

SCIENTIFIC AMERICAN
MIND

BEHAVIOR • BRAIN SCIENCE • INSIGHTS

February/March 2009

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MIND

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*Some of the articles in this issue
are adapted from articles originally
appearing in Gehirn & Geist.*

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Play Time

Every parent has probably suffered from this type of near catastrophe. My husband and I realized—too late—that we had forgotten to pack toys and books to entertain our older daughter, then about five, during a long drive. Our guilt soon turned to amusement tinged with open admiration. She solved the problem her own way: her feet instantly became two friendly characters cavorting together across her mental stage, with her narrating out loud for our benefit.

The drive to play is strong. But who knew that goofing off as children could be so constructive when it comes to establishing the long-term mental health of adults? As Melinda Wenner writes in the cover story, “The Serious Need for Play,” starting on page 22, frolicking in unstructured free play (as opposed to planned and rules-based activities such as chess clubs or after-school sports teams) is particularly critical for youngsters. Imaginary play and tumbling around in the sort of mock battles that my parents used to call “roughhousing” are both key for children to successfully acquire social skills, reduce stress, improve cognition and develop problem-solving abilities. Grown-ups can benefit from play breaks, too. We just have to remember to set the stage for our own fun times.

A different kind of performance issue, stage fright, is a common demon for many of us, causing us to seize up just when we most want to do well. In her feature, “Avoiding the Big Choke,” Elizabeth Svoboda gives tips for successfully navigating through those difficult moments. One flaw we all fall prey to, as she explains, is simply thinking too hard. Turn to page 36 to find out why.

While you’re tuning up your gray matter, flip to page 56 for the article “Six Ways to Boost Brainpower,” by Emily Anthes. Our malleable minds take well to proper mental care and feeding. To a great extent, as science tells us, we are what we make of ourselves.

Mariette DiChristina
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COVER IMAGE BY AARON GOODMAN

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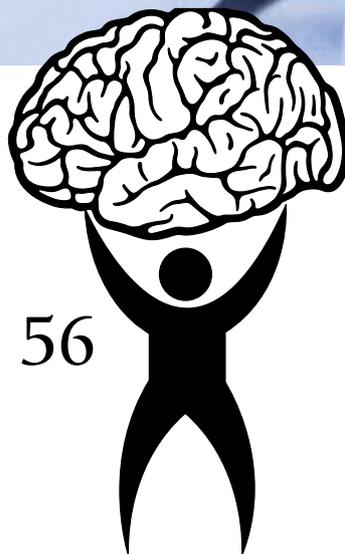
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The adult human brain is surprisingly malleable: it can rewire itself and even grow new cells. Here are some habits that can fine-tune your mind.

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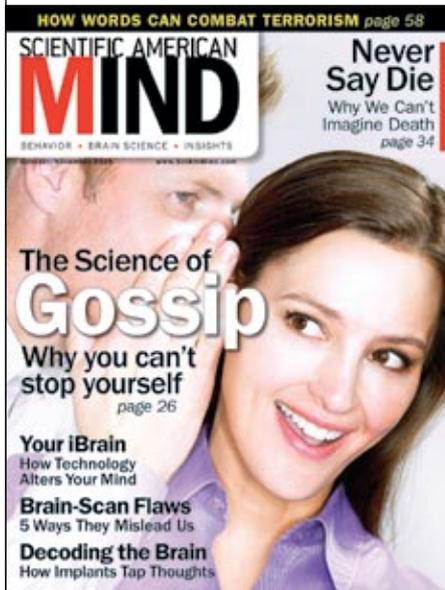
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NO WAR ON TERROR

“Talking about Terrorism,” by Arie W. Kruglanski, Martha Crenshaw, Jerr-old M. Post and Jeff Victoroff, makes an important point. Whether we are anti-terrorism, antiwar or anticancer, when we wage a war against the enemy we empower that enemy. Mother Teresa is reported to have said about her refusal to take part in antiwar rallies, “If you ever have a pro-peace rally, I’ll be there.”

As a physician, I see the difference when people battle cancer or other diseases—they either win or lose the battle. Instead of fighting, we need to look at how to heal our lives and find peace. Then there are no losers; with healing comes a true resolution of the problem.

We are not born to be killers. Think of the effect of spending billions to help other countries heal rather than spending that money to kill and eliminate terrorists.

Bernie Siegel
Woodbridge, Conn.

Everything in the article makes sense, except the point it tries to make about not considering our actions “war.” In fact, all the tactics that the article contrasts to war are familiar elements of warfare. War isn’t just killing the enemy’s soldiers; it is also determining what makes the enemy tick, attempting to be-

friend the enemy’s population and avoiding unnecessary battles.

“T. Rakei”

adapted from a comment
at www.SciAmMind.com

CLASSIFYING ANXIETY

I read with interest “Why Do We Panic?” [Facts and Fictions in Mental Health], by Hal Arkowitz and Scott O. Lilienfeld. As a clinical psychologist, I have long observed in my patients a taxonomy of anxiety and panic that I have been unable to find in the literature. I note three kinds of anxiety and panic: In the first, anxiety and panic are associated with a mood disorder, so that anxiety is one face of what the DSM regards as a depressive illness. The second type is of a posttraumatic nature, and the third kind arises as part of the onset of a psychotic disorder, such as schizophrenia or dementia.

This taxonomy covers all the patients I have ever seen in 22 years of clinical practice. The taxonomy also suggests guidelines for treatment. For the first: selective serotonin reuptake inhibitors (SSRIs), commonly known as antidepressants. For the second: talk therapy with SSRIs and/or a sleep aid. For the third: antipsychotic medication. The differential diagnosis is sometimes tricky and requires a thorough history.

Jeff Mitchell (“drmitch”)
adapted from a comment
at www.SciAmMind.com

THE BEGINNING?

Regarding Jesse Bering’s “The End?” why do we perceive death to be different from prebirth or, more precisely, pre-conception? That is also a time when our brain is not functioning—when it does not exist. Yet we do not spend nearly as much time pondering what happened to us or where our minds were before we were born.

“Farlo”

adapted from a comment
at www.SciAmMind.com

BERING REPLIES: It was fascinating to observe how many readers of my article on imagination and the afterlife—or

rather the troubles thereof—were tempted to compare “life after death” to “life before birth.” These periods of nonexistence are certainly analogous from a philosophical perspective. Both are marked by the absence of the generative phenomenological organ (that is, the brain) that we so often confuse with the soul. But psychologically speaking, I suspect that people may be disposed to reason about these two periods of the self’s inexistence in different ways.

In fact, as I write this, Natalie Emmons, a Ph.D. candidate in my lab, is en route to a small village in rural Ecuador, where she plans to systematically investigate children’s reasoning (or “folk beliefs”) about the mental status of human beings prior to conception. We believe the difference goes beyond simply hav-

LISTENING FOR SOUNDNESS

In “Why Dogs Don’t Enjoy Music”

[Head Lines], Sandy Fritz writes, “These results suggest the fine discrimination of sound is not a necessity for survival.” I’ve often thought that the ability to appreciate the quality of sounds is vital in a toolmaking species. In many crafts practiced by early humans—selecting stone for tools, judging whether wood for a boat or clay for a pot is sound or assessing whether a bow is properly strung—the ability to judge the quality of sound is essential. It would be interesting to study the ways in which contemporary Stone Age cultures use sound in toolmaking.

“Bodhi”

adapted from a comment at www.SciAmMind.com

LAUGH IN RELIEF

In “Ask the Brains,”

William F. Fry suggests that we laugh when we see someone fall down because of the incongruity of the situation. I have a different idea: laughter is an expression of relief. During the brief instant of watching someone fall, our brains gear up for a possible fight-or-flight response: Will the person be injured and create a crisis? When the event concludes positively—no crisis to respond to—our bodies release the tension with a physical, audible expression: a short burst of relieved laughter. You can also see this reflex in action when a golfer is trying to sink a putt or when a basketball player tries to make a three-point shot—spectators will release the momentary tension with a hoot of success or a groan of failure.

“Johnnorton”

adapted from a comment at www.SciAmMind.com

ERRATUM In “The End?”

by Jesse Bering [October/November 2008], we misstated the location of Queen’s University Belfast; it is in Northern Ireland.

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ing more to worry about in the future than in the past.

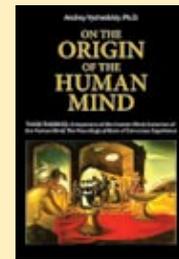
Developmental psychologists such as Deborah Kelemen of Boston University have found evidence of a “creationist bias” in young children. These findings suggest that our species’ default cognitive tendency is to reason about the origins of animate and inanimate objects in terms of a clear beginning—and furthermore, as having been designed by an intelligent creator such as God. The bottom line is that the jury is still out on this issue of how we tend to conceptualize our subjective existence in that exhaustively long epoch that was life before us.



ON THE ORIGIN OF THE HUMAN MIND

by **Andrey Vyshedskiy, Ph.D.**

Dec. 2008 ISBN: 9781607787778 (\$24.95)
book website: www.MobileReference.com



Some of the most time-honored questions in philosophy, psychology, and neuroscience center on the uniqueness of the human mind. How do we think? What makes us so different from all the other animals on planet Earth? What was the process that created the human mind?

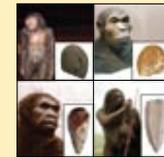
Chapter I “Uniqueness of the Human Mind”

introduces the reader to recent research into animal behavior, communication, culture and learning, as well as controlled animal intelligence experiments, and offers a new hypothesis of what makes the human mind unique.



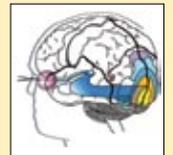
Chapter II “Evolution of the Human Mind”

combines latest genetics research and archeological discoveries to help readers understand hominid evolution. The author discusses the forces that influenced the development of the hominid intelligence and offers a step-by-step theory that links improvement in visual information processing to speech development and to the types of stone tools manufactured by the hominids.



Chapter III “The Neurological Basis of Conscious Experience”

takes the reader on an exciting journey into the neurobiology of the human mind. The author introduces the reader to the structure and function



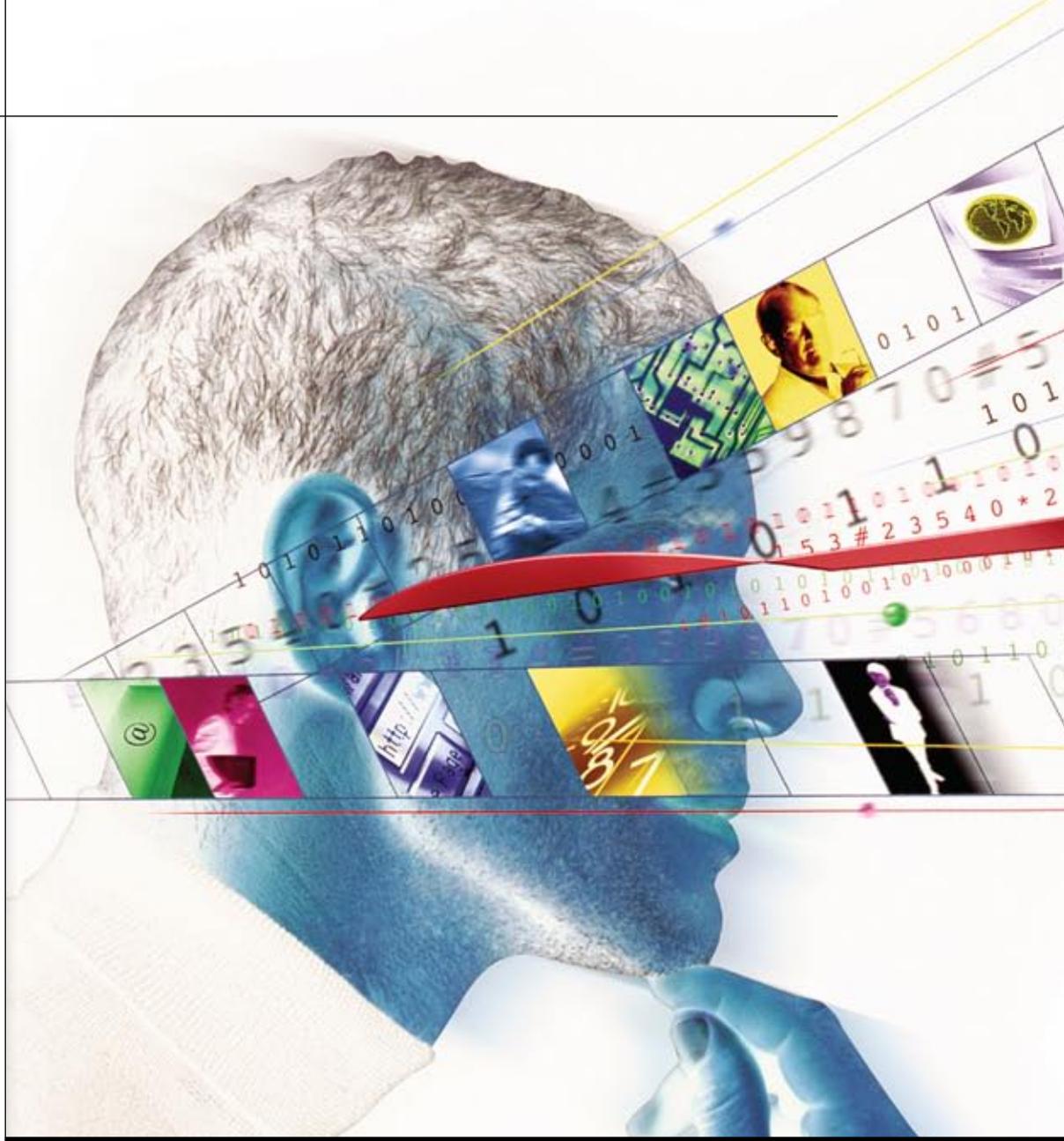
of the brain and then presents recent insights into brain organization derived from cognitive psychology, brain imaging, animal experiments, and the studies of patients with diseases of the brain. The book concludes with a unifying theory of the mind and a discussion of the evolution of the human brain and the uniqueness of the human mind from the neurological perspective.

