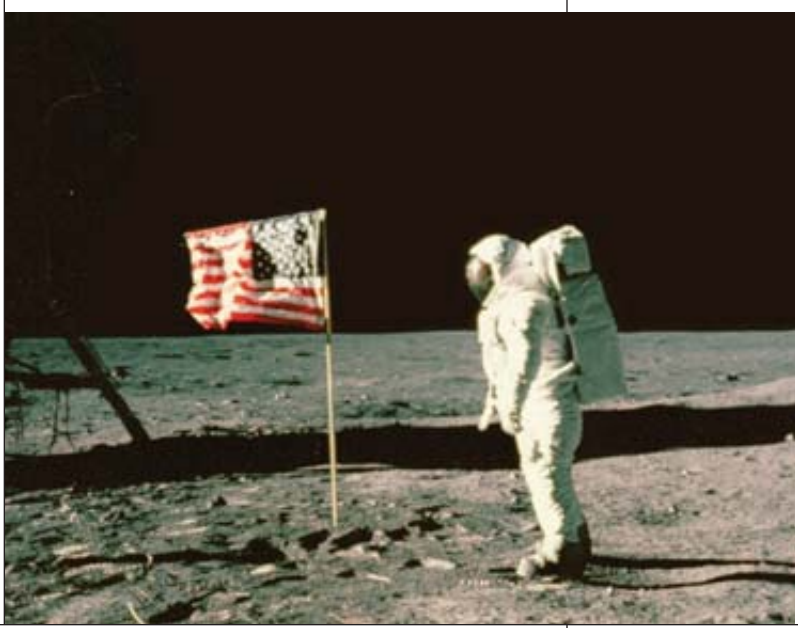
Therapists must also be careful to not mislabel facts as delusions, a trap known as the Martha Mitchell effect. Martha Mitchell was the wife of former U.S. attorney general John Mitchell. In October 1972 he was accused of having ordered the break-in at the Democratic campaign headquarters in the Watergate Hotel in Washington, D.C. Mrs. Mitchell repeatedly told the press that her husband was being made a scapegoat to protect the real culprit—President Richard M. Nixon. The White House spread disinformation about Mrs. Mitchell, saying she had a drinking problem and implying that her statements were delusional. When the scandal was ultimately unraveled, Mrs. Mitchell's statements were proved true and she was shown to be utterly sane.

Vicious Cycle of Prejudice

The many successful books and television shows about "what really happened" at Watergate or "who really killed" JFK prove that people are readily attracted to conspiracy theories. But why? One basic answer is that the theories promote a simple message. Whatever has happened, there is a single force—usually an evil one—behind it. Humans tend to drastically simplify complicated issues, reducing them to a lone cause whenever possible. This exercise brings order out of chaos; it makes a complex world intelligible. And once a person believes he understands how something works, he holds fast to this belief. Trust in a secret master plan created by a powerful organization offers simple cause-and-effect relationships that build along a linear chain of events. Chance and ambiguity have no role, which is comforting even in the face of sinister forces.

Conspiracies are especially likely to become popular when they feed already existing prejudices or superstitions. Belief in the conspiracy reinforces these positions. In this vicious cycle, any connection to reality is rapidly lost. And if the theory confirms suspicions long held by many people, the number of adherents will grow.

One good though repulsive example is the accusation, made at various times in history since the Middle Ages, that Jews sacrifice Christian children in secret rituals. This myth originated with a British Benedictine monk, Thomas of Monmouth. In his book *The Life and Miracles of St. William of Norwich,* published in 1173, Thomas reported on the death of a 12-year-old boy. Using the flimsiest of evidence, he claimed the boy was the victim of ritual murder by Jews. This libel was reiterated repeatedly until well into the 19th century. Anti-Semitic writings and falsified documents such as *The*



Accepted: the U.S. landed on the moon in 1969. Conspiracy: the U.S. government faked the landing to show it was beating the Soviets into space. The moon has no atmosphere, so why is the flag waving in the wind?

BRAND X PICTURES/GETTY IMAGES *(inset on page 68)*; BETTMANN/CORBIS *(preceding pages)*; LIBA TAYLOR *Corbis (top)*; NASA *(bottom)*

Politicians often promote conspiracy theories to defame an opponent as evil or manipulative, responsible for all kinds of terrible deeds.

Talmud Jew, published by theologian August Rohling in 1871, later lent a pseudoscientific air to the legend. These false accusations and similar ones helped to fuel anti-Semitism throughout the 20th century and into the present day.

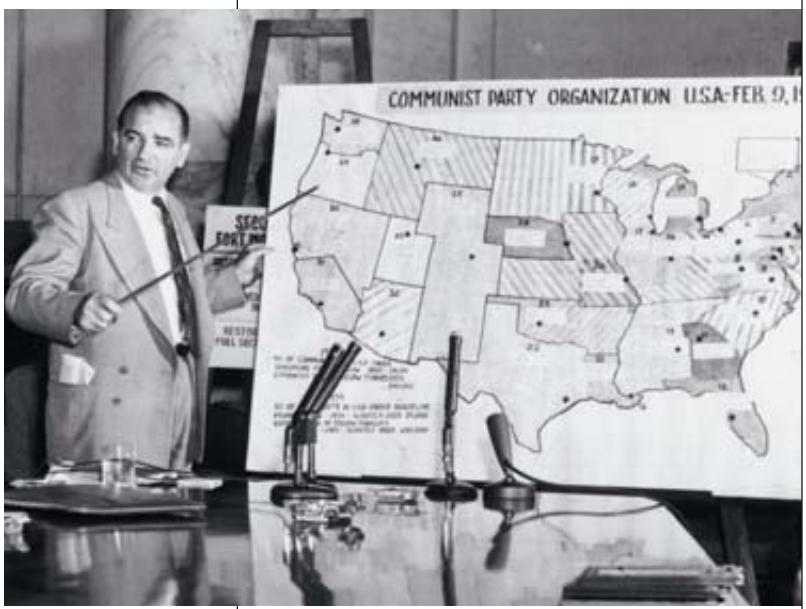
Roots of Mistrust

People seem especially willing to accept such radical tales if they spring from a general mistrust of other people. In 1994 Ted Goertzel of Rutgers University conducted a study in which subjects read 10 conspiratorial legends and were then asked which they found credible. The majority said at least one of the conspiracies was correct, and many of them accepted several as true. For example, half of the participants believed that the Japanese were conspiring to destroy the American economy. More interesting, though, Goertzel revealed that dissatisfied people were more likely than satisfied people to believe any of the conspiracies. The subjects who were especially susceptible also tended to have the greatest distrust of politicians and government officials.

Racial self-identification may play a role, too. A large proportion of African-Americans in the study believed the U.S. government had created the AIDS virus in secret laboratories and had deliberately infected black people. This belief may have had roots that the participants were not even consciously aware of. In 1932 in the town of Tuskegee, Ala., researchers from the forerunner of the Centers for Disease Control and Prevention began a notorious study of almost 400 African-American men who had syphilis.

Rather than give an honest diagnosis, the researchers simply told the men that medical reports indicated they had "bad blood"—a term used at that time for a range of disorders from anemia to chronic fatigue syndrome. The researchers offered these desperate and poor men free treatment and even volunteered to cover their funeral expenses if needed. In reality, the clinicians wanted to examine the course of untreated syphilis—to its end point, death. Even after penicillin became widely available in 1947—a drug that could have cured these patients—the study continued. Many of the subjects died, but not before infecting others. The men were treated as human guinea pigs.

Remarkably, the project went on until 1972, when journalist Jean Heller discovered the plot. Three months later the federal government declared the work unethical and broke it off. A court awarded the participants or their families $9 million in compensation as well as free health care. None of the researchers or administrators responsible were criminally tried, however. It was not until May 1997 that President Bill Clinton officially apologized to the eight remaining survivors. This history, and other stories like it, may well have fueled the widespread acceptance among African-Americans in Goertzel's study that the U.S. government conspired to inflict AIDS on members of their race. This real-life cover-up may also be the reason many blacks still distrust the CDC's current efforts to prevent and treat AIDS nationally.



In the 1950s Senator Joseph McCarthy and his Senate Permanent Subcommittee on Investigations used conspiracy theory to falsely label thousands of people as communists who threatened America.

BETTMANN/CORBIS

Poisoned Minds

A conspiracy theory need not have its roots in a real event, however. Completely invented inci-

(The Author)

THOMAS GRÜTER is a professor at the University of Münster in Germany and a freelance science writer.

Only the theorist can know how a conspiracy operates in the shadows, which raises his status to that of a prophet, satisfying his need for importance.

Soon after the Watergate scandal in 1972, the White House spread disinformation about Attorney General John Mitchell, trying to make him a scapegoat. Mitchell's wife, Martha, used the press to help expose the conspiracy, exonerate her husband and lay the blame on President Richard Nixon.

dents are good enough, if they are believable. In politics, bogus conspiracy theories are often used to defame an opponent as evil or manipulative. Throughout human history, rulers have depicted their nemeses as conspirators responsible for all kinds of terrible deeds. In the first century A.D., the Roman emperor Nero spread the rumor that the Christians had set Rome on fire. In the Middle Ages, organized massacres of Jews were set off when Russian leaders leveled bizarre, utterly imaginary accusations at them.

One of the most successful, and most evil, examples is *The Protocols of the Elders of Zion*. This book, apparently published by Russian czar Nicholas II's secret police around 1897, laid out a conspiracy by Jews and Freemasons to take over the world. The forged document accused both groups of being responsible for the French Revolution as well as the rise of socialism and anarchism—in short, everything that monarchists and nationalists in the late 19th and early 20th century feared. The *Protocols* strongly influenced public opinion in many other countries.

A shockingly inflammatory page in a 1936 German elementary school book promoted by Nazis reads, "Trust no fox on the green heather, nor any Jew on his promises!"

From the very beginning people questioned the validity of the *Protocols,* but that did nothing to slow their dissemination. Paradoxically, the arguments against their reliability strengthened belief in the existence of a worldwide Jewish conspiracy bent on discrediting them. The text appeared again and again in new guises, most of them accompanied by other anti-Semitic tracts. Among other things, the text served as an important source of Nazi ideology and was embraced by Adolf Hitler. It was even put on the assigned reading list in German schools starting in 1935. Today the *Protocols* is especially widespread in Arab countries, poisoning the minds of readers there.

Conspiracy theories provide political manipulators with justification for using any conceivable method to destroy their rivals. The notorious U.S. Senate Permanent Subcommittee on Investigations chaired by Senator Joseph McCarthy in the early 1950s sought hidden communists everywhere in the U.S.—and of course found them. One denunciation was enough to "prove" an individual was a communist—as was a person's refusal to name others who were supposedly communists, too. Almost 10,000 people lost their jobs because of untrue, sometimes extorted, accusations. Those pushing the theory of a massive communist conspiracy saw their ideas splendidly confirmed by these results.

Dictators and tyrants, in order to surround themselves with an army of abettors who will serve

BETTMANN/CORBIS (*top*); AKG-IMAGES (*bottom*)

them without question, constantly invent new conspiracies against their regimes. And because their supposed opponents act in secret, they can be anywhere or everywhere, so constant alertness is mandatory. This is how autocrats justify their repressive security systems. Furthermore, because dictatorial regimes, in the eyes of their supporters, are always right, any problems they encounter must be the work of conspirators rather than mistakes.

Even democratic societies invent or are lured into attractive tales. Many writers and publishers released "exposés" after the September 11 attacks that placed blame on all kinds of factions. Some even claimed the attacks were carried out by the CIA. The proponents of these accusations cast doubt on the official version of events and instead proposed alternative explanations, using anonymous "experts" on the Internet as their sources. Some went so far as to say that American secret agents crashed the two passenger jets into the World Trade Center by remote control. And because the agents knew the impact might not be enough to topple the towers, they had the buildings' structural elements blown out at the same moment. Why? So America the superpower could use the tragedy to justify its military operations in the Middle East. Those operations themselves were proof enough of the setup.