The theory of integration of neuronal ensembles allowing for a uniquely human experience of “mental synthesis” is fascinating and is presented in a clear and easy-to-understand language. – Dr. Maria K. Houtchens, Harvard Medical School

The idea about “mental synthesis” is brilliant and should enter the literature as an alternative to the other theories that explain the origin of humans. – Dr. Fred Wasserman, Boston Univ.

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Head Lines



>> MOOD

Think Fast

Rapid thinking makes people happy

Lousy day? Don't try to think happy thoughts—just think fast. A new study shows that accelerated thinking can improve your mood. In six experiments, researchers at Princeton and Harvard universities made research participants think quickly by having them generate as many problem-solving ideas (even bad ones) as possible in 10 minutes, read a series of ideas on a computer screen at a brisk pace or watch an *I Love Lucy* video clip on fast-forward. Other participants performed similar tasks at a relaxed speed.

Results suggested that thinking fast made participants feel more elated, creative and, to a lesser degree, energetic and powerful. Activities that promote fast thinking, then, such as whip-

ping through an easy crossword puzzle or brainstorming quickly about an idea, can boost energy and mood, says psychologist Emily Pronin, the study's lead author.

Pronin notes that rapid-fire thinking can sometimes have negative consequences. For people with bipolar disorder, thoughts can race so quickly that the manic feeling becomes aversive. And based on their own and others' research, Pronin and a colleague propose in another recent article that although fast and varied thinking causes elation, fast but repetitive thoughts can instead trigger anxiety. (They further suggest that slow, varied thinking leads to the kind of calm, peaceful happiness associated with mindfulness meditation, whereas slow, repetitive thinking tends to sap energy and spur depressive thoughts.)

It is unclear why thought speed affects mood, but Pronin and her colleagues theorize

MATSU Getty Images



Spotting a Fake Smile

At least one good thing comes from a breakup: a better fake-smile detector. Social psychologist Michael Bernstein and his colleagues at Miami University found that people who felt rejected were better at discriminating between fake and real smiles. Researchers believe that a true grin indicates real emotions, such as cooperation, because some of the muscles we use—the ones around the eyes—are not under our conscious control. Our ancestors needed to be accepted in a group to survive, Bernstein says, so an outsider would not want to waste energy by acting on a fake reaction—or to miss a real opportunity to be included.



—Rachel Mahan

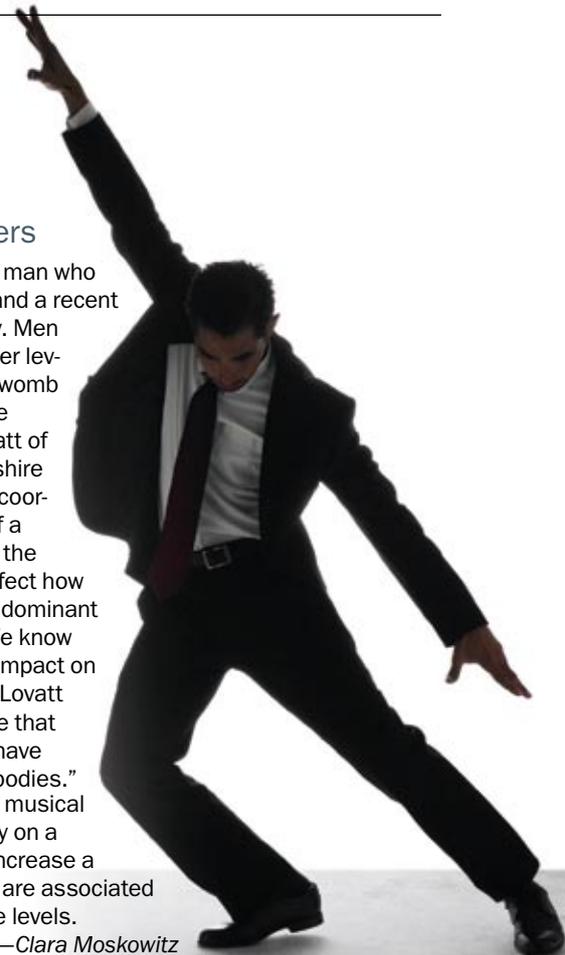
>> ATTRACTION

Men Who Can Move

More testosterone makes better dancers

Most women agree that a man who can dance is attractive—and a recent study helps to explain why. Men who were exposed to higher levels of testosterone in the womb are judged by women to be better dancers. Peter Lovatt of the University of Hertfordshire in England found that the coordination and complexity of a man's dancing, as well as the size of his movements, affect how attractive, masculine and dominant he appears to women. "We know that testosterone has an impact on physical characteristics," Lovatt says. "It might be the case that higher-testosterone men have greater control over their bodies." Dancing joins athleticism, musical ability and facial symmetry on a growing list of traits that increase a man's attractiveness and are associated with prenatal testosterone levels.

—Clara Moskowitz



that our own expectations may be part of the equation. In earlier research, they found that people generally believe fast thinking is a sign of a good mood. This lay belief may lead us to instinctively infer that if we are thinking quickly we must be happy. In addition, they suggest, thinking quickly may unleash the brain's novelty-loving dopamine system, which is involved in sensations of pleasure and reward.

The kind of rush that a person gets from rapid-fire thinking may be transient, but "these little bursts of positive emotion add up," says psychologist Sonja Lyubomirsky of the University of California, Riverside. Studies have demonstrated that happiness yields myriad benefits, including greater productivity, stronger social support and improved immune function, she explains, adding that "even brief periods of heightened mood can lead to upward spirals."

—Siri Carpenter

CRISTIAN BAITG Getty Images (woman with balloon); SIRI STAFFORD Getty Images (dancing man)

>> PERCEPTION

Finding Control in Chaos

Feeling helpless leads us to see nonexistent patterns

Even the most laid back among us crave a sense of control, and when we feel helpless we scour our surroundings for anything that will restore predictability. New research shows that when we lack control we don't simply wait for order to return: we impose it, if only in our own minds, by imagining patterns and trends where none exist.

In six experiments, psychologists Jennifer Whitson of the University of Texas at Austin and Adam Galinsky of Northwestern University manipulated subjects' sense of control. In some trials, they gave participants either random feedback or no feedback at all on a tricky experimental task; in others, they asked participants to recall a situation in which they lacked control or one in which they had full control. Results showed that not having control caused participants to mistakenly see an image in

a field of static, to smell conspiracy in other people's benign behavior, to embrace superstitious beliefs and to perceive nonexistent stock-market trends. Such illusory perceptions evaporated when participants were first denied control but then given an opportunity to write about their most deeply held values, an activity that bolsters psychological security and quells feelings of helplessness.

The authors observe that illusory pattern perception "may not be entirely maladaptive" if by soothing uncertainty and restoring a sense of control, it encourages us to actively confront unpredictable circumstances rather than withdrawing from them. One unanswered question, they add, is whether loss of control also heightens people's speed or accuracy in detecting patterns that do exist.

—Siri Carpenter

GETTY IMAGES

>> BRAIN IMAGING

How Teenagers Find Themselves

The development of a key brain area leads to self-consciousness

Teens are notoriously self-conscious. Now brain-imaging experiments are revealing how this adolescent predilection might be the result of changes in brain anatomy linked with the self, and the findings may hint at how the sense of self develops in the brain.

One way we build a sense of self is by reflecting on how others perceive us, a concept psychologists have dubbed "the looking-glass self." To see how teenagers reacted to what other people thought of them, researchers asked adolescent girls ages 10 to 18 to imagine a variety of scenarios involving onlookers that were designed to evoke social emotions such as guilt or embarrassment—for example, "You were quietly picking your nose, but your friend saw you."

Cognitive neuroscientist Sarah-Jayne Blakemore of University College London and her colleagues found that when compared with scenarios describing basic emotions that did not involve the opinions of others, such as fear and disgust, girls who thought about onlookers' opinions engaged a brain region known as the dorsal medial prefrontal cortex (MPFC) more during social emotional scenarios than adult women did. This area is one of the last

regions to develop before adulthood, and it is known to activate in adults when they think about themselves, about other people and even about the personality traits of animals.

It makes evolutionary sense for teenagers to be highly concerned about what others think, Blakemore suggests. Adolescence requires becoming more independent because one's parents might not be around much longer. Teens have to start relying more on what peers think "and develop a more socially

constructed sense of self," Blakemore says. The researchers' findings "might also help explain why peer influence is so strong in adolescence, compared with before and after."

Another way we construct a sense of self is by contemplating what our aims or traits are, and previous studies have shown that adolescents also use their dorsal MPFC when engaged in such introspection. For instance, when developmental social neuroscientist Jennifer Pfeifer of the University of Oregon and her colleagues at the University of California, Los Angeles, asked subjects whether phrases such as "I make friends easily" described them or



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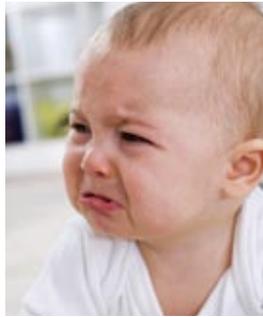
>> DEVELOPMENT

Baby Stress

A gene may affect infant anxiety, but good parenting can overrule it

Some babies stay calm when something changes in their life or environment, whereas others get fussy and fidget at even the slightest deviation from the norm. Researchers do not fully understand why some children are able to cope better with stress or whether kids' response to such situations is influenced by parenting or genes. According to a new study, it is shaped by both.

Cathi Propper, a developmental psychologist at the University of North Carolina at Chapel Hill, and her colleagues studied infants at several periods over their first year of life, inducing stress by separating them from their mothers. Using an electrocardiogram, the researchers determined the babies' vagal tone, an indicator of how strongly the vagus nerve, which runs from the brain stem to most organs in the body, is suppressing heart rate. During



stress, vagal tone decreases, allowing the heart to speed up and the body to handle the stressor. But some of the babies did not show this normal decrease in vagal tone during distressing periods; the researchers found that these infants who lacked an effective response at ages three and six months shared a particular variant of the *DRD2* gene, which regulates receptors for the neurotransmitter dopamine. The variant has been associated with a decreased number of dopamine receptors in the brain and linked with risk-taking behavior, such as gambling, in adults. Infants in the study who had different

versions of the gene showed a more typical response to stress.

But these genes are not destiny. The researchers also evaluated the parenting styles of the infants' mothers. "Exposure over time to sensitive parenting seems to counteract the effects" of the higher-risk version of the gene, Propper says. By 12 months of age, infants with this gene variant whose needs were consistently attended to responded to stress just as effectively as did the babies with other versions of the gene.

—Emily Anthes

JUPITERIMAGES

a familiar other—in this case, Harry Potter—the researchers found that thinking about oneself caused higher dorsal MPFC activation in teens as compared with adults.

The greater activity in the dorsal MPFC in adolescents hints that they are learning to attribute complex mental states such as intentions both to themselves as well as to other people, suggests social cognitive neuroscientist Kevin Ochsner of Columbia University. As teens mature, less activity may be seen in that region because the brain might become more efficient at the process of self-reflection—somewhat like a skill for which practice makes perfect, he adds.

Pfeifer also explains that in adults more activity is seen in brain regions linked with storing knowledge about oneself. "Instead of deciding who they are over and over again, adults may just retrieve what they already know about themselves," she says. "But while these areas related to self-reflection might be more active in adolescence, it is something that goes on throughout your whole life—you'll see the same kinds of processes going on in the brain in adults if they enter stages in their lives that are new to them, such as parenthood." —Charles Q. Choi

>> PSYCHOLOGY

Bias Doesn't Pay

Decision making suffers from unconscious prejudices

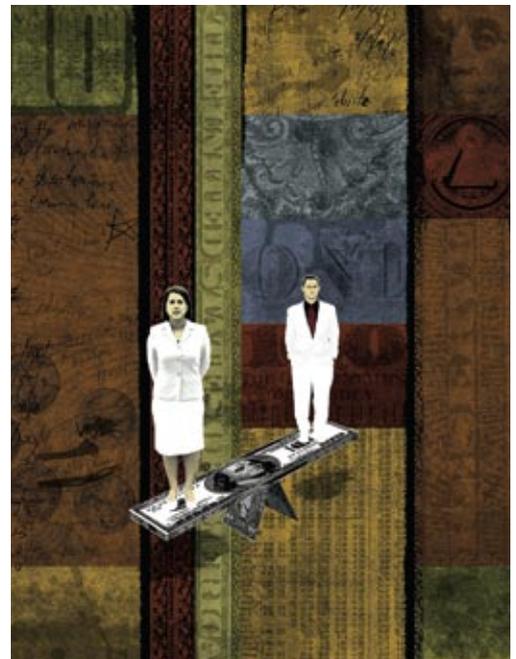
When making complex decisions, legitimate factors sometimes mask choices influenced by prejudice—so bias is hard to detect. Recent research untangled some of these complex scenarios revealing that people are willing to sacrifice quite a lot to fulfill their subconscious biases. Psychologists asked volunteers to imagine they and a partner would compete together in a trivia quiz. Participants viewed profiles of two potential partners that described each person's education, IQ and previous trivia game experience. A photograph of either a thin or an overweight person was attached to each profile. Subjects indicated which of the two potential partners they would prefer, then judged 23 more such pairings, each with a new mix of attributes.

Teasing out which variables affected people's choices, the researchers found that participants

were willing to sacrifice 12 IQ points in a trivia partner to have one who was thin. In a similar experiment, the group found that when comparing successive pairs of job offers, study subjects were willing to take a 22 percent salary cut to have a male boss.

"There's a price to pay for biases that we may not even be aware of," says lead author Eugene Caruso of the University of Chicago. "If you take a lower salary in order to have a male boss or you choose a partner who has a lower IQ but is thin, the person you're discriminating against is yourself."

—Siri Carpenter



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Borrowed Identity

Cloaking oneself in a new identity—even for only a few minutes—can disrupt long-established patterns of behavior, new research suggests. Stanford University psychologists staged an online game in which players represented by on-screen avatars competed to solve a series of math problems. Subjects' real gender didn't affect their scores, but those who were arbitrarily assigned to a female avatar and who competed against two male avatars performed worse and gave up on difficult problems more quickly than did those who were assigned a male avatar and whose opponents were female. A large body of work shows that when women are reminded of their gender, their math performance suffers—but this study is the first to suggest that the effect of identity may not be tied to a lifetime of experiences. —Siri Carpenter

>> NEUROSCIENCE

The Suicidal Brain

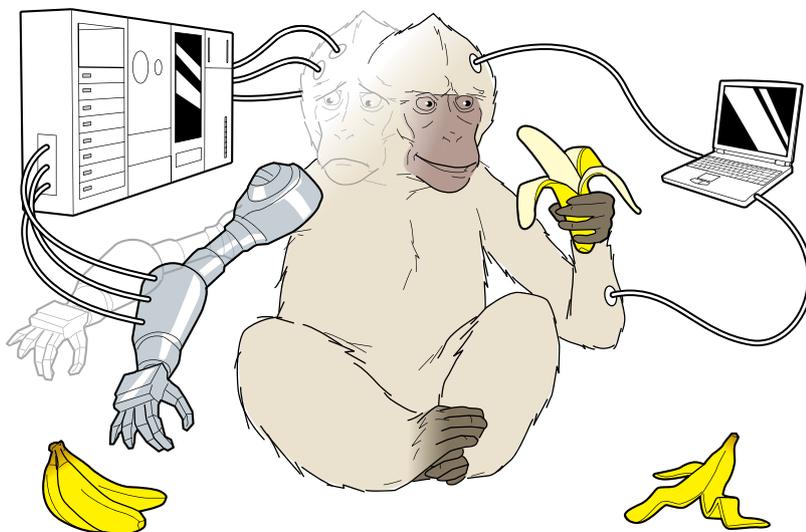
Certain life experiences may lead to brain changes in suicide victims

Suicide rates in the U.S. have increased for the first time in a decade, according to a report published in October by the Johns Hopkins Bloomberg School of Public Health. But what leads a person to commit suicide? Three new studies suggest that the neurological changes in a brain of a suicide victim differ markedly from those in other brains and that these changes develop over the course of a lifetime.

The most common pathway to suicide is through depression, which afflicts two thirds of all people who kill themselves. In October researchers in Canada found that the depressed who commit suicide have an abnormal distribution of receptors for the chemical GABA, one of the most abundant neurotransmitters in the brain. GABA's role is to inhibit neuron activity. "If you think about the gas pedal and brakes on a car, GABA is the brakes," explains co-author Michael Poulter, a neuroscientist at the Robarts Research Institute at the University of Western Ontario.

Poulter and his colleagues found that one of the thousands of types of receptors for GABA is underrepresented in the frontopolar cortex of people with major depressive disorder who have committed suicide as compared with nondepressed people who died of other causes. The frontopolar cortex is involved in higher-order thinking, such as decision making. The scientists do not yet know how this abnormality leads to the type of major depression that makes someone suicidal, but "anything that disturbs that system would be predicted to have some sort of important outcome," Poulter says.

Interestingly, this GABA receptor problem is not the result of abnormal or mutated genes. Rather the change is epigenetic, meaning some environmental influence affected how often the relevant genes



>> MEDICINE

Hope for Paralyzed Patients?

Rerouting connections from neuron to muscle allows the brain to move deadened limbs

Scientists have forged a promising avenue in the quest to restore mobility to patients paralyzed by disease or injury. Researchers at the University of Washington devised a way to reroute signals from the brain's motor cortex to trigger hand movement directly.

For the past decade researchers have focused on "listening to" and decoding the specific brain signals that trigger muscle movement, using a wall of computers running complex algorithms to translate that brain activity into instructions for moving a computer cursor or a robotic arm or leg.

By establishing a direct connection between a neuron and a paralyzed limb (and amplifying the neuron's signal through a regular computer), scientists hope to restore dexterity much more easily than via efforts to control robotic limbs by interpreting thoughts.

SECOND LIFE, LINDEN LAB (avatars); JASON LEE (monkey illustration)

were expressed—that is, made into proteins. [For more about epigenetics, see “The New Genetics of Mental Illness,” by Edmund S. Higgins; *SCIENTIFIC AMERICAN MIND*, June/July 2008.] In the frontopolar cortex of suicide brains, the gene for the GABA-A receptor often had a molecule called a methyl group attached to it, the team found. When a methyl group is attached to a gene, it keeps that gene hidden from cells’ protein-building machinery—in this case, preventing the cells from manufacturing GABA-A receptors.

The addition of this methyl tag, called methylation, occurs more extensively in rodents that are handled by humans than in rodents that are not. Less is known about what causes methylation in the human brain, but another recent study suggests it could be related to abuse during childhood. In May researchers at McGill University reported that the gene responsible for creating cells’ protein-building machinery is more frequently methylated in the hippocampus—the brain region responsible for short-term memory and spatial navigation—of depressed suicide victims who suffered child abuse than in the brains of nonsuicide victims who were not abused.

Again, the researchers do not yet know how problems with protein-building machinery lead to depression and suicide. But “it makes sense that if you have some limited capacity for protein synthesis, you gradually are depriving yourself of building critical synapses,” or connections between neurons, which could be important for staying happy, says co-author Moshe Szyf, a pharmacologist at McGill. “Our hypothesis is that there are social events early in life that kind of epigenetically program the brain,” he says. He and his colleagues are now comparing the brains of suicide victims who were abused with those of suicide victims who were not abused to see if their methylation patterns differ.

Even in the womb, epigenetic influences can change the

developing brain in ways that increase the risk of eventual suicide. In February 2008 a study revealed that baby boys who are born either short or with low birth weight are more likely to commit violent suicide as adults than longer and heavier babies are, irrespective of their height and weight as adults. Similarly, baby boys born prematurely are four times more likely to attempt violent suicide than those born at full term.

The researchers, publishing in the *Journal of Epidemiology and Community Health*, suggest that the chemical serotonin, which is involved in fetal brain growth, may play a role. A stressful or deprived womb environment may interfere with the development of the fetus and its serotonin system; other studies have shown that the brains of people who exhibit suicidal behaviors have reduced serotonin activity.

Ultimately, these findings reveal that suicide brains differ from other brains in multiple ways—in other words, “we’re really dealing with some sort of biological imbalance,” Poulter says. “It’s not an attitude problem.” And because epigenetic changes typically occur early in life, it may one day be possible to identify young people at risk for suicide by studying their methylation patterns and then to treat them with drugs that regulate this mechanism, Szyf notes. —Melinda Wenner



MARCUS MOK age fotostock (above right)

The new approach simplifies the process. Engineers and neuroscientists restored use of a monkey’s immobilized limb by replacing the lost biological connection. “Rather than decoding intention, we’ve just established a connection and encouraged the monkey to learn how to act on it,” says Chet Moritz, a neurophysiologist, who pioneered the work with fellow Washington professor Eberhard Fetz.

They trained macaques to play a simple video game using a joystick. Then they ran a wire from a single neuron in the animals’ motor cortex to a desktop computer. The electrical impulse from that cell was amplified by the computer and transmitted along another wire to one of the primates’ arm muscles, which had been temporarily anesthetized.

Within minutes, the monkeys learned to control wrist movements with their thoughts, moving the joystick left or right

to match targets on a computer screen.

The surprise, Moritz says, was that any neuron within that general region of the brain could learn to stimulate wrist muscles—regardless of whether the neuron was originally involved in that specific movement.

“Monkeys can rapidly learn to change neuron activity, in this case to generate movement, much like humans can change heart rate activity with bio-feedback,” Fetz explains. This control necessitated conscious attention; making such movements subconsciously would require repetitive training, much like learning a sport.

The long-term goal is to develop a miniaturized, implantable neuro-prosthetic device that would enable paralyzed patients to move their own paralyzed limbs. Fetz has already taken the next step, developing a cell phone–size neurochip that can be linked to a

microprocessor, small enough for monkeys to carry implanted in their head.

Many hurdles remain. It is difficult to record from the same neuron for a long period. Within days or weeks, scar tissue walls off electrodes, interrupting transmission. Guiding electrodes to new locations with tiny motors might mitigate that problem. Providing a decades-long power supply is also a challenge. Biocompatibility is another issue; fully implanting such a system under the skin presents a huge infection risk. And crucial questions exist: Can this model be scaled up to stimulate multiple neurons that trigger multiple muscles? How flexible is the brain in reassigning new functions to neurons?

The team hopes to restore arm movements in the near term—and ultimately to restore paraplegics’ ability to walk. But clinical trials remain perhaps a decade away. —Sharon Guynup

>> LOVE

Separation Anxiety for Adults

Why it hurts to be away from your partner

Everyone knows it's no fun to be away from your significant other. Studies using anecdotal evidence have indicated that long-term separation from a romantic partner can lead to increased anxiety and depression as well as problems such as sleep disturbances. Now researchers are identifying the neurochemical mechanisms behind these behavioral and physiological effects.

In a study published last fall, researchers showed that male prairie voles that had been separated from their female partners for four days—a much shorter amount of separation time than researchers had previously found to affect the voles' physiology—exhibited depressionlike behavior and had increased levels of corticosterone, the rodent equivalent of the human stress hormone cortisol. Males that had been separated from their male siblings did not display any of these symptoms, implying the response was tied specifically to mate separation, not just social isolation. When the animals received a drug that blocked corticosterone release, they no longer exhibited depressionlike behavior following partner separation, confirming that stress hormones were at the root of the response.

In many ways, separation appears to



resemble drug withdrawal. Studies have shown that in monogamous animals, cohabiting and mating increase levels of oxytocin and vasopressin—hormones that foster emotional attachments—and activate brain areas associated with reward. As a result, when prairie voles are separated from their partners even for a short time, they experience withdrawal-like symptoms, says Larry Young, a behavioral neuroscientist at Emory University's Yerkes National Primate Research Center and co-author of the study. "In the short term, I think [this mechanism] creates an aversive state so that the animals want to seek out their partner to hold that bond together," Young says.