This logic—a reversal of cause and effect—is a hallmark of conspiracy theory thinking. Events occurring now—such as the "war on terrorism," which is in large part a reaction to the attack on the World Trade Center—are used as evidence to prove that the current actions had already been planned far in advance. Conspiracy theorists can scarcely imagine that history might have played out any other way.

Interpreting Signs

Inside their cocoons of imputed motives and machinations, the authors of conspiracy theories also create their own defense systems. Their reputations depend on their ability to defend their theories against all attackers. A chief tactic is the claim of absolute insight. In ancient societies, unique insight was drawn from oracles and omens. The ability to read signs was also the foundation of priestly power. Only these select few were able to read secret runes or interpret the entrails of sacrificed animals and therefore explain the will of the gods.

Society's willingness to put on pedestals people who can interpret such veiled knowledge persists even in today's fact-based culture. Sherlock Holmes, the fictional forefather of modern detectives, could solve crimes from just a handful of clues. Doctors diagnose internal disorders on the basis of exterior signs of illness. Astronomers can explain both the beginning and end of the universe simply from what they see in the night sky.

Because conspiracies by definition operate in the shadows, only those in the know can understand them. That elevates conspiracy theorists to the status of prophets and satisfies their emotional need for importance. And they can always count on support, because their interpretations feed the needs or prejudices of many people.

Conspiracy theories tell us a lot about their believers' imagined enemies, their fears and prejudices, and as a result can be useful in documenting contemporary history. In today's world, which so many people find overwhelmingly complicated, a simple explanation is all the more attractive. It may well be that the first years of the 21st century are a boom time for belief in conspiracies.

How to Build a Conspiracy

"Experience shows that many conspiracies are made, but few succeed," wrote Niccolò Machiavelli, the famous theoretician of power, in his classic 1532 book *The Prince*. Anyone who wants to unleash a conspiracy theory should remember nine rules for success.

1. Doubt that anything in the world happens by chance, especially when it comes to disaster. Dismiss out of hand any existing explanation of an extreme event.
2. Take seemingly unrelated events, omens or statements and give them a new meaning.
3. Name an enemy.
4. Expose evil intentions, the more common the better.
5. Discredit authorities, politicians and officials as stupid or as being paid by the enemy.
6. Establish a club of perpetrators and cite it as proof of your theory.
7. Shield yourself from detractors and declare them to be wrong or in the pay of the enemy.
8. Issue warnings of looming evil acts by the conspiracy and stress the need to take action against them.
9. Call for people to be alert, for more helpers and for financial contributions.

(Further Reading)

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Test Subjects in Diapers

When do babies recognize the intentions of others–and become capable of deliberate actions themselves?

By Gisa Aschersleben

Toby lies in his crib watching his mother, Claudia, as she does housework. He babbles happily and kicks his legs with delight as one piece of clothing after another disappears into the washing machine. "I wonder if he realizes that I am intentionally picking up this T-shirt to put it into the machine?" Claudia asks. "And does he consciously control his movements?"

Parents aren't the only ones who wonder. Researchers have been asking similar questions in studies during the past two decades. In recent years, they have gained some surprising insights into the cognitive development of infants. As it turns out, even the smallest babies know far more than we have traditionally given them credit for.

For centuries, infants were viewed as virtually passive beings who absorbed little information from their environment and whose movements were almost exclusively reflexive. The situation is very different today: scientists know that a human being learns at an astonishing rate during the first few months of birth, perhaps faster than at any other time in his or her life. Babies explore the world with all senses, and their brains process an abundance of experiences and stimuli. Psychologists are probing exactly when the seeds of reasoning begin to sprout.

FAST FACTS
THE ONSET OF REASONING

1 ›› **Psychologists are studying the development of analytical reasoning in infants during the earliest months of life.**

2 ›› **Far from being passive observers, babies as young as six months can understand the intentions of others and begin to be able to foresee the outcomes of their own actions.**

Little Test Subjects

How does one study the capabilities of children who cannot yet talk? Psychologists turn to an array of testing techniques based on the systematic observation of baby behavior. First, the procedures take advantage of an infant's natural attentiveness to new objects or situations. The more surprising the situation, the longer the infant focuses. Babies also find dolls, plush animals, unusual sounds and light effects appealing. Second, infants are very imitative, providing another way to delve into their development. Tests do, nonetheless, have to take a youngster's physical

progress into account. For instance, tasks that involve grasping and shaking an object are not suitable for a child younger than about six months.

One of the major questions about babies' capabilities that researchers have explored is, Do babies learn from watching the actions of others? For example, suppose a child watches an adult manipulating a puppet that is wearing a glove. The adult removes the puppet's glove and shakes it three times, causing a bell to ring, and then puts the glove back on. After demonstrating this sequence several times, the adult gives the puppet to the baby. While the baby plays with the puppet, researchers analyze their little subject. Surprisingly, children as young as six months make use of their previous observation. They repeat the first step of the action sequence they have observed—taking off the glove—far more often than do members of a control group, who did not see the sequence. Over a 24-hour period, they continue

Does he understand the purpose behind your actions? Probably yes.

DIGITAL VISION/GETTY IMAGES

How does one study the capabilities of children who cannot yet talk? Psychologists turn to testing techniques based on observations of baby behavior.

An eight-month-old can recognize someone else's intention and act on it. If an adult leaves a toy car out of reach, for instance, the baby will pull an attached string to get it.

to remember the action, as long as the opportunity to play with the puppet is repeated often enough. Children are not able to master all three steps, however, until about they are between 15 and 18 months old.

Another research question is, Do infants merely copy the movements of others, or can they imagine an effect that they then set out to produce? "Conditioning" experiments, popular in the 1960s, established that even newborns can learn to elicit pleasurable effects by making particular movements—that is to say, they can be conditioned at a very early age. They move about and take in and process interesting phenomena in their surroundings almost as soon as they are born. From their experiences they then discover contingency, the relation between their own movements and events that occur in the environment around them. In experiments with nursing newborns, they can learn to suckle at a certain frequency to elicit through a headset the soothing voice of their own mother but not that of another woman. Another way we have studied infants' familiarity with contingency in the lab is with mobiles. The baby lies in a crib, with a string fastened to her ankle and to a mobile. Whenever she kicks, she sees the mobile move. Within a few minutes she discovers this contingency, and she kicks more frequently.

Experiments based on imitation, rather than on conditioning, also can be revealing. In 2002 the research group at our institute conducted a study in which 72 12- and 18-month-olds watched a man perform a three-part series of actions. The adult picked up a cylindrical wooden block that had been placed in front of a teddy bear, shook it and then returned it to its original position. For one group of children, shaking the block made an interesting buzzing sound; for another group, putting it back caused the sound.

After the demonstration, children played with the bear and the block. They imitated the action that caused the sound both more often and earlier than did children in a control group, where no demonstration had been made. From this study, we learned that at the age of one year (and perhaps earlier) children use the knowledge gained from observation to anticipate the effects of their actions.

In another experiment, we wanted to determine the age at which babies recognize that the effects they themselves initiate are not identical to the effects they have observed previously. This time, when a tester pulled on a red plastic ring, a clear tone sounded; pushing on the ring caused it to light up. Subsequently, before letting children play freely with the object, experimenters reversed the order: pulling led to the light, whereas pushing created the sound. Children from about the age of 15 months noticed this difference; only at that age did they perform the observed movement with the ring less often than did children in a control group, for whom the order wasn't reversed. This outcome means that only during year two do children begin to recognize the particular relation between someone else's action and its effect and those of their own.

Intentional or Inadvertent?

Further experiments suggest that babies only five or six months old can recognize the actions of others as intentional. Amanda Woodward of the University of Chicago conducted just such a study in 1998. Infants watched a hand on a stage repeatedly grasp a particular object, such as a tower, but not a second object that had been placed right next to it, such as a cube. The positions of the

COURTESY OF GISA ASCHERSLEBEN

(The Author)

GISA ASCHERSLEBEN is a lecturer in psychology and heads the Infant Cognition and Action research group at the Max Planck Institute for Human Cognitive and Brain Sciences in Munich.

By about a year old, children can anticipate the effects of their actions. If a child has seen that shaking a teddy bear causes an interesting sound, he will shake a cylindrical block much more frequently.

> The upshot for parents is: even during their first year of life, your children probably understand a good deal more about your actions than you realize.

tower and cube were then switched. In one variation of the test, the hand again reached for the tower but used a different motion to grab it because of the switched position. In a second version, the same motion was made, but the hand picked up the cube. The tots found this latter maneuver much more fascinating: they watched considerably longer when the target object of the action changed but the hand movement remained the same. This observation demonstrates that children between five and six months can interpret as intentional the grasping movements of others.

What if the actions are new and unfamiliar? Seeking an answer, our research group extended Woodward's experiment. We presented the babies with a hand, the back of which touched a tower and pushed it to a new position. We found that babies as young as six months can realize that this unfamiliar action is intentional—but only if the actions are accompanied by a clearly recognizable effect, such as a change in the tower's position. If this effect is omitted, babies treat the action as inadvertent. Another Woodward study, reported at the February meeting of the American Association for the Advancement of Science in Seattle, found that babies can even recognize that separate actions made by another person are governed by an underlying plan.

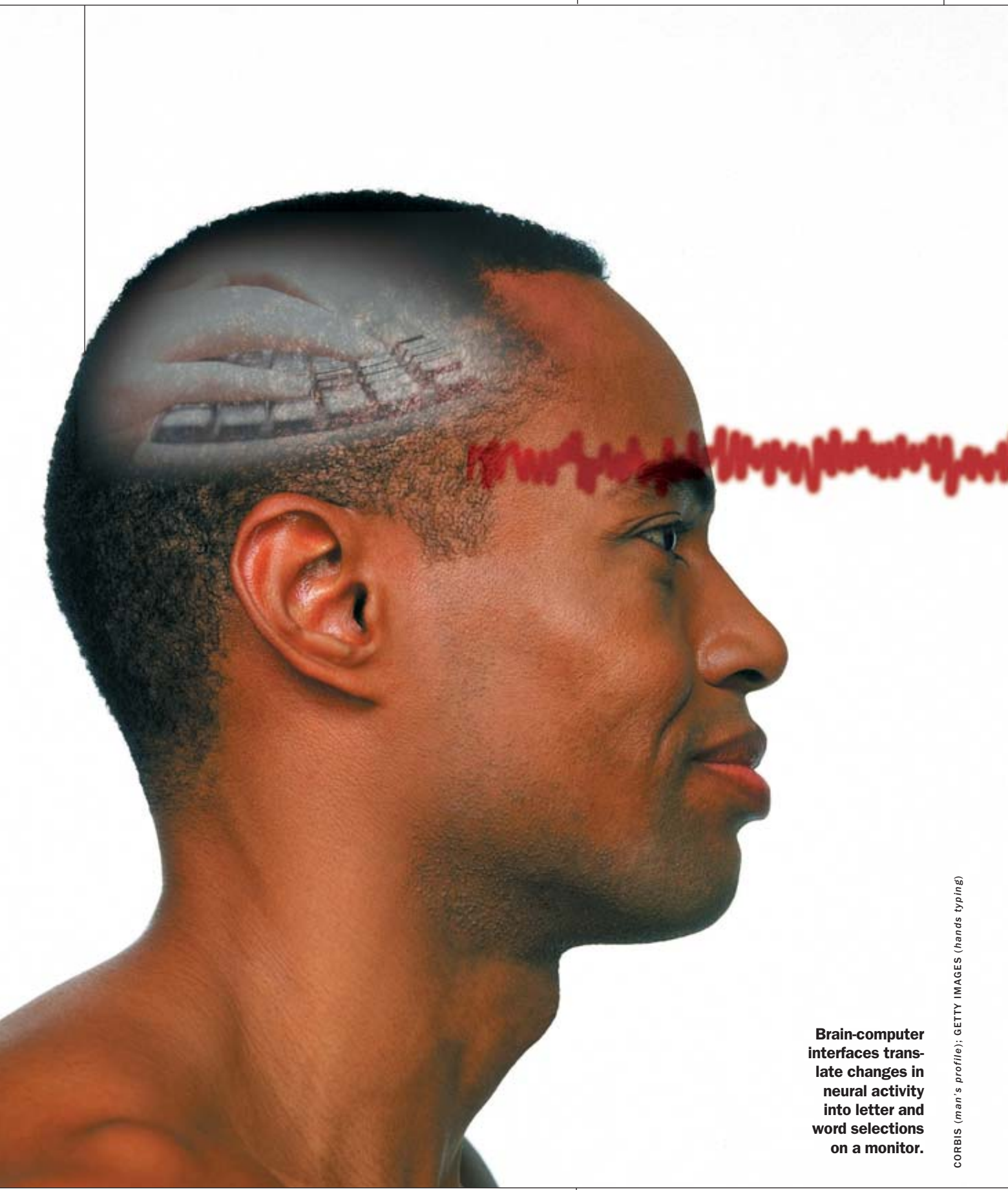
Thus, the traditional perspective—that understanding the behaviors of others is predicated on one's own prior actions—has been called into question by the latest research conducted by developmental psychologists. It may be that these capacities develop in parallel. Even if Toby is as yet unable to carry out particular movements purposefully, he certainly can comprehend his mother's intentions. This aspect of baby development is similar to speech, where the ability to understand comes well before that of speaking.