In a recent study of human couples, social psychologist Lisa Diamond of

the University of Utah observed minor withdrawal-like symptoms, such as irritability and sleep disturbances, along with an increase in cortisol in subjects after they were separated four to seven days. Participants who reported high anxiety about their relationships had the biggest spikes in cortisol levels, but even those who reported low levels of stress and anxiety during the separation exhibited some degree of increased cortisol and physical discomfort. These results, like those from Young's study, indicate a specific link between separation and increased cortisol, implying cortisol-blocking drugs may benefit people struggling to cope with partner separation, too.

Researchers believe the pair bond evolved from the parent-child bond,

REG CHARITY Corbis

>> SOCIETY

Speaking of Race

People who avoid mentioning race appear more prejudiced

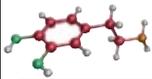
White people often avoid mentioning race because they fear that even noticing skin color might somehow make them appear racist, but two new studies from psychologists at Tufts and Harvard universities show that such "strategic colorblindness" can backfire. White participants studied a batch of photographs, then tried to deduce, as quickly as possible, which picture a black partner was holding by asking questions about each one in succession. Asking whether the person pictured was black or white would have sped up their performance, yet subjects—adults in one study and children as young as age 10 in the other—rarely mentioned race unless their partner did so first. Black observers who watched the recorded interactions perceived whites who avoided talking about race as more prejudiced than the intrepid few who acknowledged skin color. And blacks who watched silent video clips of the interactions even rated whites who avoided mentioning race as having more unfriendly nonverbal behavior. —Siri Carpenter



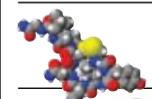
JUPITERIMAGES

Love in Neurochemistry

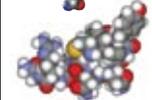
Key players in pair bonding, these molecules are also involved in a range of other, better-studied brain and body functions:



Dopamine: motor function; reward (from pleasurable stimuli such as food and sex)



Oxytocin: lactation and childbirth; feelings of trust and affection



Vasopressin: feelings of trust and affection; but helps to activate the brain's stress response, whereas oxytocin exerts a calming effect

which may explain why we feel romantic attachments so strongly. The same neurochemicals—oxytocin, vasopressin and dopamine—have been implicated in both relationships, and the behavioral patterns associated with parental and romantic bond formation and separation are also similar. “We think about parent-child relationships and adult romantic relationships as being fundamentally different,” Diamond explains, “but it really boils down to the same functional purpose: creating a psychological drive to be near the other person, to want to take care of them, and being resistant to being separated from them.”

Future studies about romantic attachment will focus on using the findings from research such as Young’s and Diamond’s to develop new treatments for grief associated with partner separation or loss and for disorders that involve social deficits, such as schizophrenia and autism. —Erica Westly

Marrying Mom?

A new study suggests that we prefer mates who resemble our opposite-sex parent. A Hungarian team found correlations of facial proportions between men and their partner’s father and between women and their partner’s mother. The

findings support a “sexual imprinting” hypothesis: children shape a mental template of their opposite-sex parent and search for a partner who looks like it. —Nicole Branan



>> SEX

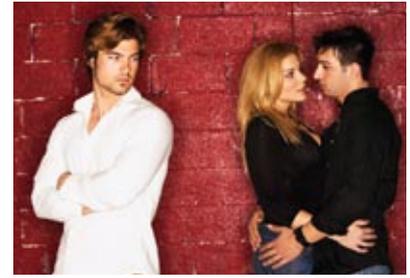
See No Beauty

Attractive faces hold no power over people in love

If your loved one claims to “only have eyes for you” this Valentine’s Day, it might be truer than you think. Research shows that people in a committed relationship who have been thinking about their partner actually avert their eyes from attractive members of the opposite sex without even being aware they are doing it.

Psychologist Jon Maner of Florida State University and his colleagues flashed pictures of faces on a computer screen for half a second, following it immediately with a square or circle, which participants had to identify by pushing the correct button. Earlier research using this method has found that it takes longer for viewers to shift their attention away from attractive faces of the opposite sex.

Maner, however, took subjects who were married or living together monogamously and asked half of them to write about feelings of love for their partner



and the other half to write about a happy experience. Those who wrote about love actually turned their attention away from attractive members of the opposite sex even more quickly than they looked away from average-looking people. Subjects who wrote about being happy, however, remained as distracted by a pretty face as ever.

This unconscious attentional bias probably evolved to help men and women stay in monogamous relationships, which in humans tend to have a reproductive advantage, Maner explains: “This whole research area is guided largely by an evolutionary perspective. These biases have been built into our psychology to enhance people’s reproductive success.”

—Kurt Kleiner

>> VISION

Seeing in Three Dimensions

Scientists unlock our brain’s ability to perceive depth



When we look at a photograph, we effortlessly identify people and objects—re-creating a three-dimensional scene in our mind from the two-dimensional image. As easy as that task seems, scientists have long puzzled over exactly how our brain does it; even the most powerful computers still struggle to pick 3-D objects out of 2-D images. Until now, most research has focused on the simpler neural representation of 2-D patterns, but a new

study shows for the first time that some neurons are also tuned to 3-D details.

The sheer number of possible 3-D shapes has made it hard to study how the brain processes them. A team headed by Charles Connor and Yukako Yamane, neuroscientists at Johns Hopkins University, sidestepped this problem by using a computer program that generated a series of shapes that evolved according to which items provoked the greatest response from certain neurons. They eventually pinpointed several neurons that each responded to specific 3-D configurations.

Object fragments such as projecting points or ridges elicited the greatest response. “Neurons carry very clear information for 3-D parts and for where those parts are relative to each other,” Connor says. The findings support a classical theory that the brain can comprehend objects as spatial combinations of 3-D parts rather than only learning to recognize objects from different 2-D perspectives. Connor notes, however, that the brain may still rely heavily on faster 2-D processing in situations that require rapid recognition. —Jeremy Hsu

Psychotherapy for the Poor

Innovative counseling programs in developing countries are repairing the psyches of civil war survivors and depressed mothers alike **BY MASON INMAN**

IT HAD BEEN FOUR YEARS since 13-year-old Mohamed Abdul escaped civil war in Somalia, but he still had nightmares and flashbacks. When he was nine years old, a crowd fleeing a street shooting trampled him, putting him in the hospital for two weeks. A month later he saw the aftermath of an apparent massacre: about 20 corpses floating in the ocean. Soon after, militiamen shot him in the leg, knocked him unconscious, then raped his best friend, a girl named Halimo.

Recovering in the hospital, Abdul (not his real name) was overwhelmed by fear—and guilt, for not having helped Halimo. He felt unprovoked fury: he mistook people he knew well for the rapist and threatened to kill them. A few months later Abdul fled his homeland and landed in the Nakivale refugee settlement in Uganda. “I felt as if there were two personalities living inside me,” he said at the time. “One was smart and kind and normal; the other one was crazy and violent.”

Abdul had post-traumatic stress disorder (PTSD), an ailment characterized by fear, hyperarousal and vivid replays of the traumatic event. Fortunately, this refugee camp had an extraordinary resource. Psychologist Frank Neuner of Bielefeld University in Germany was offering “narrative exposure therapy” to its 14,400 Africans, mostly Rwandans. The approach coaxes trauma survivors to assimilate their troubling memories into their life stories and thereby regain some emotional balance.

After four 60- to 90-minute therapy sessions, Abdul’s flashbacks and nightmares disappeared; he was still easily



Survivors of wars in nations such as Somalia often develop post-traumatic stress disorder.

started but no longer felt out of control. His doctors deemed him “cured.”

Researchers and aid workers have historically overlooked mental health in developing countries, focusing instead on issues such as malnutrition, disease and high infant mortality, but that is changing. “What’s changed in the past 10 years is the realization that mental health is not separate from general health,” explains child psychiatrist Atif Rahman of the University of Liverpool in England.

Recent psychotherapy trials have achieved remarkable success in improving the lives of war survivors such as Abdul, poor mothers with postpartum depression and others victimized by the

stresses of extreme poverty. The keys to a workable program for the impoverished include training ordinary citizens to be counselors and, in some cases, disguising the remedy as something other than a fix for emotional troubles.

Treating Trauma

Although many people think of mental illness as a plague of fast-paced modern life, some psychiatric ailments are actually more prevalent in the developing world, according to the World Health Organization. Of the several dozen wars and armed conflicts around the globe, nearly all are in developing countries, and this violence is leading to PTSD, which hinders recovery after the

(Researchers and aid workers have **historically overlooked** mental health in developing countries—but that is changing.)

CHRIS STEELE-PERKINS/Magnum Photos

Across South Asia, mothers suffer from **postpartum depression** more frequently than they do in richer countries.

conflicts subside. Across South Asia, new mothers suffer from depression more frequently than they do in richer countries, according to a 2003 report by Rahman and his colleagues.

People in underprivileged nations also experience more severe economic stresses. “This pileup of adversities is associated with low mental health,” says sociologist Ronald Kessler of Harvard Medical School. For individuals living on the edge of survival, the economic ramifications of a mental illness can be especially devastating. When someone has a major mental illness, “you’ve lost their labor and their input,” notes mental health researcher Paul Bolton of Johns Hopkins University.

To make up for the deficit of mental health care professionals in the developing world, Neuner and his team recruited refugees from the camp. Anybody who could read, write and be empathetic was a candidate. Because nearly one third of the Rwandan refugees and half of the Somalis suffered from PTSD, many of the would-be counselors needed to be treated first.

For a PTSD sufferer, distressing experiences are divorced from time or place and out of sync with the person’s life story. “Once these memories are activated, usually the interpretation of the brain of what’s happening is that there’s a danger right now, because the brain is not really aware that it’s just a memory,” Neuner points out. “We want to nail down this vivid emotional representation. We want to bring it where it belongs and connect it with your life history.”

Accordingly refugee therapists spent six weeks learning to help patients shape their lives into a coherent story, incorporating major traumas into the narrative. The strategy worked. Seventy percent of those who received the therapy no longer displayed significant PTSD symptoms at a nine-month follow-up assessment



In a trial in Pakistan, government health workers were trained to deliver psychotherapy to new mothers.

compared to a 37 percent recovery rate among a group of untreated refugees.

Empowering Mothers

In Rawalpindi, a largely rural district of Pakistan, nearly 30 percent of new mothers become depressed—about twice the rate in the developed world. In addition to its toll on mothers, postpartum depression can harm babies’ emotional and, in South Asia, physical development. Most of these women consider their symptoms the fate of poor folk or believe that they are caused by *tawiz*, or black magic. Many are anxious about talking about their problems

and being labeled as ill. What is more, Rawalpindi has only three psychiatrists for its more than 3.5 million residents.

To get around such stigmas and barriers, Rahman and his colleagues recruited government employees known as lady health workers to integrate mental health therapy into their home visits to mothers. Ordinarily, these workers visit homes 16 times a year to give advice on infant nutrition and child rearing.

A two-day course enabled these health workers to add mental health to their curriculum. Rahman’s approach is based on cognitive-behavior therapy, in which a counselor tries to correct distorted and negative ways of thinking either by discussing them openly or by suggesting more adaptive behaviors. If a mother said she could not afford to feed her baby healthful food, for example, the lady health worker would question that assumption and suggest incremental improvements to the baby’s diet. A year after giving birth, mothers given this psychologically sensitive advice showed half the rate of major depression of those who received traditional health visits. The strategy worked by empowering the women to solve problems, Rahman believes.

More efforts to bring psychiatry to the poor are under way, such as a trial in Pakistan in which community health workers help to ensure that schizophrenics take their medications. But the biggest hurdle is scaling up these treatments to meet the great need. **M**

MASON INMAN is a science and environmental journalist in Karachi, Pakistan.

(Further Reading)

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- ◆ **Treatment and Prevention of Mental Disorders in Low-Income and Middle-Income Countries.** Vikram Patel et al. in *Lancet*, Vol. 370, No. 9591, pages 991–1005; September 15, 2007.
- ◆ Both *Lancet* articles are available at www.globalmentalhealth.org
- ◆ The World Health Organization’s call to action on mental health: www.who.int/mental_health/mhgap/en/index.html

Measure More, Argue Less

One sign of progress in unraveling the mind-body problem is the development of new and ingenious ways to measure consciousness **BY CHRISTOF KOCH**



AT THE HEART OF SCIENCE are judicious observations and measurements. This reality presupposes that something can be measured. But how can consciousness—the notorious ineffable and ethereal stuff that can’t even be rigorously defined—be measured? Recent progress makes me optimistic.

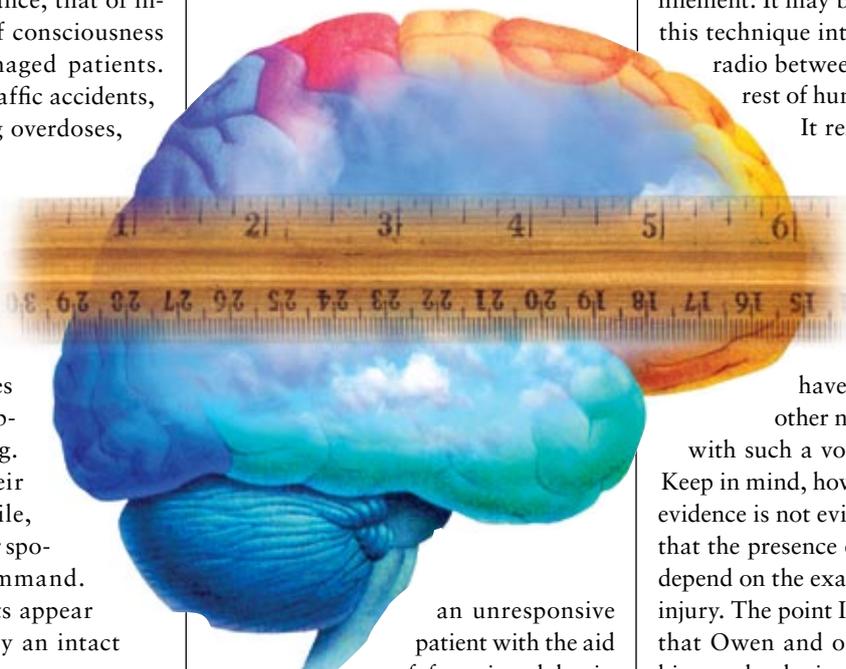
Consider a problem of great clinical, ethical and legal relevance, that of inferring the presence of consciousness in severely brain-damaged patients. Often the victims of traffic accidents, cardiac arrests or drug overdoses, such patients have periods when they are awake, and they may spontaneously open their eyes. On occasion, their head turns in response to a loud noise, or their eyes might briefly track an object, but never for long. They might grind their teeth, swallow or smile, but such activities occur sporadically, not on command. These fragmentary acts appear reflexlike, generated by an intact brain stem.

As many as 25,000 such “vegetative” patients in hospices and nursing homes hover for years in this limbo, at a steep emotional and financial cost. The extent of the damage and the persistent absence of purposeful behavior usually leave little doubt that consciousness has fled the body for good. Terri Schiavo was such a case, alive but unconscious for 15 years before her court-ordered death in 2005 in Florida.

Even worse, though, is the possibility that some of these patients may experience some remnants of consciousness, unable to communicate their feelings of discomfort or pain, agonizing

thoughts or poignant memories to the outside world. Until recently, nothing could be done to diagnose when an awake mind was entombed inside a damaged brain.

Technology has come to the rescue with the demonstration—by Adrian M. Owen and his research group at the University of Cambridge—of awareness in



an unresponsive patient with the aid of functional brain imaging. The patient, a young woman who sustained massive head injury as a result of a car accident, fulfilled all criteria for the vegetative state. In particular, she was unable to signal with her eyes or hands in response to commands. Owen placed the noncommunicative patient in a magnetic scanner and asked her to imagine playing tennis or to imagine visiting the rooms in her house. You and I have no trouble doing these tasks. In healthy volunteers given these instructions, regions of the brain involved in motor planning, spatial navigation and imagery light up. They did likewise in the unfortunate woman. Her brain ac-

tivity in various regions far outlasted the briefly spoken words and in their specificity cannot be attributed to a brain reflex. The pattern of activity appeared quite willful, indicating that the patient was, at least occasionally, conscious but unable to signal this fact, more effectively cut off from her loved ones than any prisoner in solitary confinement. It may be possible to develop this technique into a kind of two-way radio between the patient and the rest of humankind.

It remains an open question how prevalent such a tragic condition—aware yet utterly uncommunicative—is. Brain scans of 17 vegetative patients have turned up only one other non-responsive patient with such a voluntary brain signal. Keep in mind, however, that absence of evidence is not evidence of absence and that the presence of consciousness will depend on the exact nature of the brain injury. The point I want to emphasize is that Owen and other researchers like him are developing scanning tools to spot consciousness without any external behavior.

Betting on Consciousness

The ultimate judge of any conscious feeling is the subject itself. This truism is used in everyday life: Can you see the angry face? Well, if you can’t, then you’re not conscious of it. This seductively simple strategy has drawbacks; in particular, people disagree on what exactly “consciously seeing” is if the face was only briefly flashed on a computer display screen. (*Did you see any part of a face? Did you think you saw something like a face?*) To get around this problem,

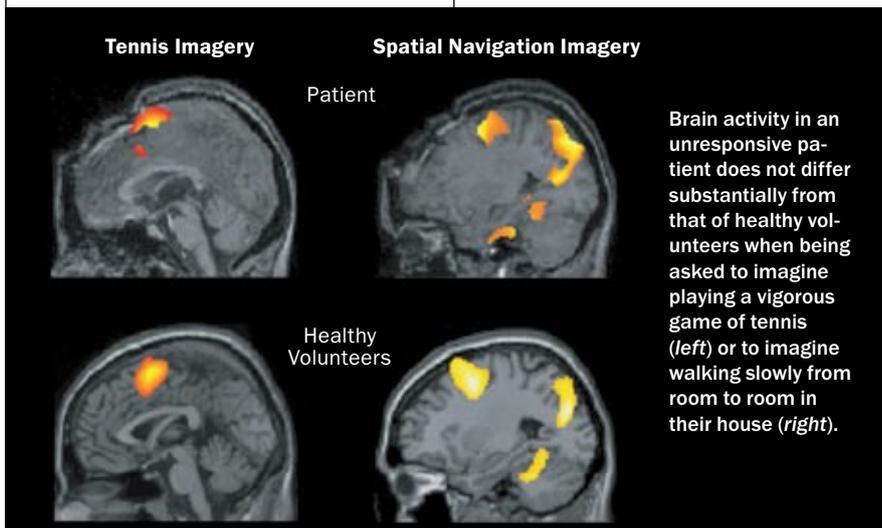
FATMA KONUSKAN (Koch); VICTOR DE SCHWANBERG SPL/Photo Researchers, Inc. (brain); NANCY NEHRING iStockphoto (ruler)

I have no doubt that **science will develop** better consciousness meters in the future.

neuropsychologists Navindra Persaud, Peter McLeod and Alan Cowey of the University of Oxford exploit gambling.

Their research is based on the insight, backed up by a philosophical theory of consciousness called higher-order thought, that when you are conscious of something, you can confidently judge what you saw. Say you come to my lab and I show you a number of fake six-letter words such as XTNVMT and ask you to remember as much about them as possible. After you have seen these training words, I tell you that they are actually generated by some fixed rules (for example, that an X is always followed by a T). Next, I show you similar nonsense words you have not seen before, and you have to judge whether you think each test word obeys the same unknown rules as do the training words you have just seen. It is well known that you will do much better than chance even though you feel that you are guessing. You are not conscious of the grammatical rules, yet something in your brain knows whether or not the test words follow the rules, without you feeling confident about this knowledge.

Persaud and his colleagues varied this game in a very clever way, relying on people's instinct to make money. In this variant, every time you decide whether or not the word follows the unknown rule you bet either \$1 or \$2 on your decision. If you're right, you get to keep the money, and if you're wrong, you lose it. You clearly should wager high if you are confident that the six-letter word either follows or does not follow the rule. The Oxford volunteers confounded these expectations. In most trials they made the correct choices, but they placed low wagers. The volunteers thus failed to convert their above-chance performance on the yes-no decisions into money. Their failure to reap a profit despite performing better than expected by pure guessing indicates that the subjects were using unconscious



Brain activity in an unresponsive patient does not differ substantially from that of healthy volunteers when being asked to imagine playing a vigorous game of tennis (left) or to imagine walking slowly from room to room in their house (right).

processing. One advantage of the wagering measure is that it does not force subjects to focus their consciousness on what they are conscious of, in the process perturbing the very phenomenon that scientists wish to measure.

Ironically, the leitmotif of Western philosophy since the days of Apollo's temple at Delphi, "know thyself," could have been put to pecuniary use if subjects would have learned to trust their gut instincts and bet on something about which they were not yet conscious. I leave it to others to figure out whether such unconscious thought patterns have contributed to the abysmal state of the financial markets and our retirement accounts.

Instead of arguing with people about whether or not they are conscious of grammatical rules or when these rules are violated, wagering means that we can study consciousness without hav-

ing an agreed-on formal definition of consciousness.

Both the brain-based measure and the wagering technique are far from ideal instruments to infer the presence or absence of feelings in any creature, whether healthy human adult or baby, monkey or bee. The situation is a bit analogous to detecting a black hole. You can't see it directly, as it sucks up all matter and all radiation. Yet its position can be inferred by the gravitational effect it exerts on nearby stars. I have no doubt that science will develop better consciousness meters. And herein lies progress, for what can be measured has a much better chance of being understood by us than does something that can only be argued about. Hence the motto of this essay. **M**

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

(Further Reading)

- ◆ **Detecting Awareness in the Vegetative State.** Adrian M. Owen et al. in *Science*, Vol. 313, page 1402; September 8, 2006.
- ◆ **Post-decision Wagering Objectively Measures Awareness.** Navindra Persaud, Peter McLeod and Alan Cowey in *Nature Neuroscience*, Vol. 10, No. 2, pages 257-261; February 2007.
- ◆ **Measuring Consciousness: Relating Behavioural and Neurophysiological Approaches.** Anil K. Seth et al. in *Trends in Cognitive Sciences*, Vol. 12, No. 8, pages 314-321; August 2008.

Half a World

Victims of a disorder called neglect just don't get the whole picture

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

A PATIENT NAMED SALLY recently suffered a stroke that damaged her right parietal lobe without affecting other parts of the brain. The left side of her body—controlled by the right hemisphere—was paralyzed. But she was mentally normal and continued to remain the talkative, intelligent woman that she was before the stroke.

Yet Sally's father observed other disturbing symptoms to which—oddly enough—Sally herself seemed oblivious. When she attempted to move around the room in her wheelchair, she would sometimes bump into objects on her left.

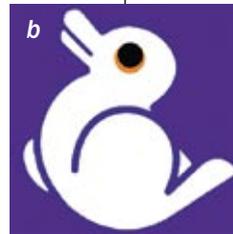
Further testing confirmed that Sally was largely indifferent to objects and events on her left, even though she was not blind to them; once her attention was drawn to them, she could see them. Her eyesight was normal; her problem was in *attending* to the left. For example, when she ate, she would consume only the food on the right (a), ignoring the left side of the plate. But if her attention was drawn to the food on the left, Sally could see it perfectly, recognize it and reach for it. Sally's deficits indicate that she suffers from hemineglect (or simply neglect), which can also occur in isolated form, unaccompanied by major paralysis.

Seeds of Neglect

How do such perturbations of perception arise? Neglect is, fundamentally, a disorder of attention. Although the hu-



man brain has 100 billion neurons, only a small subset of them can be active at any time creating meaningful patterns, and this limit results in an attentional bottleneck. That is why you can see either a duck or a rabbit in *b* but never both simultaneously. It also explains why when you are driving, you are not consciously aware of most things going on around you while you focus on the pedestrian in front of you. Seen in this light, the neurological syndrome of neglect is really a floridly exaggerated version of the kind of



neglect we all engage in to avoid sensory overload.

To understand neglect, we need to consider some anatomy. Visual input from the retina is sent along the optic nerve and diverges into two parallel pathways called the “old” and the “new,” reflecting when each evolved. The former, sometimes called the “where” pathway, projects into the parietal lobes and is involved in locating and orienting to things around you. The latter projects to the visual cortex, and from there two other pathways emerge called “what” and “how,” which project into the temporal and parietal lobes, respectively. The what pathway is involved in object recognition and identification, whereas the how pathway directs how to attend to and interact with objects. The how and where pathways converge

on the parietal cortex and are functionally linked—you must process both where a chair is and how to move to avoid bumping into it. Sally had damage to the how pathway in her right hemisphere, so she was ignoring everything on her left side.

Curiously, neglect is seen only with damage to the right brain. Why doesn't left damage result in neglect of the right half of the world? Marsel Mesulam of Harvard University proposed an ingenious explanation. The right hemisphere, which

(Sally was indifferent to **objects and events** on her left, even though she was not blind to them.)

(We should think of it as an **existential annihilation** of the left side of the universe.)



has more attentional resources and a preeminent role in spatial vision, can survey the entire visual scene, both right and left hemifields, simultaneously. The left parietal, in contrast, can attend to only the right side of the world. So when the left hemisphere is damaged, the right can compensate. If the right parietal is damaged, however, the left visual field is unattended; in other words, unilateral neglect occurs.