The upshot for parents is: even during their first year of life, your children probably understand a good deal more about your actions than you realize.

(Further Reading)

- **Infants Selectively Encode the Goal Object of an Actor's Reach.** Amanda L. Woodward in Cognition, Vol. 69, No. 1, pages 11–45; 1998.
- **How Infants Make Sense of Intentional Action.** A. L. Woodward, J. A. Sommerville, J. J. Guajardo in *Intentions and Intentionality: Foundations of Social Cognition.* Edited by B. Malle, L. Moses and D. Baldwin. MIT Press, 2001.
- Information about the Infant Cognition and Action research group at the Max Planck Institute for Human Cognitive and Brain Sciences is available at **www.mpipf-muenchen.mpg.de/INCA/Projekte_e.htm**

COURTESY OF GISA ASCHERSLEBEN



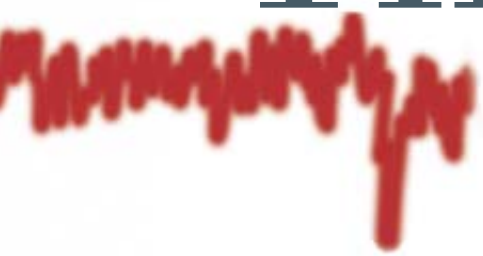
Brain-computer interfaces translate changes in neural activity into letter and word selections on a monitor.

CORBIS (*man's profile*); GETTY IMAGES (*hands typing*)

Thought-deciphering systems are enabling paralyzed people to communicate—and someday may let them control wheelchairs, prosthetics and even their own muscles

By Nicola Neumann and Niels Birbaumer

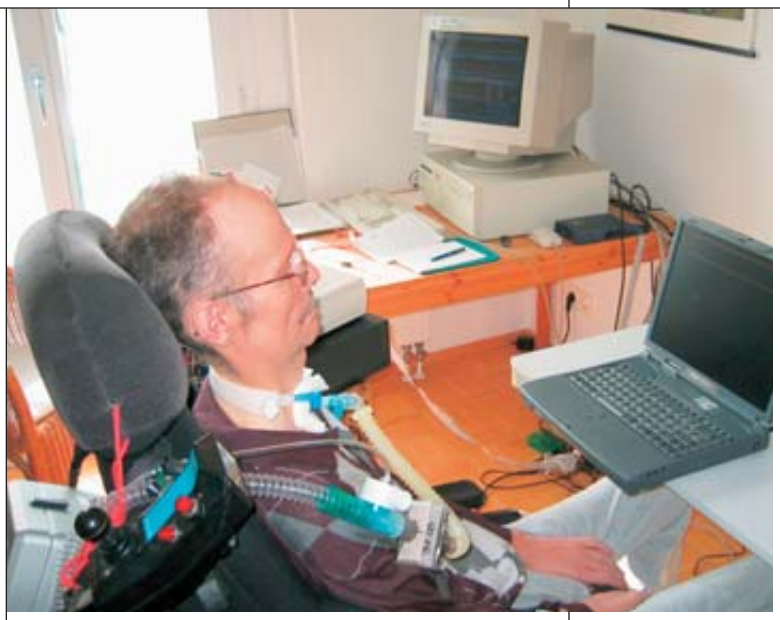
Thinking Out Loud



GETTY IMAGES

Consider the plight of Hans-Peter Salzmann. The 49-year-old former lawyer is confined to a wheelchair and cannot eat or breathe on his own. For the past 15 years he has been suffering from amyotrophic lateral sclerosis, also known as ALS or Lou Gehrig's disease, an incurable degenerative disease of the nerve cells that breaks down the entire voluntary motor system. To spell out words, Salzmann blinks his left eye to choose letters from a printed list on a board, a tedious process that requires an experienced interpreter. Sometimes his eyelid is too weak to make the selections. Ultimately, people with ALS, brain stem stroke or other illnesses may lose all ability to move—becoming a functioning mind "locked in" an immobile body.

Now technologies called brain-computer interfaces, which read aspects of brain activity and react to them, are offering patients such as Salzmann ways to continue to express themselves despite their disabilities. The systems enable a person to use his mind to guide cursors



Hans-Peter Salzmann trains to use a brain-wave-reading device that enables him to communicate.

on a screen for communication. Someday they may lead to mental command of environmental-control devices in a home, "smart" wheelchairs and prosthetics.

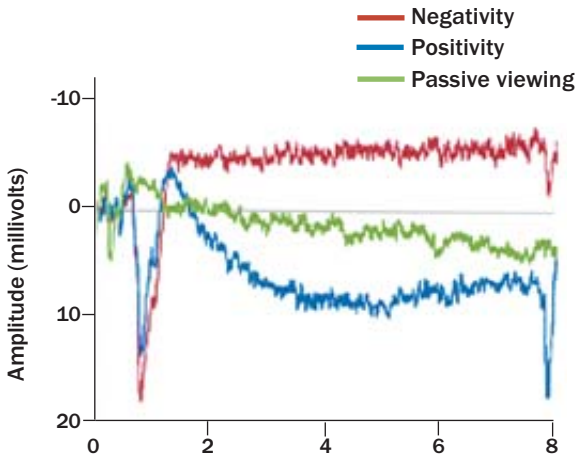
Reading Signals

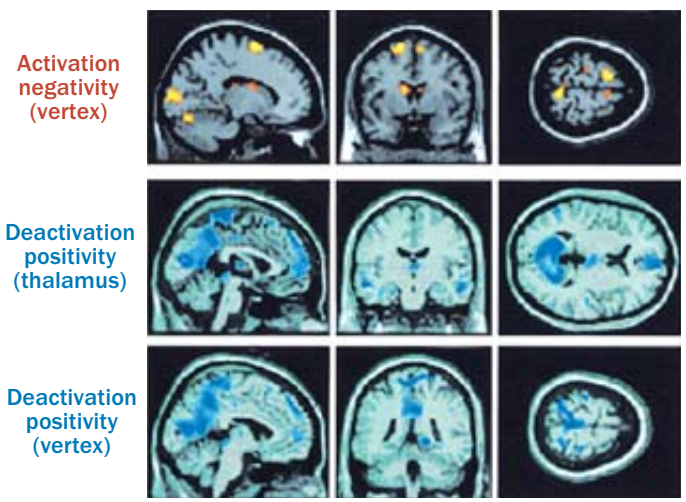
Since 1929, when Hans Berger first described the electroencephalogram (EEG), an instrument that could read electrical impulses produced by nerve cells, people have speculated that it might be used for communication and control. Electrodes attached to the scalp measure the voltage difference, or potential, between two points in the brain. A few laboratories created prototype brain-computer interfaces in the 1980s and have been refining them since then.

One such unit, developed by one of us (Birbaumer) and his colleagues at the Tübingen Institute of Medical Psychology and Behavioral Neurobiology in Germany, is the Thought Translation Device, which works on the principle of biofeedback. Since 1996 Salzmann and 10 other paralyzed patients around the world have been testing the translator. Using the device to report the status of brain waves called the slow cortical potential (SCP), the patient learns to manage a normally imperceptible physiological occurrence. Unlike the millisecond pulses typically measured by an EEG, SCPs build up over several seconds. This relatively slow speed makes SCPs the easiest brain waves to detect by outside means and to be influenced by the patient himself. These brain waves are not necessarily connected to concrete actions or feelings; rather they correspond to the general state of activity in the brain.

Electrodes attached to the top of the head record the brain waves, which are amplified, transmitted to a control processor with an analog-digital transformer card and then sent to a notebook computer. On the monitor, the patient can observe the progression of his SCP as a moving cursor. When the machine reads an electrically negative potential, the cursor rises in response; a positive potential drops it downward. The challenge is to learn how to deliberately move the cursor into either of two goals, at the top or bottom of the computer screen. When the patient scores a goal, he sees one point added to his total and a smiley face appears—this simple reward has been proved to increase the success rate. In each session, the person repeats the activity several hundred times. After a few weeks, many subjects are able to steer the

Brain waves displayed on a monitor during training give patients feedback (*below left*). Imaging shows corresponding areas of activity (*below right*).





COURTESY OF HANS-PETER SALZMANN (*top*); NIELS BIRBAUMER ET AL. IN *IEEE TRANSACTIONS ON NEURAL SYSTEMS AND REHABILITATION ENGINEERING*, VOL. 11, NO. 2; JUNE 2003 (*bottom*)

> The ability to correspond without the need for an interpreter has enabled patients to regain a very important part of their private lives.

cursor correctly some 70 to 80 percent of the time.

When asked how they control their SCP, patients offer various answers. Salzmann reports that when he wants to push the cursor upward, he attempts to think of nothing at all. To force the cursor downward, he imagines a situation that involves anticipation and release—such as a traffic light turning from red to green or a sprinter starting a race. Others may think of specific words or previous tasks that required concentration. Some do not even think about anything in particular, but rather they move the cursor much as they would move their own limbs, without making any specific associations.

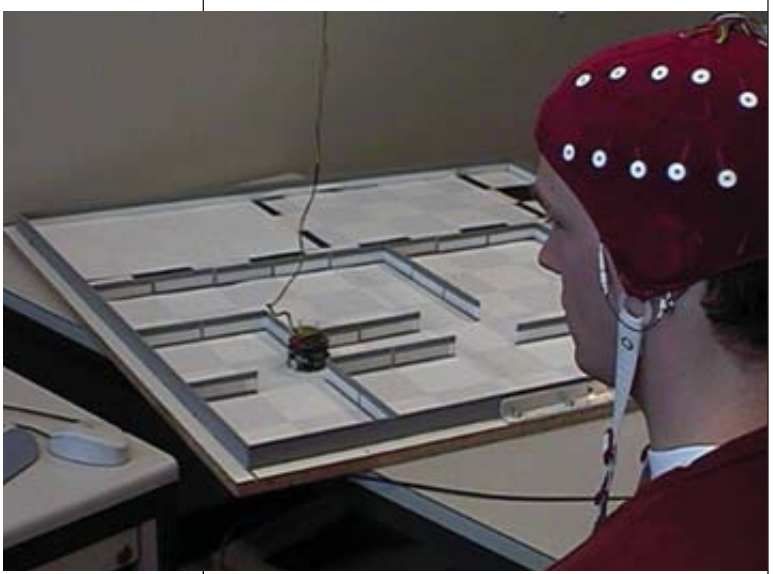
Once a patient masters the cursor, he can use this skill to select letters from the lower part of the screen. If the one he wants is not there, the patient signifies this lack by guiding the cursor away from the field of letters. Every time he refuses a set, a new one appears, which he then either accepts or rejects. Each selected group is cut in half until only the desired letter remains. The system also contains a list of common words from which to choose.