It is fairly easy to diagnose neglect. The patient will tend to look rightward constantly and will not spontaneously look left even if a person approaches from that direction. When tracking an object moving from right to left, she will “lose” the object halfway through its excursion—not following it leftward past her nose. She applies makeup only on the right side of her face. A male patient will shave only his right chin. Or brush only the teeth on the right.

You can also diagnose neglect with some simple tests. Have the subject copy or draw from memory a flower or other object, and she will draw only half of it (c). Strangely, this half-drawing effect is true even if she works with her eyes closed, implying that she is even neglecting the left half of the object that she

conjugates in her head. (Our colleague Stuart Anstis has requested that if he ever develops neglect from stroke, we ensure his Botox series continues on both sides of his face!)

When asked to draw a clock, the patient draws only half of it. The entire circle is drawn—partly because this is an overlearned “ballistic” response that does not require focused attention. But she packs the 1 to 12 on the right half of the clock (d) or inserts only 1 to 6.

Ask her to bisect a horizontal line; her bisector is way off to the right because she is bisecting the right half of the line. Now you might think that if the horizontal line is moved entirely into her right (nonneglected) side, she would bisect it accurately. But she does not. Even if her plate of food is moved entirely into her nonneglected right visual field, she continues to eat the food only on the right side of the plate. In addition to neglecting the left side of her visual world, she neglects the left sides of objects even if they are entirely on her right.

There is no sharp line going down the center of the visual field separating the neglected left and the nonneglected right. We should think, instead, in terms of a gradient of neglect. This effect is different from what one sees when the right visual cortex—rather than right parietal lobe—is damaged. In this case, the result is a sharp boundary between the blind region on the left and the intact right region of the visual field. And of course, the subject cannot see objects on her left even if she is forced to “attend” to the blind region. She can no more see these items than she can see behind her head.

Annihilation of the Left

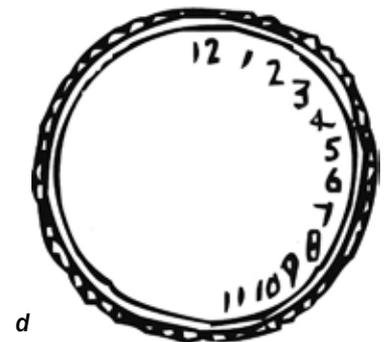
A curious aspect of neglect is that the patient is largely unaware of it. He neglects the neglect! At some level, he may be dimly aware that something is wrong, telling us he “needs glasses.”

Sally’s obliviousness to her neglect

suggests yet again that what she has is not merely a sensory deficit or blindness to visual input coming from her left nor even just a failure to attend to the left. We should think of it instead as an existential annihilation of the left side of the universe. For her, “left” has simply ceased to exist. Maybe she even has problems with abstract ideas or words that require the use of the word “left,” but we have not tested this idea.

Extraordinarily, neglect patients may be even unaware of the paralysis of their left arm, a condition called anosognosia. When we asked Sally to touch her nose with the nonparalyzed right hand, she did so. When asked if she could move her left hand, she said, “Yes, I can move it fine.” But when we then asked her to touch her nose with her left hand, she promptly grabbed the lifeless left hand with her right and raised it toward her face using it as a “tool” to touch her nose! Clearly, even though “she” (the conscious person) was unaware of the paralysis, some part of the brain “knew” the left arm was paralyzed. Why else would she unhesitatingly grab it and raise it toward her nose?

The inadvertent humor of her response was lost on her. Bear in mind that in every other respect she was completely lucid, intelligent and articulate. The full implications of neglect were brought home to us even more vividly when we hung a two-foot-by-two-foot mirror on the wall to her right. When she turned her head to the right to look in the mir-



Recognizing a mirror image as a mirror image requires a peculiar **dual representation** in the brain.



ror, she saw her face and, of course, reflections of objects on her left that she had been neglecting. She “knew” she was looking at her face in the mirror. But our question was, Would the mirror “correct” her neglect by making it obvious to her that there was a whole world on the left that she had been ignoring?

We asked a student to stand on her left holding a pen so Sally could see the reflection of the pen in the mirror on her right (and she said she could). We then asked Sally to take the pen with her (non-paralyzed) right hand and write her name on a notepad on her lap. Imagine our astonishment when Sally reached straight toward the mirror and attempted to grab the reflection! When asked where the pen was, she replied with frustration: “The pen is inside the darned mirror, doctor.” On other occasions, she reached behind the mirror, groping for the pen, insisting that “the pen is behind the mirror.” It was as though her brain were saying, “This is a mirror reflection, so the pen is on my left. But left doesn’t exist in my universe,

so the pen must be *in* the mirror. That is the only ‘solution’ to the problem.”

What is surprising is the illusion’s resistance to intellectual correction. Her high-level knowledge about mirrors and what they do cannot correct her behavior even after repeated failed attempts to grab the pen. Indeed, it is the other way around: her knowledge of mirror optics has been warped to accommodate the strange sensory world she is now trapped in (to the extent of rationalizing her action by saying things such as “The pen is inside the darned mirror, doctor”). We have dubbed this new neurological disorder (or “sign”) mirror agnosia.

Hope for Recovery?

Mirror agnosia is unlikely to be a deficit that is restricted to mirrors. In fact, we have seen patients recover temporarily

from neglect (by irrigating the ear with cold water) but continue to reach for the pen in the mirror. We should regard it as a specific—if dramatic—manifestation of a more general disorder: an inability to deal with complex spatial relations caused by the right parietal damage. Recognizing a mirror image as a mirror image requires a peculiar dual representation in the brain: a mirage superimposed on reality (*e*). With a damaged right parietal lobe, Sally’s brain cannot handle this peculiar juxtaposition. Even a four-year-old child or an orangutan rarely confuses a mirror image of a banana for the real thing, but the older, wiser Sally does, despite her lifetime experience with mirrors.

Neglect is a common clinical problem. It is frustrating to therapists who try to educate the use of the left arm during the critical window of the first few weeks after a stroke; the patient’s indifference to her left side becomes an impediment to therapy. We found that with repeated coaxing, Sally would start reaching for the pen on the left, but when we came back after a few hours the mirror agnosia returned. Would repeated training sessions, spread over several days, finally correct her mirror agnosia? Would it get rid of the neglect entirely? This cure remains to be seen.

What is clear for now, though, is that studying patients with Sally’s deficits can give us valuable insight into how the brain constructs reality. **M**

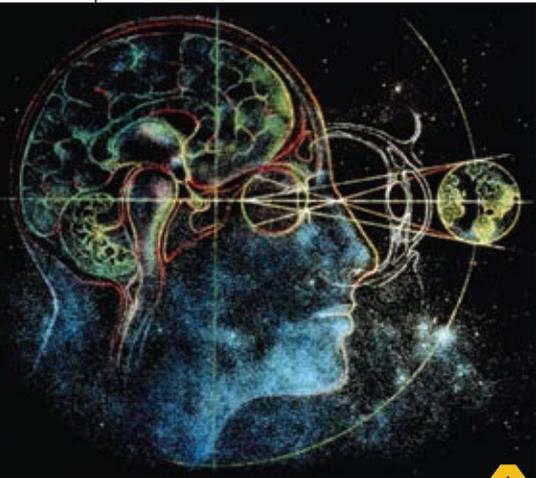
VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN collaborate on studies of visual perception at the Center for Brain and Cognition at the University of California, San Diego. They serve as members of the board of advisers for *Scientific American Mind*.

(Further Reading)

- ◆ **Can Mirrors Alleviate Visual Hemineglect?** Vilayanur S. Ramachandran et al. in *Medical Hypotheses*, Vol. 52, No. 4, pages 303–305; April 1999.

(calendar)

February



9–10 Scientific advancement often requires thinking outside the box. At the **Subjectivity, Creativity and the Institution** conference, experts in sociology, anthropology, history and education, among other disciplines, will discuss how tradition and modernity interact to shape the creative process.
Perth, Australia
<http://subjectivitycreativityandtheinstitution.com>

14 Meanwhile, on the other side of the globe, you can home in on creativity's role in science. In a roundtable discussion on **Creative Ambiguity in Scientific and Humanistic Thought**, panelists including Rockefeller University neuroscientist Donald Pfaff and Pulitzer Prize-winning poet C. K. Williams will explore how the imaginative process enriches both science and the humanities.
New York City
<http://philoctetes.org/Calendar>

14 **Valentine's Day**, 1903: Swiss psychiatrist **Carl Jung** marries psychoanalyst Emma Rauschenbach in a grand expression of his symbolist philosophy. Jung theorized that people share a common set of unconscious archetypes that are represented symbolically in art, religion and dreams. Jung went on to have an enduring influence on psychology—his terms “introvert” and “extrovert” are still in popular use today.

24–28 Stressed out? Lighten your load with two conferences in one. Find out how stressors such as sleep deprivation affect decision making and other aspects of performance at the first half of the **National Conference on the Neural and Physiological Effects of Stress on Performance**, sponsored by the University of Texas at Austin. Then check out two days devoted to stress's effects on language, hosted by the University of Maryland.
College Park, Md.
www.csit.utexas.edu/conference2009

March

10 Children decide the winning research projects at the **Kids Judge! Neuroscience Fair**. In this “reverse science fair,” Washington State University students will present their work to fifth graders from local schools. The aspiring scientists learn to communicate their ideas clearly while sparking the young judges' interest in brain science. The fair is associated with **Brain Awareness Week**, March 16–22, during which institutions all over the world host brain education events. For a calendar of activities, visit <http://brainweek.dana.org>
Pullman, Wash.
www.vetmed.wsu.edu/depts-vcapp/BAW

Ongoing

Get to know your most mysterious organ at **BRAIN: The World Inside Your Head**. This traveling exhibit sponsored by Pfizer encourages kids (and adults) to walk inside a giant model of the brain, perform simulated brain surgery and experience phantom limb syndrome. Meet your brain at the Strategic Air and Space Museum through May 3.
Ashland, Neb.
www.strategicairandspace.com



The Sound of Science



The field of “neuro-music” is growing exponentially as more and more researchers become engrossed in the mysteries of music and the brain. Hear about their latest findings—and some tunes—at these upcoming events:

March 6

From neuroscience, a new kind of composition: musicians at the University of Southern California's Thornton School of Music perform “Self Comes to Mind,” created by U.S.C. neuroscientist Antonio R. Damasio and composer Bruce Adolphe, a lecturer at the Chamber Music Society of Lincoln Center. This work for cello and percussion is based on a poetic narrative of how consciousness develops. In 2009 cellist Yo-Yo Ma will premiere the piece in New York City.
Los Angeles
<http://web-app.usc.edu/ws/ea2/calendar/113/event/866416>

March 13

“Halt or I'll Play Vivaldi!” Although the lecture's title is tongue-in-cheek, criminologist Jacqueline Helfgott and musician Norman Middleton, both at Seattle University, will take a serious look at the use of classical music to discourage crime. The talk, which is part of a two-year lecture series at the Library of Congress entitled Music and the Brain, will be followed by a concert.
Washington, D.C.
www.loc.gov/today/pr/2008/08-176.html

March 27–29

Rice University brings together composers and neuroscientists for a conference about the effects of music on our thinking and behavior. Exploring the Mind through Music will include such speakers as neuroscientist Mark Tramo, director of the Institute for Music and Brain Science at Harvard Medical School, and award-winning Columbia University composer Fred Lerdahl.
Houston
<http://culture.rice.edu/conferences.html>

The Serious Need for Play

Free, imaginative play is crucial for normal social, emotional and cognitive development. It makes us better adjusted, smarter and less stressed

By Melinda Wenner





O

n August 1, 1966, the day psychiatrist Stuart Brown started his assistant professorship at the Baylor College of Medicine in Houston, 25-year-old Charles Whitman climbed to the top of the University of Texas Tower on the Austin campus and shot 46 people. Whitman, an engineering student and a former U.S. Marine sharpshooter, was the last person anyone expected to go on a killing spree. After Brown was assigned as the state's consulting psychiatrist to investigate the incident and later, when he interviewed 26 convicted Texas murderers for a small pilot study, he discovered that most of the killers, including Whitman, shared two things in common: they were from abusive families, and they never played as kids.

Brown did not know which factor was more important. But in the 42 years since, he has interviewed some 6,000 people about their childhoods, and his data suggest that a lack of opportunities for unstructured, imaginative play can keep children from growing into happy, well-adjusted adults. "Free play," as scientists call it, is critical for becoming socially adept, coping with stress and building cognitive skills such as problem solving. Research into animal behavior confirms play's benefits and establishes its evolutionary importance: ultimately, play may provide animals (including humans) with skills that will help them survive and reproduce.



When animals play, their body language signals that any nipping or tumbling is meant to be friendly and fun. Play similarly teaches kids to better communicate with one another.

Most psychologists agree that play affords benefits that last through adulthood, but they do not always agree on the extent to which a lack of play harms kids—particularly because, in the past, few children grew up without ample frolicking time. But today free play may be losing its standing as a staple of youth. According to a paper published in 2005 in the *Archives of Pediatrics & Adolescent Medicine*, children’s free-play time dropped by a quarter between 1981 and 1997. Concerned about getting their kids into the right colleges, parents are sacrificing playtime for more structured activities. As early as preschool, youngsters’ after-school

hours are now being filled with music lessons and sports—reducing time for the type of imaginative and rambunctious cavorting that fosters creativity and cooperation.

A handful of studies support Brown’s conviction that a play-deprived childhood disrupts normal social, emotional and cognitive development in humans and animals. He and other psychologists worry that limiting free play in kids may result in a generation of anxious, unhappy and socially maladjusted adults. “The consequence of a life that is seriously play-deprived is serious stuff,” Brown says. But it is never too late to start: play also promotes the

continued mental and physical well-being of adults [see box on page 27].

Worries over the demise of play began surfacing as far back as 1961, when the International Play Association was founded in Denmark to protect, preserve and promote play as a fundamental right for all children. But the idea became more popular a little over a decade ago, when many more nonprofit foundations—such as the National Institute for Play in Carmel Valley, Calif., started by Brown, and other organizations, including the Alliance for Childhood and the Association for the Study of Play—began forming around the globe to promote the value of play and to raise concerns over its demise.

Freedom Counts

But kids *play* soccer, Scrabble and the sousaphone—so why are experts concerned that these games and more structured activities are eating into free play? Certainly games with rules are fun and sources of learning experiences—they may foster better social skills and group cohesion, for instance, says Anthony D. Pellegrini, an educational psychologist at the University of Minnesota. But, Pellegrini explains, “games have a priori rules—set up in advance and followed. Play, on the other hand, does not have a priori rules, so it affords more creative responses.”

This creative aspect is key because it challenges the developing brain more than following predetermined rules does. In free play, kids use their imagination and try out new activities and roles.

The child initiates and creates free play. It might involve fantasies—such as pretending to be doctors or princesses or playing house—or it might include mock fighting, as when kids (primarily boys) wrestle and tumble with one another for fun, switching roles periodically so that neither of them always wins. And free play is most similar to play seen in the animal kingdom, suggesting that it has important evolutionary roots. Gordon M. Burghardt, author of *The Genesis of Animal Play*,

FAST FACTS

Go Ahead, Horse Around

- 1>> Childhood play is crucial for social, emotional and cognitive development.
- 2>> Imaginative and rambunctious “free play,” as opposed to games or structured activities, is the most essential type.
- 3>> Kids and animals that do not play when they are young may grow into anxious, socially maladjusted adults.

PRECEDING PAGES: AARON GOODMAN (man with toy blocks); BLOCKS COURTESY OF FAO SCHWARTZ; THIS PAGE: JUPITER IMAGES



Dressing up and pretending to be someone else is a type of “free play,” as psychologists call it—the unstructured, imaginative fun that is most challenging to the developing brain.

spent 18 years observing animals to learn how to define play: it must be repetitive—an animal that nudges a new object just once is not playing with it—and it must be voluntary and initiated in a relaxed setting. Animals and children do not play when they are undernourished or in stressful situations. Most essential, the activity should not have an obvious function in the context in which it is observed—meaning that it has, essentially, no clear goal.

Face Time

How do these seemingly pointless activities benefit kids? Perhaps most crucially, play appears to help us develop strong social skills. “You don’t become socially competent via teachers

telling you how to behave,” Pellegrini says. “You learn those skills by interacting with your peers, learning what’s acceptable, what’s not acceptable.” Children learn to be fair and take turns—they cannot always demand to be the fairy queen, or soon they have no playmates. “They want this thing to keep going, so they’re willing to go the extra mile” to accommodate others’ desires, he explains. Because kids enjoy the activity, they do not give up as easily in the face of frustration as they might on, say, a math problem—which helps them develop persistence and negotiating abilities.

Keeping things friendly requires a fair bit of communication—arguably the most valuable social skill of all. Play

Studies show that children use more sophisticated language when playing with other children than when playing with adults. They have to provide contextual clues.

that transpires with peers is the most important in this regard. Studies show that children use more sophisticated language when playing with other children than when playing with adults. In pretend play, for instance, “they have to communicate about something that’s not physically present, so they have to use complicated language in such a way that they can communicate to their peer what it is that they’re trying to say,” Pellegrini explains. For example, kids



can’t get away with just asking, “Vanilla or chocolate?” as they hand a friend an imaginary cone. They have to provide contextual clues: “Vanilla or chocolate ice cream: Which one would you like?” Adults, on the other hand, fill in the blanks themselves, making things easier for kids.

If play helps children become social-

ized, then lack of play should impede social development—and studies suggest that it does. According to a 1997 study of children living in poverty and at high risk of school failure, published by the High/Scope Educational Research Foundation in Ypsilanti, Mich., kids who enrolled in play-oriented preschools are more socially adjusted later in life than are kids who attended play-free preschools where they were constantly instructed by teachers. By age 23, more than one third of kids who had attended instruction-oriented preschools had been arrested for a felony as compared with fewer than one tenth of the kids who had been in play-oriented preschools. And as adults, fewer than 7 percent of the play-oriented preschool attendees had ever been suspended from work, but more than a quarter of the directly instructed kids had.

Animal studies lend support to the idea that play deprivation leads to poor social skills. According to a study published in 1999 in *Behavioural Brain Research*, rats that are kept isolated during the two weeks of development when they most frequently play—the fourth and fifth weeks after birth—are much

less socially active when they later encounter other rats as compared with rats that are not isolated during the same two-week period. And a study published in *Developmental Psychobiology* in 2002 revealed that male rats reared in isolation during their youth fail to display normal avoidance behaviors when introduced to dominant male rats that repeatedly attack them. Could play deprivation specifically cause these behav-

By age 23, more than one third of kids who had gone to play-free preschools had been arrested for a felony as compared with fewer than one tenth of play-oriented preschool alums.

ioral problems—or could social isolation in general have been the culprit?

Another study suggests that play promotes neural development in “higher” brain areas involved in emotional reactions and social learning. Scientists reported in 2003 that play fighting releases brain-derived neurotrophic factor (BDNF)—a protein that stimulates the growth of new neurons—in these regions. The researchers allowed 13 control rats to play freely with companions for three and a half days and kept 14 other rats isolated for the same period. On examining the rats’ brains, the researchers found that the cortex, hippocampus, amygdala and pons of the rats that had played contained much higher levels of BDNF than those of the rats that had not. “I think play is the major mechanism whereby higher regions of the brain get socialized,” says Washington State University neuroscientist Jaak Panksepp, who co-authored the study.

Stress Relief

Research suggests that play is also critical for emotional health, possibly because it helps kids work through



Many children (especially boys) like to engage in mock fighting, or rough-and-tumble play. By constantly alternating who is “winning” the fight, they learn give-and-take and other social skills. Such roughhousing has even been shown to improve creativity and problem-solving abilities.

JUPITERIMAGES

anxiety and stress. In a 1984 study published in the *Journal of Child Psychology and Psychiatry*, researchers assessed the anxiety levels of 74 three- and four-year-old children on their first day of preschool as indicated by their behavior—whether they pleaded, whined and begged their parents to stay—and how much their palms were sweating. Based on the researchers' observations, they labeled each child as either anxious or not anxious. They then randomly split the 74 kids into four groups. Half of the kids were escorted to rooms full of toys, where they played either alone or with peers for 15 minutes; the other half were told to sit at a small table either alone or with peers and listen to a teacher tell a story for 15 minutes.

Afterward, the kids' levels of distress were assessed again. The anxiety levels of the anxious kids who had played had dropped by more than twice as much as compared with the anxious kids who had listened to the story. (The kids who were not anxious to begin with stayed about the same.) Interestingly, those who played alone calmed down more than the ones who played with peers. The researchers speculate that through imaginative play, which is most easily initiated alone, children build fantasies that help them cope with difficult situations.

Animal studies also support the idea that play helps to alleviate stress—a concept known in neuroscience as social buffering. In a study published in 2008, Gettysburg College neuroscientist Stephen Siviy put rats into a chamber by themselves and exposed them to a collar previously worn by a cat, which made them visibly anxious. Later, the chamber was cleaned so it no longer smelled of the cat, the rats were put back in without the cat collar, and the rats immediately became anxious again,

(The Author)

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All Work and No Play ...

Although researchers usually emphasize the positive effect of play on the developing brain, they have found that play is important for adults, too. Without play, adults may end up getting burned out from the “hustle-bustle busyness that we all get involved in,” says Marc Bekoff, an evolutionary biologist at the University of Colorado at Boulder. Adults who do not play may end up unhappy and exhausted without understanding exactly why.

So how can adults get more play into their lives? Stuart Brown, psychiatrist and founder of the National Institute for Play in Carmel Valley, Calif., suggests three ways:

>>Body play

Participate in some form of active movement that has no time pressures or expected outcome (if you are exercising just to burn fat, that is not play!).

>>Object play

Use your hands to create something you enjoy (it can be anything; again, there doesn't have to be a specific goal).

>>Social play

Join other people in seemingly purposeless social activities, “from small talk to verbal jousting,” Brown suggests.

If you are still not sure what to do, try to remember what you enjoyed doing as a child. “Find your childhood play's ‘true north’” and try to translate those memories into activities that fit the current circumstances, Brown says. You might even spark your memory better if you spend a little time around kids, notes Gordon M. Burghardt, an evolutionary biologist at the University of Tennessee.

Ultimately, what matters is not *how* you play but *that* you play. And to make sure you do, schedule time in your day for it, Bekoff suggests. “Work will always get done,” he says. “In fact, I know that if I don't play, I really don't get more work done.” And, Burghardt adds, the happiness and renewed energy you will experience from playing will “more than compensate for the time ‘lost.’” —M.W.

probably because they associated the space with the cat. But if Siviy and his colleagues then introduced another rat into the chamber—one that had never been exposed to the cat collar and was not afraid—the two would begin playing by chasing each other, tumbling and pretend fighting. And shortly there-

lasted 10 minutes. Immediately afterward, the researchers asked the children to come up with ideas for how one of the objects could be used. The kids who had played with the objects named, on average, three times as many nonstandard, creative uses for the objects than the youths in either of the other two groups

something—so does play precede those sorts of skills—or is it merely practice or consolidation of skills that are already developing?” he asks. Although no one knows, “either way, at some level, it would be beneficial,” he concludes.

Does lack of play, then, impede the development of problem-solving skills?



One study found that kids who played with blocks scored higher on language tests than kids who had no blocks. Perhaps the children with blocks simply spent less time on unproductive activities such as watching TV—but the end result was good for them in any case.

after, the first rat would relax and become calm, suggesting that play helped the rat to lessen its anxiety.

Play to the Head of the Class

Relieving stress and building social skills may seem to be obvious benefits of play. But research hints at a third, more counterintuitive area of influence: play actually appears to make kids smarter. In a classic study published in *Developmental Psychology* in 1973, researchers divided 90 preschool children into three groups. One group was told to play freely with four common objects—among the choices were a pile of paper towels, a screwdriver, a wooden board and a pile of paper clips. A second set was asked to imitate an experimenter using the four objects in common ways. The last group was told to sit at a table and draw whatever they wanted, without ever seeing the objects. Each scenario

did, suggesting that play fosters creative thinking.

Play fighting also improves problem solving. According to a paper published by Pellegrini in 1989, the more elementary school boys engaged in roughhousing, the better they scored on a test of social problem solving. During the test, researchers presented kids with five pictures of a child trying to get a toy from a peer and five pictures of a child trying to avoid being reprimanded by his mother. The subjects were then asked to come up with as many possible solutions to each social problem; their score was based on the variety of strategies they mentioned, and children who play-fought regularly tended to score much better.

Pellegrini does question, however, how much cause and effect one can glean from these studies. “What does play do? Is it the vanguard of learning

Through play, animals learn to try new things. Animals that do not play simply do not acquire this same behavioral flexibility.

Perhaps, according to animal studies. In a paper published in *Developmental Psychobiology* in 1978, experimenters separated young rats by mesh partitions—they could see, smell and hear other rats but could not play with them—for the 20 days during development when they would have most frequently played. The researchers taught these rats, and a group that had been allowed to play without constraints, to pull a rubber ball out of the way to get a food treat. A few days later they switched the setup so the rats would have to push the same ball to get the treat. The isolated rats took much longer to try new approaches, and thus solve the problem, than did the rats that had played. The authors speculate that through play, animals learn to try new things, and animals that do not play simply do not acquire this same behavioral flexibility.