Even with the aid of this tool, it may take most of an hour to pick 100 characters or several days to compose a full letter. Still, the ability to correspond without the need for an interpreter has enabled patients to regain a very important part of their private lives.

Live Chat

Enabling spontaneous conversation would be preferable, but that would require extensive improvements in the technology. Toward this end, our research group at Tübingen began work in early 2000 with Jonathan Wolpaw and his colleagues at the Wadsworth Center of the New York State Department of Health and others. Together we created the BCI2000, a flexible and universal platform on which new brain-wave technologies could be tested.

Scientists on Wolpaw's team work not with SCP but with mu waves, which have frequencies between eight and 12 hertz, and beta rhythms, which have about double that frequency range. The system enables a person to move the cursor up or down by raising or lowering the amplitude of the mu or beta rhythms. These oscillations occur when a subject uses motor skills for movement or when he simply imagines such movement; a typical strategy is to imagine lifting or lowering a hand or other body part.



EEG readings of thought patterns guide a miniature robot through a model house.

With the combined brain-computer interface, paralyzed patients can select a signal that they can operate with the most accuracy. We also have new interpretational programs that allow for differentiation between more than two cursor states—for example, the cursor could also be moved to the left and right as well as up and down.

Another type of brain-wave sensor integrated into the BCI2000 device is for detection of the P300 potential, a brief voltage increase that peaks

(The Authors)

NICOLA NEUMANN and NIELS BIRBAUMER collaborate on brain-computer interfaces. Neumann is an assistant professor at the Institute of Medical Psychology and Behavioral Neurobiology at the University of Tübingen in Germany. Birbaumer is director of the institute as well as a professor at the Center for Cognitive Neurosciences at the University of Trento in Italy. For his work in helping epileptics stave off impending seizures by controlling their own slow cortical potential (rather than with drugs), Birbaumer won the Leibniz Prize in medicine in 1995. He used the $1.5-million award to research ways to help locked-in patients communicate.

JOSÉ DEL. R. MILLÁN *Dalle Molle Institute for Perceptual Artificial Intelligence*

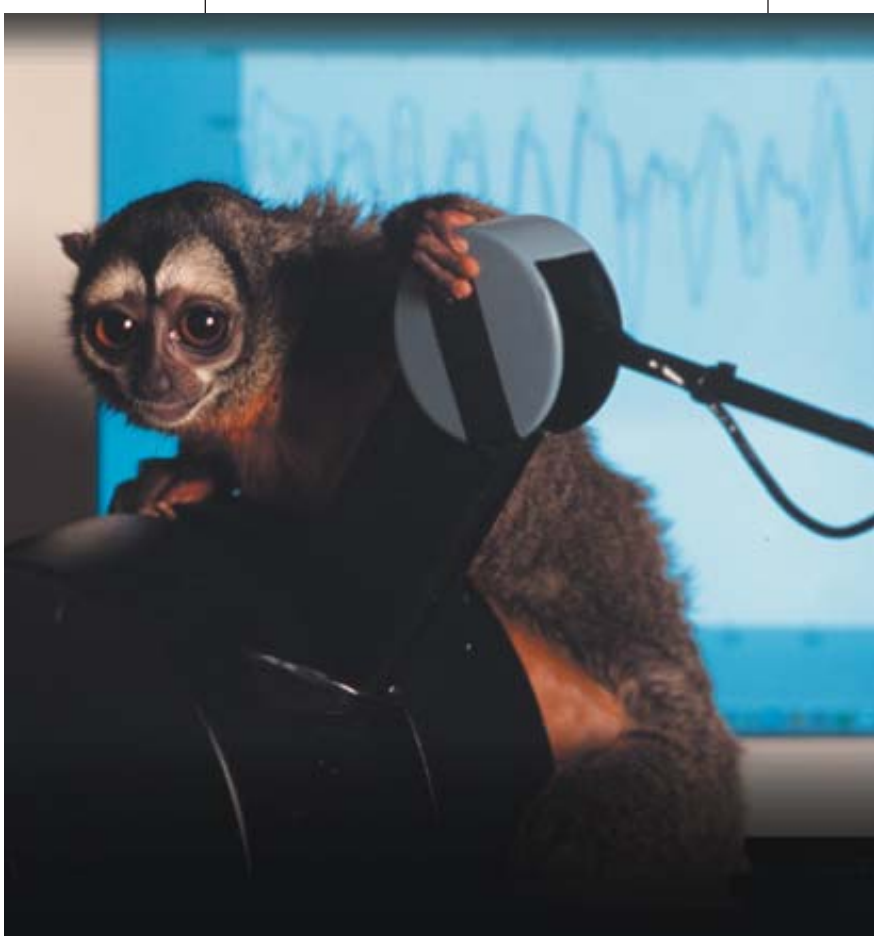
With the combined brain-computer interface, paralyzed patients select the signal that they can operate with the most accuracy.

about 300 milliseconds after the brain registers the onset of a surprising event. Emanuel Donchin, a psychologist emeritus at the University of Illinois and now at the University of South Florida, has focused on "event-related potentials," particularly on P300.

Donchin's system exploits the fact that the human brain reacts very differently to a novel stimulus among standard ones—in this case, the target letter rather than any of the others. Subjects focus attention on a specific character within a letter matrix. While the separate rows and columns within the matrix light up, one after another, the person must count how many times the desired letter appears. When the brain realizes "There it is!" it generates a P300 potential. A computer program then compares which rows and which columns elicited P300 waves and thereby identifies the desired letter. Students without neurological impairments who participated in tests were able to select up to eight characters per minute with a high level of accuracy. Researchers are currently testing the performance of Donchin's brain-computer interface in paralyzed individuals.

An advantage of this method is that it can recognize thoughts within a predetermined category—in this case, letters of the alphabet—without the chore of learning to regulate brain activity, as SCP detectors require. On the downside, the device cannot make sense of anything going on in the brain outside this predetermined category.

Taking the idea of mental control a step beyond the cursor, José del R. Millán and his colleagues at the Dalle Molle Institute for Perceptual Artificial Intelligence in Martigny, Switzerland, have developed an interface that analyzes overall EEG signals at eight locations on the skull. It captures the different types of patterns produced by thinking about very different things. Using a neural network algorithm, a computer learns to distinguish among three types of such thoughts. It is then able to perform a programmed command based on the mental pattern that it detects. In experiments, healthy individuals learn to direct a small wheeled robot (a stand-in for a smart wheelchair).



Owl monkey named Belle climbs on a robot arm she was able to control from a distant room purely by imagining her own arm moving through three-dimensional space.

JIM WALLACE *Duke University Photography*

Listening In

The systems described here all rely on EEG measurements of the activities of millions of nerve cells—thereby making these approaches rather imprecise. The process could be compared to trying to hear the conversation between two individuals sitting in a packed sports stadium with the use of a directional microphone located in the parking lot. Wouldn't it be much more practical to listen in to conversations among nerve cells from closer range?

Miguel A. L. Nicolelis and his colleagues at Duke University are attempting to create exactly this kind of situation. In 2001 they implanted so-called multimicroelectrode arrays in various regions of the motor cortex in monkeys. The monkeys used a joystick to guide a cursor on a computer screen

into a goal, while Nicolelis measured the signals related to this motion in up to 92 motor neurons using the implanted electrode arrays. The monkeys had to carry out the hand motion many times so that Nicolelis's team could calculate a mathematical algorithm that would properly assess the activity of the individual nerve cells. Then the joystick was disabled, and control of the cursor was left to the nerve cell activity alone. The monkeys steered the cursor purely by thought—probably by visualizing its path of movement.

This was a considerable advance, in that the scientists succeeded for the first time ever in translating a neural signal based entirely on a mental visualization into a real, two-dimensional movement. With a setup like this, thought reading could become reality. If a brain activity is measured at the exact moment that a person is having a thought, that same thought could be recognized later, by comparing it with a reading of the identical activity.

Brain-computer interfaces translate a person's thoughts into words on screen.

But how many of the countless ideas that go through our heads every day could be linked with the corresponding activation patterns? Basically a thought in the brain is not imaged by the firing of one single nerve cell but rather by means of the activity in entire cell structures. Such a neural network combines the individual aspects of a piece of information into a complete impression. For example, a woman walks into a café and immediately has a hankering for a delicious, steaming cup of cappuccino, just like the one sitting on the counter.This desire is represented by synchronous activities of various nerve cells: some neurons react to the smell of the coffee, others to the color and form of the cup; still others guide the customer's memory to her last mug of cappuccino.

To "measure" these thoughts, it is not enough to simply record which nerve cells are firing together and which electrochemical processes accompany this event. One also has to know what these cells represent for that individual—say, whether the neural impulses in the hippocampus, our brain's memory storage center, stand for a pleasant or an unpleasant past experience with cappuccino. This memory-signal recognition requires registering the activities of millions of individual nerve cells, and such imaging is not yet possible even with the most advanced visual technologies and invasive means of measuring brain activity.

Human tests of such mind readers are far off. Nevertheless, the work of Nicolelis and others points to the promise of the brain-computer interface to eventually enable paralyzed people to control their surroundings, perhaps even their own bodies. Building on that concept, Patrick D. Wolf, also at Duke, built a prototype neurochip and computer "back pack" that might allow a person to move limbs that have been stilled by spinal injury. Tiny arrays in the brain wired to a chip in the skull would convert electrical activity to radio-frequency signals, which would be sent wirelessly to the back pack. The processor would forward the signals to chips in limbs to stimulate nerves directly, thereby moving muscles.

Although we have far to go in achieving such empowerment, brain-computer interfaces offer hope for a better life to those who suffer from serious disabilities.

LABORATORY OF NERVOUS SYSTEM DISORDERS, WADSWORTH CENTER,
NEW YORK STATE DEPARTMENT OF HEALTH AND STATE UNIVERSITY OF NEW YORK

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Casting Out the Demons

Adolescents are naturally drawn to occult ideas, but parents and therapists should know the signs that indicate when this fascination has become deeper and more dangerous

By Gunther Klosinski

Recent activity in several U.S. church communities has seemed almost unbelievable: churchgoers have gathered around bonfires and cheered as they cast Harry Potter books into the flames. They fear that the wildly popular series about a school for young wizards is spurring children and adolescents toward a life of witchcraft and onto the dangerous path toward satanism. For these congregations, J. K. Rowling's books are none other than the work of the devil herself.

To most people, the Harry Potter books and movies are merely compelling adventure stories, not a threat to children's psyches. But what has been forgotten in the heat of Pottermania is that boys and girls have been fascinated by magic and sorcery for generations. Surveys about occult practices among adolescents vary widely, but some indicate that as many as 44 percent have dabbled to some degree. Although satanically motivated violence occasionally makes headlines, research shows that less than 5 percent of young people take part in more extensive witchcraft, and very few end up in the kind of organized devil worship that can lead to such acts as ritual murder.

There is still cause for concern, however, because even simple forays into the supernatural, such as divination with tarot cards or Ouija boards, can provoke trouble for some sensitive young people. If, for example, a teenager's occult experiences provide a negative prophecy for the future, he or she might develop such psychological problems as anxiety disorders or compulsive behavior. And regular use of such games, or more involved rituals such as séances and witchcraft, can lead some children to become dependent on the supposed revelations, gradually giving up their sense of self-direction and self-control. To ward off such situations and to successfully intervene if the behavior has already gone too far, parents,

Harry Potter uses wizardry to fight off a demon in *Harry Potter and the Chamber of Secrets*. The book and movie series have become wildly popular, in part because the story involves witchcraft as a way for boys and girls to exercise control, a strong need that is often not satisfied in real life.

HARRY POTTER AND THE CHAMBER OF SECRETS © 2000 WARNER BROTHERS; COURTESY OF EVERETT COLLECTION

teachers and therapists should understand the psychological motives that can prompt a young person's interest in the occult.

The Search for Meaning

Unlike magic and astrology, organized occultism is a modern phenomenon. Few of the various orders have existed for more than 150 years; some formed as a belated countermovement to the Enlightenment, when people began to follow rational schools of thought that taught that the world adhered to concrete laws. Today's occult views are based on the idea that there are events within nature and one's spiritual life that cannot be explained by science.

Examples include extrasensory perceptions such as telepathy and clairvoyance, telekinesis, and haunted places or people. Believers maintain

Adolescents are typically driven to the occult by questions about their own identity—questions that, if unsatisfied, can become consuming.

that these phenomena stem from unknown powers that often can be accessed only by those with special abilities—the so-called mediums. In many cases, objects such as minerals, plants, tarot cards, planets, or otherworldly beings such as angels, gods and demons are thought to embody human characteristics and to be connected to current or future events.

From the viewpoint of a developmental psychologist, a belief in hidden powers is not necessarily unnatural, especially during childhood. Children in the "magical phase," between age three and the start of school, often attribute special powers or human qualities to objects. They form causal connections between arbitrary occurrences, such as "I fell off my bike because Mommy wasn't watching me." When at play, children "make" animals fly or have their toys "die" only to bring them back to life. These enactments give children the feeling that they are in control.

This egocentric way of thinking is often reactivated during puberty. And adults can temporarily regress into the magical phase, especially when facing extreme stress. Many young people and adults who have actually joined occult groups say they became involved out of curiosity, interest in the unusual, or amusement. But often there is more to it than that, particularly during puberty. Adolescents are typically driven by questions about their own identity—questions that, if unsatisfied, can become consuming.

Adolescents who turn to the esoteric are often searching for meaning in their lives or for ethical values and goals they think adults have lost in their quest for professional advancement and wealth. Not surprisingly, many young people in the occult scene suffer from identity crises, hopelessness and anxiety about the future. They yearn for a sense of belonging. At the same time, adolescents are confronted with physical changes in their bodies as well as confusing emotions brought on by their sexual awakening. And if social or religious norms work to suppress these libidinal drives, worship of "the sinister" can offer an opportunity to identify with one's own aggressive and sexual desires. In the end, such activities reflect an effort to quell one's fears.

Two additional motivations, proposed by

Tarot cards have been consulted since the late 18th century to foretell the future or uncover secrets through supposedly mystical powers.

COOPERPHOTO *Corbis*

Paraphernalia such as Ouija boards supposedly invoke magic, which can be very attractive to the adolescent psyche.

VCL/SPENCER ROWELL *Taxi/Getty Images*

Werner Helsper of the Martin Luther University in Halle-Wittenberg, Germany, may connect adolescents with occultism: desire for prestige and power. Flirting with practices such as séances helps teenagers cloak themselves in a veil of mystery as they try to boost their self-image and compensate for their sense of worthlessness and helplessness. In less extreme cases, adolescents may merely be searching for the answers to life's questions.

It is unclear whether certain personality traits make a teenage boy or girl more susceptible to the occult. In 1993 Jorinde Bär, then a medical student and doctoral candidate at the University of Tübingen in Germany, surveyed 500 students between the ages of 15 and 19. Those who had schizophrenic tendencies were more likely to believe in magical powers. Studies conducted by psychologist Johannes Mischo when he was a researcher at the University of Freiburg in Germany concluded that neurotic personality traits and psychological instability often made people more likely to believe in occult influences. And yet many psychologically healthy adults are enthralled with everything from magic to the Holy Spirit, with no harm to themselves or others. The real question is: At what point does a person's involvement become dangerous?

Warning Signs

The vast majority of adolescents who dabble in the occult are just rebelling against their parents or society. They want to experiment with something taboo or forbidden, much as others try marijuana without becoming regular users. Yet when young people become involved with organized groups that have rigid codes of behavior, then the possibility exists that they will sever ties with the rest of the world.

Although very few adolescents join formal satanic organizations, members of these groups do recruit others. Membership in an order or cult is not always evident from a person's appearance: black clothing, white-powdered faces, spiky hair, studded accessories and morbid T-shirts are worn by members of some groups but also by countless unaffiliated adolescents. Often young people who are initiated into cults are sworn under penalty of torture, rape or even death not to reveal any information about the group, and therefore they do not make their association known publicly. Tattoos of occult symbols may be worn on parts of the body that are not visible. Even when the subject of satanism is raised, cult members may remain silent.

Whether adolescents have joined groups or are just experimenting with occult practices, a significant change in behavior is often the first sign that they could be headed for increasingly dark, depressive or even brutal traits.

Adolescents may turn to relatives in such times of doubt, or they may even seek out a psychologist, but this is rare. Usually it is parents who try to intervene. But parents rarely succeed in steering their children away from the occult by confronting them or arguing against worrisome behaviors, mainly because children at this stage of development want to exercise their independence. Parents can easily drive their children deeper into reliance on a questionable group.

(The Author)

GUNTHER KLOSINSKI is medical director of the child and adolescent psychiatry and psychotherapy department at the University of Tübingen in Germany.

Daniel and Manuela Ruda explained that they acted by order of the devil when accused of a brutal 2002 murder. Court experts persuaded the jury to find them not guilty by reason of insanity. They were both committed to mental institutions.

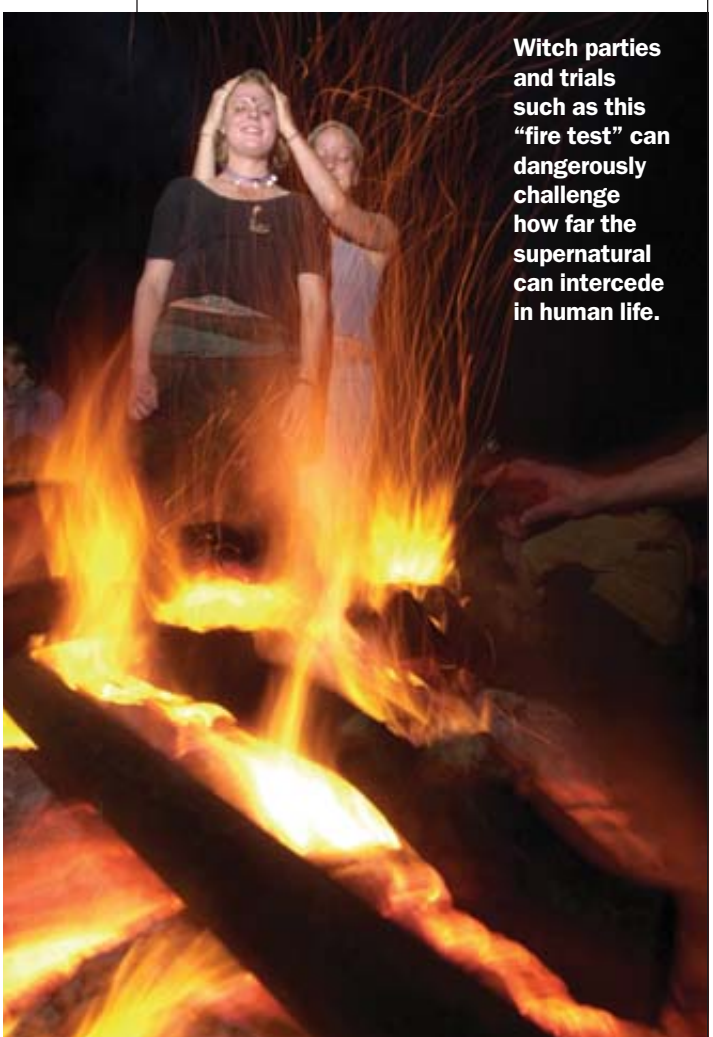
Breaking Dependency

To increase chances for success, inquiring parents must not immediately attempt to show adolescents the error of their ways. Instead they should exhibit understanding for how a young person might wish to seek answers in occultism. And they should communicate that the person's involvement in an occult circle probably stems from a reasonable, internal need.

The same lesson holds for therapists as they open discussions with prospective patients. Parents who succeed in bringing their sons or daughters to a therapist are often crushed when the child proves unwilling to enter into a dialogue. Therefore, parents—or adolescents themselves—who are seeking a therapist should choose one who is familiar with New Age ideas, the tarot, divination guides, parapsychology and the tools of satanism. And they should choose a therapist who will not prohibit conversation on such subjects. Only if a therapist can display a certain level of knowledge of the occult and a willingness to explore the subject will the patient accept him or her as a viable counselor. Only then can the therapy be useful.

From the moment therapist and patient meet, the therapist must be careful not to prohibit conversation of any topic and must take care in addressing a patient's point of view. When young people meet me as a prospective therapist, they often ask questions like "Do you believe that objects can be made to move during a séance?" or "Do you think voodoo magic actually works?" Such questions can be a trap: if a therapist professes disbelief, a young person might immediately conclude that he or she is not being taken seriously or is being labeled as mentally disturbed. Furthermore, a patient's own occult experiences should not be dismissed. The therapist must recognize the incidents as subjective and should not challenge them too seriously. When the therapist's relationship with the patient becomes more solid and positive, he can scrutinize the reality of such incidences and perhaps offer alternative explanations, such as the influence of dreams or drugs.

Because adolescents who become seriously in-



Witch parties and trials such as this "fire test" can dangerously challenge how far the supernatural can intercede in human life.

BERND THISSEN *DPA/Landov (top)*; SCHROTH *Ullstein Bild (bottom)*

volved in the occult are often psychologically unstable, they must be approached cautiously. That was the case with a 17-year-old patient of mine whom I will call Steve. After Steve's parents divorced, he moved in with his mother. Soon after, he got his girlfriend pregnant and started searching for counseling on how to deal with the situation. He turned to a "guru," a man who had spent a good deal of time in India. Steve also became interested in the occult, particularly the *I Ching*—the Chinese *Book of Changes*—which can be used for divination. Steve began consulting the *I Ching* more and more, sometimes daily, in the hopes of arming himself against fate's blows. When he started taking drugs, the situation worsened. Ultimately, he had to be admitted to a psychiatric hospital.

Steve received therapy for addiction and help from family crisis counselors. In my own sessions with him, I helped Steve to gradually recognize that the *I Ching* has two sides. The pictures, symbols and answers could be useful in showing alternatives to his own notions and could therefore help him reevaluate his life. But when the answers offered by the *I Ching* were taken too much to heart, they could lead to obsession, which could greatly compromise his quality of life; simple, everyday decisions like "Should I go to the movies tonight?" could no longer be made without the help of divination. With this new approach to evaluating his ties to the occult, Steve was able to overcome his dependence on it.

To succeed in reaching a young patient, a therapist must accept his attraction to the unusual before she can convince him that many paths are available to anyone who dabbles in the occult or belongs to occult groups. The person can blindly follow occult practices and be a fanatical member of a group, or he can remain open-minded and continue to distinguish between the occult's positive and negative aspects. And ultimately, a patient must understand—even if the notion is difficult at first—that it is always possible to leave the occult. The therapist should keep this goal in sight at all times.

When a therapist establishes trust and a dialogue, she can begin to mention other people who have left occult groups. Or she can suggest that the patient seek out an expert on the group in question. This path is a tightrope walk: the patient almost always perceives the therapist as an authority figure, which can easily lead to defensive behavior, especially when the therapist brings up conflicts relating to the patient's parents. But if the adolescent senses that the therapist is trying to help him search for truth, it is possible for him to put dogmatic suspicion into perspective. In every case, the patient must be treated as a spiritually independent person. Then the idea of a patient's personal responsibility for his own behavior can be reinforced.

Cult leaders can spur enthusiasm by glorifying followers. Here newlyweds are blessed by Rev. Sun Myung Moon in a 1995 mass ceremony.

CORBIS SYGMA

> Parents who want to pry children from a cult should acknowledge that involvement probably stems from a reasonable internal need.

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Frequent washing is a ritual shared by a number of people who have obsessive-compulsive disorder.

PIXLAND/age fotostock

For people trapped in obsessive-compulsive thoughts and rituals, therapy and medication may offer the best way out

Taming Compulsion

BY MARION SONNENMOSER

Even as a girl, Ursula had a penchant for tidiness. Her parents encouraged her tendencies, reminding her not to get dirty. As a young woman, her disdain for germs became an unhealthy preoccupation. She would not let visitors into her home for fear they might bring in dirt or bacteria. Panicked by the idea of infection, she declined invitations to family outings and wore gloves, even in midsummer. She cleaned her house thoroughly several times a day. Even when everything appeared spotless, the young woman avoided handling any of the doorknobs in her house. If she did happen to touch one, she immediately scrubbed the offending finger with disinfectant until it was red and raw. Ursula (her last name withheld to protect privacy) knew her behavior was excessive, but she could not stop.

Ursula is among the approximately 2 percent of all people who suffer from obsessive-compulsive disorder, or OCD. This disorder may take many forms. Some patients' rituals involve washing or checking again and again to see if a burner or faucet has been turned off. Other patients are plagued by thoughts that frequently revolve around religion, sex or physical aggression. They often live in fear that their fantasies could turn into unwanted reality and struggle desperately against their repetitive behaviors. "There is no way to outwit the compulsion," wrote Ursula in her diary.

FAST FACTS

Obsessive-Compulsive Disorder

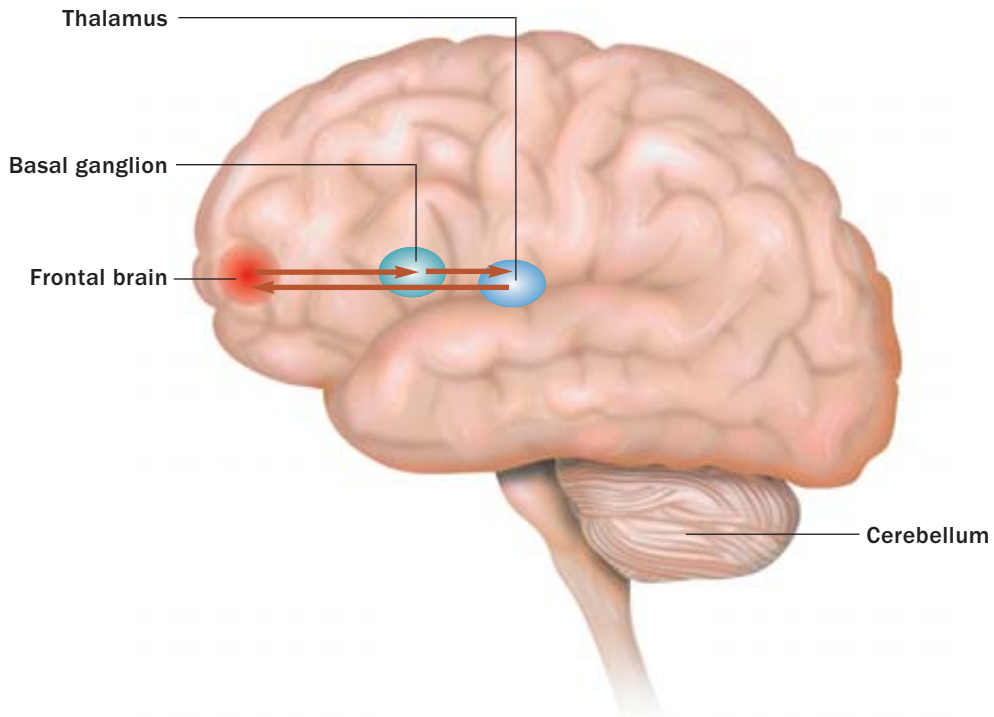
1 » **Obsessive-compulsive disorder (OCD) involves involuntary, repetitive thoughts—ideas, impulses, images—or repeated stereotyped behaviors, which generally serve to diffuse fear and tension in the patient.**

2 » **Two percent of all people suffer from OCD—six million in the U.S. alone.**

3 » **Recent research shows that psychological and biological factors play a role in the onset of OCD, so successful treatment most often requires a combination of psychotherapy and medicines.**

"There is no way to outwit the compulsion," wrote Ursula in her diary. Untreated, the habits may grow more elaborate over time.

Out of Balance



OCD is thought to result from overarousal of the feedback loop controlling behavior, located in the frontal cortex, basal ganglion and thalamus.

Untreated, the habits may grow more elaborate over time.

Foundations of Obsession

No single root cause has been found for OCD, although it seems to involve both psychological and physical factors. A decisive or unpleasant event may trigger the disorder. For Ursula, it was entry into her professional career: she felt overwhelmed and was plunged into self-doubt. Eventually she experienced an outbreak—"explosive," she wrote—of compulsive behavior.

OCD seems to run in families, suggesting it has a genetic component, although no specific gene has been identified. "The influence of genetics, however, seems to be less in obsessive-compulsive disorders than in other mental problems," says Wolfgang Maier, who studies the genetics of psychiatric ailments at the University of Bonn in Germany.

Injuries or infections in particular regions of the brain can also lead to OCD. These areas are typically the basal ganglion, the frontal brain and the thalamus, which are bound into a feedback loop that collectively controls our behavior [*see illustration above*]. In OCD, this control system gets out of balance. The caudate nucleus (one of the masses of nerve cells within the basal ganglion) and the frontal brain work with extraordinary intensity. That unusual activity is difficult for the brain to shut off. After deciding to do something, people with OCD have trouble responding to new outside stimuli or events. "They get trapped in a motor or cognitive process once they start," explains Fritz Hohagen, director of the Lübeck University Clinic for Psychiatry and Psychotherapy, which specializes in caring for OCD patients.

(The Author)

MARION SONNENMOSER has a degree in psychology and is a science writer in the Palatinate region of Germany.

SIGANIM *Gehirn & Geist*

Two-Pronged Treatment

With both mental and physical factors at work in OCD, successful remedies generally combine behavioral and medical approaches. Behavioral therapy can help the patient, step by step, do what she once feared so much, such as touching a "contaminated" handrail.

At the outset of therapy, "assessment of thoughts plays an important role in successful treatment of obsessive-compulsive disorders," explains Hans Reinecker, professor of clinical psychology at the University of Bamberg in Germany. Ursula, for example, could not bear it when she saw someone spit on the street. She was not just annoyed and disgusted—she actually felt threatened. A healthy person might have experienced brief revulsion and then moved on. But the young woman could not shake her thoughts of filth and germs. Her inner tensions grew until they were released by an episode of hand washing. Afterward she felt better, but only briefly; her thoughts soon circled back to the filth.

Compulsive behaviors are often just the outlet for tormenting thoughts. In their conversations, therapists and patients must therefore discuss such extreme feelings and obsessions. The patient learns to withstand uncertainty and inner tension, to reflect on her behavior and to accept imperfection. The heart of the therapy lies in confrontation: the therapist leads the patient to face first imaginary, then real, objects of her fear. Ursula, for example, had to climb an observation tower, which meant grabbing the banisters repeatedly. She agreed to try it without wearing gloves or washing her hands. Performing this exercise and many others taught Ursula that her fears about infection were unfounded. Gradually, she developed a more relaxed attitude toward dirt.

Calming the Feedback Loop

Drugs called serotonin reuptake inhibitors, a class that includes some antidepressants, also can moderate symptoms of OCD. Serotonin is a neurotransmitter, a chemical messenger in the brain. Scientists believe that in OCD patients the sensitivity of the serotonin receptors decreases. This change could, in turn, cause overarousal of the feedback loop that normally helps to control behavior, because many nerve cells that use serotonin as a messenger substance terminate in the thalamus, basal ganglion or frontal brain.

When therapy and drugs fail, surgery may be the next step. The operations involve the thermal destruction of areas in a brain region called the gyrus cinguli or the severing of fibers linking the frontal brain and caudate nucleus. Using a "brain pacemaker," also known as deep-brain stimulation, is still an experimental approach to OCD. (At present, the Food and Drug Administration has approved the technique only for certain ailments, and OCD is not yet one of them.) A surgeon inserts small electrodes into the lower part of the forebrain through holes bored into a patient's skull. A pacemaker implanted below the skin of the chest sends weak electrical impulses through the electrodes intended to moderate the processes that lead to the patient's uncontrollable repeated behaviors. Brain surgeon Volker Sturm of the department of stereotactic and functional neurosurgery at Cologne University in Germany has implanted such pacemakers in five patients since 1999. Three of them now are apparently symptom-free. In the fourth patient, a technical problem (dislocation of the electrode) prevented the pacemaker from having any effect. The other patient, who was also schizophrenic, discontinued treatment during testing because of paranoid thoughts.

Ursula, after two years of behavioral therapy, has conquered OCD without such measures. She can now make plans to go out with friends and family, have visitors over and enjoy experiences she did without for so long. In fact, she recently confided to her therapist that she has a new problem: smile lines.

CORBIS

OCD sufferers are often aware that behaviors such as repeated house cleanings are excessive but feel they cannot stop.

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The road to hell is said to be paved with them: good intentions that we never realize. But you can do something about that

BY MAJA STORCH

Crossing Your Personal Rubicon

DO YOU PLAN to make New Year's resolutions? Or do you resolve to do nothing, because you know that you will surely fail to make good on your intentions?

Why don't people carry out what they claim to have always wanted to do? Time and again, we make big plans but do not follow through. At the Max Planck Institute for Psychological Research in Munich (now the Max Planck Institute for Human Cognitive and Brain Sciences), the late Heinz Heckhausen and his successor Peter Gollwitzer extensively studied this problem. The two motivational psychologists developed the so-called Rubicon model, which describes a plan's various stages of maturation from wish to realization. The model's name refers to the river in northern Italy that General Julius Caesar and his army crossed in 49 B.C., thereby disobeying the Senate and triggering a civil war in the Roman Empire. "Crossing the Rubicon" has come to mean the act of passing a critical point of no return.

New Year's resolutions are, in our minds, usually somewhat less than this kind of firm threshold. They merely represent simple desires or motives that emerge from our unconscious needs and are, as such, only the first step in the process of realization. For these desires to become actual resolutions—or firm intentions—we have to cross our own psychological Rubicon. Only with purposeful aim can we overcome the various pitfalls that inevitably lurk on the way to every long-term goal.

How does one realize that he or she has made this first step toward realization? Try to remember something that you always wanted whole heartedly. You probably felt a strong positive feeling—something like an electrifying energy or just simple joy. Such bodily feelings are called somatic markers—signals from our emotional memory, where our experiences are weighed and memorized. These emotions can help us find out how far a wish has advanced toward fulfillment and can thus help us revitalize those half-forgotten New Year's resolutions.

Consider, for example, the plans of schoolteacher Joan Smith (not her real name). Fearing burnout, she resolves to reduce her workload in the new year. But after several weeks, Joan becomes aware that she is not realizing her goals. Why? It is obvious: she has not crossed her Rubicon yet. When she talks to the school principal, she expresses no joyful emotion about limiting her workload. "Well, I know I should cut down on work," she sighs, "but somehow I don't want to. I'm not that old! I keep telling myself that I should say 'no' when the next project comes up. And every time, I find it so interesting that I become excited. I just agreed to go on a school trip or take a snowboarding course in order to test some new pedagogic concepts. You know, this trip is led by a young colleague; he is such a talented teacher.... "

As soon as Joan starts talking about the physical education teacher's new ideas, clear somatic markers appear: her face brightens, her cheeks redden, her eyes are wide open and her gestures become emphatic. Her enthusiasm for her work is highly visible.

Plum Tactics

How can she resolve her work dilemma? Joan still wants to do fascinating projects. "If I could pick only the plum jobs and leave the boring rest to someone else, that would be great!" she says longingly—thus showing that she has crossed her personal Rubicon. Consequently, she begins to regard her workload under her "plum" rule. She delegates less interesting tasks and focuses her energy on projects she finds stimulating.

In contrast, Henry Jones can't seem to get out of his hardworking mode. At age 45, the food importer has recently become a father again. He rarely saw his two sons—now teenagers—during their early childhood and wants to reduce his hours so he can spend more time with his baby daughter, Eva. De-

Emotional signals can help us find out **how far a wish has advanced toward fulfillment** and can thus help us revitalize those half-forgotten New Year's resolutions.

spite positive somatic markers—for instance, when talking about baby Eva's first steps and his intense feelings as a father—he simply does not succeed in carrying out his plan. His problem is that he is struggling to reconcile the (usually helpful) ability of the brain to automate repetitive processes.

Within fractions of a second, our mind perceives a given situation, analyzes it, and searches our personal repertoire of memorized activities and reactions for an appropriate behavior or response. If certain situations occur fairly often and if a particular behavior or strategy solves them successfully, the repetition reinforces links between nerve cells in the brain that cause these reactions. Recurring situations create durable neuronal networks that respond to certain stimuli with established responses—fully automated and unconscious.

Useful as this process is most of the time, however, it also makes it difficult to change established routines. Henry says his small business was successful because he was "always prepared." As his father taught him: "To be independent is not a job. It must be in your character." Henry learned that lesson too well. Neuronal networks created in early childhood are particularly persistent and resistant. Henry's instinctive "always prepared" network makes him say, "No problem, I will deliver the antipasti on Saturday night," while at the same time he is thinking, "No, I have promised to tell Eva a bedtime story!" He is fully conscious of his intention but unable to change his behavior.

Fatal Triggers

How can Henry escape his habits? He must develop specific and precise guidelines for certain situations and memorize them: "If X happens, I will do Y." To this effect, he keeps a log for a week and notes the occasions when he catches himself sabotaging his intentions. In this way, he can determine the triggers that activate the old, unwanted routines. Once he has identified those triggers, he can exchange them for stimuli that activate a new neuronal "free time" network whenever the situation occurs and thus reinforce his intention, until "free time" is fully automated and replaces his "always prepared" network.

At the time of the baby's birth, Henry resolved to take off every Wednesday and Friday afternoon to spend time with his family. He instructed his secretary not to make any appointments, but after just a few weeks, he caught himself working on those afternoons. Now he knows why: he undermined the achievement of his intention with his personal digital assistant. Whenever Henry consults his daily schedule on the PDA, he learns that he squeezes additional appointments into the remaining available free time. He also finds that he sometimes drops by to see a customer while he is on his way home. This "salami tactic" of cutting thin slices off his spare time soon whittled it away.

The trigger for the always-prepared network is thus unmasked: free slots in the appointment list of his PDA. Henry then decides to turn his electronic organizer into a helpful tool to protect his reserved free time. He sets his PDA to display daily overviews in a so-called block mode, in which thick black strokes represent specific time segments.

The trick works. "As soon as I see these strokes, I find it easier to decline a new task," Henry reports some weeks later. "And I am no longer tempted to put something there or move something there."

And what about your New Year's resolutions? Will you cross the Rubicon or find yourself running up and down the riverbank? To find out, you should first look for your own positive somatic markers. Do you experience an energizing, good feeling related to your resolution? If so, congratulations, you have already made the critical first step. If the realization stalls, however, try Henry's strategy: keep a logbook to identify the trigger and help you establish a new neuronal network.

Choose Your Path

If, however, your decision-making memory remains silent or reacts negatively, you must make a choice. You can give up on your intention. (Unless your health is threatened, why not just ban the scale from your bathroom forever and thus bury the idea of a diet for the rest of your life?) Or you can run through various possible solutions, either in your own mind or by talking to people whom you trust.

If crossing you personal Rubicon still poses difficulties even after such efforts, it may be worth using a coach or psychologist as a ferry. Usually a few sessions are sufficient to bring the other riverbank within reach.

Hardworking Henry **struggled to reconcile his desire for free** time with the (usually helpful) ability of the brain to automate repetitive processes.

Mind Reads

Thoughts about Thought

A BRIEF TOUR OF HUMAN CONSCIOUSNESS: FROM IMPOSTOR POODLES TO PURPLE NUMBERS

by V. S. Ramachandran. Pi Press, New York, 2004 ($23.95)

Patient X declares that his mother is an impostor. The diagnosis? Freud might say the patient has a troubled Oedipus complex. But the same patient thinks his poodle is a fraud, too. Ramachandran offers a more rigorous neurological explanation in *A Brief Tour of Human Consciousness*.

Examining the cause for patient X's behavior is just one stop on the writer's journey through the neural pathways of the brain. As the tour guide, Ramachandran, a neuroscientist at the University of California at San Diego, leads readers through a collection of his experiments and theories, championing the idea that charting the brain on a neurological level will provide us with a robust understanding of everything from politics to love.

Case studies of patients with obscure syndromes help the author solve the brain–mind puzzle piece by piece. In the case of patient X, communication between regions responsible for visual recognition and the production of emotional responses has been impaired. Because the patient recognizes his mother's face but feels no corresponding emotion, he deduces that she is simply a look-alike.

Parts of the book are fascinating and accessible, especially Ramachandran's work with phantom limbs and synesthesia—in which patients seem to transpose the processing of senses, such as sensing the note "middle C" as the color green. Ramachandran presents a convincing argument relating the syndrome to the enhancement of an ability we all possess: drawing connections between objects and events.

In a noticeable departure from the empirical explanations of the early sections, Ramachandran later explores possible psychological underpinnings for the evolution of human language and a universal definition of art. The final chapter, an abstract, philosophical foray into free will and the human sense of self, is even more speculative.

At times a captivating presentation of facts and anecdotes and at other times an assortment of theories, the book is more of a tour of Ramachandran's opinions and experiences than the concise introduction one expects from the title. In the end, the book succeeds in delivering an entertaining and thought-provoking look at how and why we should think about thought.

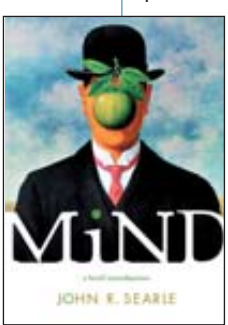
—Lisa DeKeukelaere

From Debris, Philosophy

MIND: A BRIEF INTRODUCTION

by John R. Searle. Oxford University Press, New York, 2004 ($26)

Many of the most time-honored questions in philosophy center on how to analyze and understand the essence of the mind. What motivates us? What makes us conscious? What makes us ourselves? In *Mind: A Brief Introduction*, Searle aims to introduce the reader to the historical aspects of the philosophy of mind, deconstruct existing theories, and offer new perspectives using logic, personal experiences and cases from neuroscience and psychology research.



The opening chapters provide an engaging, easy-to-follow primer. Searle, a professor of philosophy at the University of California at Berkeley, discusses how the work of Descartes and dualism—the idea that mind and body are separate—have colored and discolored the way we define the mind. Searle also examines subsets of monism and materialism, disciplines of thinking that run counter to dualism and became increasingly influential in the 20th century.

Searle explains such theories not merely to educate readers but to systematically point out problems in their arguments, then build his proposed philosophy of mind from the debris. He is even-handed, however, admitting that past theories have elements of truth.

Searle then sets out to reconcile these beliefs by rethinking specific aspects of the mind, including consciousness, causation and free will. He sharply shows readers his method of analyzing these concepts by applying them to observations of everyday experiences, such as thoughts about his dog. Searle then guides the discussion toward deeper meaning, extrapolating his sensory experience to an internal reflection and logical argument of what his observation says about mental processes. These dialogues eventually flesh out his perspective on the brain versus mind debate.

Along the way, Searle ties in examples from neuroscience and psychology to accentuate his ideas, but the book speaks best to readers who want to approach the mind from a primarily philosophical perspective. He fulfills his stated intent of aiding the reader in beginning his or her own reflections on the mind. The historical reviews, coupled with Searle's own research and perspectives, provide an excellent starting point.

—Nicole Garbarini

Wandering Models

ON INTELLIGENCE: HOW A NEW UNDERSTANDING OF THE BRAIN WILL LEAD TO THE CREATION OF TRULY INTELLIGENT MACHINES

by Jeff Hawkins, with Sandra Blakeslee. Times Books, Henry Holt and Company, New York, 2004 ($25)

"This book and my life are animated by two passions," writes Hawkins in *On Intelligence*. Those passions are mobile computing and brains.

This curious combination becomes less puzzling when one realizes that Hawkins is a founder not only of two leading mobile computing companies—Palm Computing and Handspring—but also of the Redwood Neuroscience Institute in Menlo Park, Calif., which explores memory and cognition. Hawkins contends that the human brain and intelligence have little in common with today's computing systems. Therefore, he offers his perspective on artificial intelligence, neural networks, cognition, consciousness and creativity, with the goal of explaining the mind.

The book is elegantly written with Blakeslee, a veteran science writer for the *New York Times*. At its core, the book puts forth Hawkins's "memory-prediction framework of intelligence"—a model of cognition positing that the main function of the human neocortex, and the basis of intelligence, is to make predictions. The brain constantly compares new sensory information with stored memories and experiences and combines the information to anticipate the future.

In essence, as we wander around, we build a reserve of information from which we construct an internal model of the world. But we constantly update that model. When we see a friend wearing a new hat, the brain automatically predicts what that person ought to look like and contrasts that prediction with the new sensory rendering, updating its model. Brain prediction "is so pervasive," Hawkins says, "that what we 'perceive' … does not come solely from our senses."

The continuous interplay of sensory input, memory, prediction and feedback—which occurs instantly through parallel processing in the neocortex—ultimately gives rise to consciousness and intelligence. "Correct predictions," Hawkins contends, "result in understanding."

Hawkins argues that creativity and imagination emerge from prediction as well. Imagination utilizes a neural mechanism to transform predictions into a form of sensory input—which is why our fantasies have such a strong "feel."

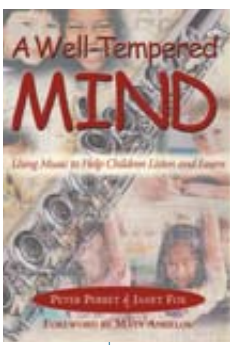
Moving on, Hawkins says that true machine intelligence will arise only if it is rooted in the same principles as brain-based intelligence. By the book's end, Hawkins proffers a "comprehensive theory of how the brain works," of "what intelligence is," and of "how your brain creates it." He acknowledges that many aspects of his theory have been developed by other scientists and that his role is to weave a comprehensive explanation. As such, this book provides some provocative thoughts on how the brain and the mind may actually function.

—Richard Lipkin

Sounds like Learning

A WELL-TEMPERED MIND: USING MUSIC TO HELP CHILDREN LISTEN AND LEARN

by Peter Perret and Janet Fox. Dana Press, Washington, D.C., 2004 ($22.95)



A chance event in 1992 prompted an unusual experiment. Perret, music director of the Winston-Salem Symphony in North Carolina, happened to hear a National Public Radio report about neuroscientists who were investigating the influence of music on learning. Young children who learned to play keyboards scored higher than their peers on tests of spatial-temporal reasoning, which is related to abstract and mathematical thinking. Perret, who had a lifelong interest in neuroscience, was so intrigued that he decided to apply the core principles to education.

The result was the Bolton project, initiated in 1994 at the Bolton Elementary School in Winston-Salem to integrate live orchestral music into the curricula of "at risk" children, aiming to improve their academic performance. Many students represented challenging demographics: poverty, minority status, language barriers, learning disabilities and below-average IQs.

Nevertheless, as little as 30 minutes of group music instruction three times a week made a difference. "Measured by the standard state-prescribed tests of reading, writing and mathematical achievement, the children we worked with did better than expected and better than children who hadn't had their instruction blended with music," Perret and his collaborator Fox report. That was the case for the first pupils the duo worked with, later classes, and schools elsewhere that have used the now expanded program (some are described briefly in the book). The authors say that the Bolton project "succeeded beyond our wildest expectations."

At the program's outset, fewer than 40 percent of Bolton's third graders scored at or above grade level in reading and math. Subsequently, of third graders who had studied music since the first grade, 85 percent scored at or above grade level in reading and 89 percent did so in math. After several years with a music curriculum, Bolton was reclassified from an "at risk" to an "exemplary" school.

Needless to say, these results do not constitute a scientific study. Nor do Perret and Fox claim to know how or why these effects occurred, acknowledging that many factors came into play, including social, psychological, motivational and possibly neurological ones. Indeed, they spend most of the book describing the Bolton program and teaching process, and only support their descriptions with high-level summaries of scientific research that backs up the educational theory. The studies do highlight a positive relation between music and learning. And they posit neural mechanisms to explain the effects, including sensory integration and enrichment of the corpus callosum, which connects the brain's two hemispheres.

"This book does not have formulas for creating young geniuses; nor is it a book of science," Perret and Fox explain. "Rather, it tells a story, describes an educational process, and attempts to share some insights into the world of cognitive neuroscience." In this context, they amply succeed. *—Richard Lipkin*

Match wits with the Mensa puzzler

BY ABBIE F. SALNY

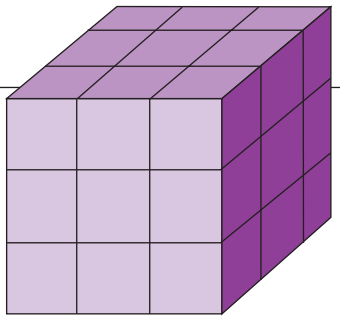
Head Games

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

1 An accurate alteration of a well-known statement is coiled in the grid at the left. To spell it out, start with one letter and move to an adjacent letter in any direction. **HINT:** start with the "F." One letter on the grid is not used.

2 Fill in the blanks below to complete three words that contain the letters "jul."

_ _ JU _ _ _ _ _L _ (harmfully)
_ _ JU _ _ _ _ _ _ _L _ (unwisely)
JU _ _ L _ _ (celebration)

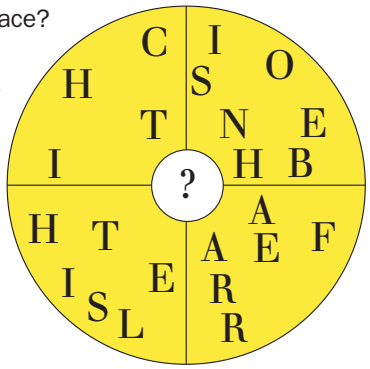


3 The outside of the cube above has been painted purple. How many blocks in the cube have no paint on them? How many have paint only on one side?

4 Stu made some snacks. To share the snacks with Sue and Shelley, he divided the snacks into three parts. Then each of the three ate half of their snacks. Shelley then ate one fourth of what was left of her snacks, Sue ate three fourths of what she had left, and Stu ate one eighth. Sue had two snacks left. How many snacks did Stu make in the first place?

5 Billy and Bob, who are twins and their parents' only children, went to visit their mother's only sister-in-law's only son's only daughter. What relationship was she to the twins?

6 Unscramble the letters in each pie segment at the right and then find the missing letter that completes each word. (The missing letter, indicated by the question mark, is the same for each word.)



7 What is the number that is more than one half of one tenth of one fourth of 2,400?

8 To the best of my knowledge, only one other word can be made from all the letters in the word "directions." Can you figure out what it is?

9 What is the four-digit number (no zeros) in which the last digit is the number of sides on a hexagon, the first digit is one half of the last, the second digit is the first digit subtracted from the last, and the third digit is the sum of the first and second digits? (The digits total 18.)

10 Figure out the pattern in the series below and fill in the blank:

1 8 __ 64 125

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

Answers

1. For every action, there is an equal and opposite criticism.
2. Injuriously, injudiciously, jubilee.
3. The only block with no paint on it is the one in the middle of the middle row. The middle blocks on each of the cube's six sides have paint on only one side.
4. The answer is 48. Sue had two left, which was one quarter, so she had eight. That was half of her original total of 16. Sixteen times three equals 48.
5. She is their cousin's daughter, so she is a second cousin.
6. Wishbone, warfare, whistle, witch. The missing letter is "W."
7. The number is 31. 2,400 divided by two equals 1,200, divided by 10 equals 120, divided by four equals 30; plus one equals 31.
8. The word is "discretion." Good for you if you found another!
9. The number is 3,366.
10. The answer is 27. (The series is 1 cubed, 2 cubed, 3 cubed and so on.)

The feeling of being touched on a fake hand illuminates how the brain makes assumptions about the world

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

The Phantom Hand

IN ONE VERY STRIKING ILLUSION, you can become convinced that you can feel a rubber hand being touched just as if it were your own. To find out for yourself, ask a friend to sit across from you at a small table. Use blocks or coffee cups to prop up a vertical partition on the table, as shown in the illustration on the preceding page. A flat piece of cardboard will do. Rest your right hand behind the partition, so you cannot see it. Then, in view beside the partition, place a plastic right hand—the kind you can buy from a novelty shop or a party store around Halloween. Ask your assistant to repeatedly tap and stroke your concealed right hand in a random sequence. Tap, tap, tap, stroke, tap, stroke, stroke. At the same time, while you watch, he must also tap and stroke the visible dummy in *perfect synchrony*.

If he continues the procedure for about 20 or 30 seconds, something quite spooky will happen: you will have an uncanny feeling that you are actually being stroked on the fake hand. The sensations will seem to emerge directly from the plastic rather than from your actual hidden flesh.

Why does this happen? Matthew Botvinick and Jonathan Cohen, then at the University of Pittsburgh and Carnegie Mellon University, who reported the so-called rubber-hand illusion in 1998, have suggested that the physical similarity between your real hand and the model is sufficient to fool the brain into attributing the touch sensations to the phony fingers. They believe this illusion is strong enough to overcome the minor discrepancy of the position of your real hand signaled by your body's joint and muscle receptors versus the site of the plastic hand registered by your eyes.

But that is not the whole story. At about the same time that Botvinick and Cohen observed the rubber-hand effect, we and our colleagues William Hirstein and Kathleen Carrie Armel of the University of California at San Diego discovered a further twist: the object your helper touches does not even need to resemble your palm and digits. He can produce the same effect if he just pets the table. Try the same experiment, but this time have your acquaintance rub and tap the surface in front of you while making matching movements on your real, concealed hand. (If using the table alone does not work, practice on a dummy hand first before graduating to furniture.) You may have to be patient, but you will eventually start feeling touch sensations emerge from the wood surface before you. The illusion is even better if you have a rubber sheet covering the tabletop to mimic the tactile qualities of skin.

Assimilating the Hand

This illusion is extraordinarily compelling the first time you encounter it. But how can scientists be certain that you have now perceptually assimilated the table into your body image (rather than merely assigning ownership to it the same way you own a house)? Last year Armel and one of us (Ramachandran) learned that once the illusion has developed, if you "threaten" the table or dum-

Continued on page 99

You will have the uncanny feeling that you are actually **being stroked on a fake plastic hand.**

PHOTODISC/GETTY IMAGES

Once the illusion has developed, **if you "threaten" the dummy by aiming a blow at it,** the person winces and even starts sweating.

Continued from page 100

my by aiming a blow at it, the person winces and even starts sweating, as she would if she were facing a real threat to her own body. We demonstrated this reaction objectively by measuring a sudden decrease in electrical skin resistance caused by perspiration—the same galvanic skin response used in lie detector tests. It is as if the table becomes incorporated into a person's own body image so that it is hooked up to emotional centers in the brain; the subject perceives a threat to the table as a threat to herself.

These illusions demonstrate two important principles underlying perception. First, perception is based largely on extracting statistical correlations from sensory inputs. As you feel your unseen hand being tapped and stroked and see the table or dummy hand being touched the same way, your brain in effect asks itself, "What is the likelihood that these two sets of random sequences [on the hidden hand and on the visible table or dummy] could be identical simply by chance? Nil. Therefore, the other person must be touching *me*."

Second, the mental mechanisms that extract these correlations are based on automatic processes that are relatively unsusceptible to higher-level intellect. With information gathered by sensory systems, the brain makes its judgments automatically; they do not involve conscious cogitation. Even a lifetime of experience that a table is not part of your body is abandoned in light of the perceptual decision that it is. Your "knowing" that it cannot be so does not negate the illusion. (Just as some people cling to superstitions even while recognizing their absurdity.)

Question Assumptions

The experiment was inspired by earlier work we had done with patients who had phantom limbs. After a person loses an arm from injury or disease, he may continue to sense its presence vividly. Often, the phantom seems to be frozen in a painfully awkward position. We asked a patient to put his phantom left arm on the left side of a mirror propped vertically on a table in front of him. He then put his intact right arm on the right side, so its reflection was seen in the mirror superimposed on the phantom, creating the visual illusion of having restored the missing arm. If the patient now moved his right arm, he saw his phantom move. Remarkably, this "animated" the phantom so it was felt to move as well—sometimes relieving the cramp. Even more surprising: in some cases, if the physician touched the real hand, the patient not only saw his phantom being touched but experienced the touch as well. Again the brain regards this combination of sensory impressions as unlikely to be a coincidence; therefore, it quite literally feels the touch emerging from the phantom hand.

If an assistant taps and strokes your hidden real hand and a visible fake hand in synchrony, the sensations will seem to come from the plastic.

Consider what these illusions imply. All of us go through life making certain assumptions about our existence. "My name has always been Joe," someone might think. "I was born in San Diego," and so on. All such beliefs can be called into question at one time or another for various reasons. But one premise that seems to be beyond question is that you are anchored in your body. Yet given a few seconds of the right kind of stimulation, even this axiomatic foundation of your being is temporarily forsaken, as the table next to you seems to become part of you. As Shakespeare aptly put it, we are truly "such stuff as dreams are made on."

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

(Further Reading)

- **The Perception of Phantom Limbs.** Vilayanur S. Ramachandran and William Hirstein in *Brain,* Vol. 121, Part 9, pages 1603–1630; September 1998.
- **Rubber Hands "Feel" Touch That Eyes See.** Matthew Botvinick and Jonathan Cohen in *Nature,* Vol. 391, page 756; February 19, 1998.
- **Projecting Sensations to External Objects: Evidence from Skin Conductance Response.** Kathleen Carrie Armel and Vilayanur S. Ramachandran in *Proceedings of the Royal Society, Biological Sciences,* Vol. 270, No. 1523, pages 1499–1506; July 22, 2003.

JASON LEE