Playing also appears to help with language development, according to a 2007 study in the *Archives of Pediatrics & Adolescent Medicine*. Research-

ers at the University of Washington gave a box of toy blocks to children from middle- and low-income families aged 18 months to two and a half years. Parents of these kids, as well as parents of a similar group of kids who had no blocks, kept track of how often the children played. After six months, the kids who had played with blocks scored sig-

the absence of play, children miss learning experiences.”

Let Loose

If play is so crucial, what happens to children who are not playing enough? Ultimately, no one knows—but many psychologists are worried. Because play is somewhat risky—animals that are

ing—still engage in normal play, which suggests that play motivation comes from the brain stem, a structure that precedes the evolution of mammals. “This means that the core, genetically-provided circuitry for play is situated in very ancient regions of the brain,” explains Panksepp, who led the experiment in 1994.

Of course, many parents today believe they are acting in their kids’ best interests when they swap free play for what they see as valuable learning activities. Some mothers and fathers may also hesitate to let their kids play outside unattended, and they may fret about the possibility of the scrapes and broken bones that sometimes arise during play fighting or rambunctious fantasy play, says Sergio M. Pellis, a behavioral neuroscientist at the University of Lethbridge in Alberta. Although those instincts are natural, protecting kids “simply defrays those costs to later, when those same children will have difficulty in dealing with an unpredictable, complex world,” Pellis says. “A child who has had a rich exposure to social play experiences is more likely to become an adult who can manage unpredictable social situations.”

Parents should let children be children—not just because it should be fun to be a child but because denying youth’s unfettered joys keeps kids from developing into inquisitive, creative creatures, Elkind warns. “Play has to be reframed and seen not as an opposite to work but rather as a complement,” he says. “Curiosity, imagination and creativity are like muscles: if you don’t use them, you lose them.” **M**



Far from engaging in mindless destruction, children who explore everyday objects by playing with them in unusual (albeit occasionally messy) ways are developing their creativity.

nificantly higher on language tests than the others did. The researchers are not sure, however, whether these improvements resulted from playing with blocks per se—because by playing with blocks, the youngsters were spending less time in unproductive activities such as watching television.

But why might play help kids excel? Animal researchers believe that play serves as a kind of training for the unexpected. “Play is like a kaleidoscope,” says evolutionary biologist Marc Bekoff of the University of Colorado at Boulder, in that it is random and creative. The bottom line, he posits, is that play encourages flexibility and creativity that may, in the future, be advantageous in unexpected situations or new environments. Some child psychologists, such as Tufts University child development expert David Elkind, agree. Play is “a way in which children learn,” Elkind says, “and in

not alert and watchful are at risk of being attacked by predators—it probably evolved and persists because it confers survival advantages. “If it wasn’t important, it wouldn’t have evolved in its elaborate form,” Bekoff says.

Indeed, evidence indicates that play is evolutionarily quite ancient. Rats that have had their neocortex removed—a large brain region that is involved in higher-order thinking such as conscious thought and decision mak-

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THE FATHER FACTOR

Could becoming a father after age 40 raise the risks that your children will have a mental illness? **By Paul Raeburn**

When my wife, Elizabeth, was pregnant, she had a routine ultrasound exam, and I was astonished by the images. The baby's ears, his tiny lips, the lenses of his eyes and even the feathery, fluttering valves in his heart were as crisp and clear as the muscles and tendons in a Leonardo da Vinci drawing. Months before he was born, we were already squabbling about whom he looked like. Mostly, though, we were relieved; everything seemed to be fine.

Elizabeth was 40, and we knew about all the things that can go wrong in the children of older mothers. We worried about Down syndrome, which is more common in the offspring of older women. Elizabeth had the tests to rule out Down syndrome and a few other genetic abnormalities. That was no guarantee the baby would be okay, but the results were reassuring to us.

The day after Henry was born, while we were still bleary-eyed from a late-night cesarean delivery, we caught part of a report on the hospital television about an increased risk of autism in the children of older fathers. Until then, all we'd thought about was Elizabeth's age—not mine. We'd had no idea that my age could be an important factor in our baby's health.

When we got home, I looked up the study. Researchers had analyzed medical records in Israel, where all young men and most women must report to the draft board for mandatory medical, intelligence and psychiatric screening. They found that children born to fathers 40 or older had nearly a sixfold increase in the risk of autism as compared with kids whose fathers were younger than 30. Children of fathers older than 50—that includes me—had a ninefold risk of autism.

The researchers said that advanced paternal age, as they call it, has also been linked to an increased risk of birth defects, cleft lip and palate, water on the brain, dwarfism, miscarriage and “decreased intellectual capacity.”

What was most frightening to me, as someone with mental illness in the family, is that older fatherhood was also associated with an increased risk of schizophrenia. The risk rises for fathers with each passing year. The child of a 40-year-old father has a 2 percent chance of having schizophrenia—double the risk of a child whose father is younger than 30. A 40-year-old man's risk of having a child with schizophrenia is the same as a 40-year-old woman's risk of having a child with Down syndrome.

We wouldn't know for two years or so whether Henry had



autism. And because schizophrenia does not usually appear until the early 20s, we had decades to wait before we would know if Henry was affected.

Advancing Years

Data collected by the National Center for Health Statistics, part of the Centers for Disease Control and Prevention, show that in the U.S. the number of births to men aged 40 to 49 nearly tripled between 1980 and 2004, rising from 120,702 to 328,465. Much of that jump is the result of an increase in the overall population. But there has been a shift over the past generation toward more older fathers beyond what can be accounted for by the growth in population. Birth *rates* for men in their 40s (a number that takes population growth into account) have risen by up to 40 percent since 1980—whereas birth rates for men younger than 30 have fallen by as much as 21 percent.

The idea that a father's age could affect the health of his children was first hinted at a century ago by an unusually perceptive and industrious doctor in private practice in Stuttgart, Germany. Wilhelm Weinberg was a loner who devoted much of his time to caring for the poor, including delivering 3,500 babies during a 40-year career. He also managed to publish 160 scientific papers without the benefit of colleagues, students or grants. His papers, written in German, did not attract much

The trend: birth rates for men in their 40s have risen by up to 40 percent since 1980—whereas birth rates for men younger than 30 have fallen by as much as 21 percent.

attention initially; most geneticists spoke English. It was not until years later that some of Weinberg's papers were recognized as landmarks.

One of these was a 1912 study noting that a form of dwarfism called achondroplasia was more common among the last-born children in families than among the first-born. Weinberg didn't know why that was so, but he speculated that it might be related to the age of the parents, who were obviously older when their last children were born. Weinberg's prescient observation was confirmed decades later when research showed that he was half right: the risk of dwarfism rose with the father's age but not the mother's.

Since then, about 20 inherited ailments have been linked to paternal age, including progeria, the disorder of rapid aging, and Marfan syndrome, a disorder marked by very long arms, legs, fingers and toes, as well as life-threatening heart defects. More recent studies have linked fathers' age to prostate and other cancers in their children. And in September 2008 researchers linked older fathers to an increased risk of bipolar disorder in their children.

Eggs vs. Sperm

Dolores Malaspina, a professor of psychiatry at the New York University Langone Medical Center, was in college when her sister, Eileen, who was two years younger, began behaving in ways the family couldn't explain. At first, Malaspina recalls, Eileen seemed like she was going through the usual problems of adolescence. Eileen's behavior became harder to overlook, however, and she was soon diagnosed with schizophrenia.

It was the early 1970s, when many psychiatrists believed schizophrenia was caused by a dominant, overpowering mother who rejected her child. Further, Eileen's doctors said, there was no treatment. The damage done by a schizophrenia-inducing mother was irreparable.

At the same time Eileen was deteriorating, Malaspina earned a master's in zoology and took a job at a drug company, where she drifted into research on substances that could alter brain chemistry. She was in the job for a while before she made the connection with her sister. "I was looking at molecules in the lab that might be related to psychosis," she says. "My sister had very bad psychosis." Researchers were then beginning to establish a biological basis for schizophrenia that would ultimately demolish the so-called schizophrenogenic-mother theory. Malaspina quit her job, went to medical school, became a psychiatrist and focused her research on schizophrenia.

While schizophrenia was being recast as a biological illness, most researchers still looked to mothers as the cause of

FAST FACTS

Older Fathers

1 >> It is widely recognized that a 40-year-old woman has an increased risk of bearing a child with Down syndrome. What is not known is that a 40-year-old man has the same risk of fathering a child with schizophrenia—and even higher odds of his offspring having autism. The risk of bipolar disorder appears to rise as well.

2 >> In the past couple of decades, the number of older fathers has increased. Birth rates for men older than 40 have jumped as much as 40 percent since 1980.

3 >> The mechanisms behind the higher risks are still being investigated, although scientists have several hypotheses that could someday lead to better therapies or possibly even cures for these mental illnesses.

the illness. A woman's eggs age as she does, and it seemed reasonable to conclude that they deteriorate over the years, giving rise to increased problems in her offspring. Sperm are freshly manufactured all the time.

That's not quite the way biology works, however. Because sperm are being continuously manufactured, genetic copying is going on constantly. Geneticists think it is that incessant copying and recopying that gives rise to the genetic errors that cause dwarfism, Marfan syndrome and the other inherited ailments. Malaspina decided to explore whether genetic errors in sperm might be at least partly responsible for schizophrenia. It was an unfashionable line of research. Nobody worried about fathers because everybody assumed mothers were the source of most problems in children. But Malaspina and others were beginning to think about it differently.

Schizophrenia and Autism

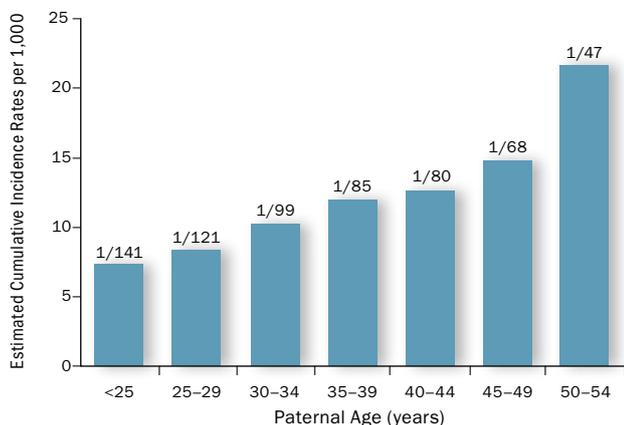
Later, while doing her residency at Columbia University, Malaspina learned about a unique research opportunity in Israel. During the 1960s and 1970s, all births in and around Jerusalem were recorded in conjunction with information on the infants' families, including the ages of the parents. And all those children received a battery of medical tests as young adults, a requirement of Israel's military draft. Because the records cover an entire population, the data are free from the biases that might creep in if researchers looked at, say, only people who graduated from college or only those who went to see a doctor.

Malaspina used the Israeli group to look first at the risk of schizophrenia in children of older fathers—and then at the risk of autism. Then she correlated birth and family information on some 90,000 children with information on which of them had developed schizophrenia as recorded on their military physicals. In 2001 Malaspina and her colleagues reported that paternal age was strongly linked to the risk of schizophrenia, as she had suspected.

It was the first large-scale study to link sporadic cases of

A Rising Risk

The rate of offspring estimated to have an onset of schizophrenia by age 34 grows with paternal age.



When a large study linked schizophrenia to paternal age, some researchers wondered if the root cause, rather than age, was that men who had waited had the makings of the disease themselves.

schizophrenia to fathers' age, and few researchers believed it. "We were absolutely convinced it was real, but other people didn't think it was," Malaspina says. "Everybody thought men who waited to have children must be different." That is, maybe these older fathers had some of the makings of schizophrenia themselves—not enough for the disease to be recognized but enough that it took them a little longer to get settled, married and have children.

Other groups tried to repeat the study using different populations. In all these studies, researchers took a close look at whether there was something about the older fathers—unrelated to age—that increased the risk of schizophrenia in their children. When they did, the link with age became even clearer. "That result has been replicated at least seven times," says Robert K. Heinssen, chief of the schizophrenia research program at the National Institute of Mental Health (which has funded some of Malaspina's work). "We're talking about samples from Scandinavia, cohorts in the United States, Japan.

(The Author)

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This is not just a finding that pertains to Israeli citizens or people of Jewish background.”

Malaspina knew that the draft-induction tests identified young men and women with autism, and she realized that, too, could be looked at to see whether it was linked to paternal age. “There are similarities between autism and schizophrenia—they both have very severe social deficits,” says one of her collaborators, Abraham Reichenberg, a neuropsychologist at the Mount Sinai School of Medicine and the Institute of Psychiatry at King’s College London. “There was some reason to think similar risk factors might be involved.” In 2006 they and their colleagues published a report showing that the children of men who were 40 or older were nearly six times as likely as the kids of men who were younger than 30 to develop autism or a related disorder.

Autism and related disorders—referred to as autism spectrum disorders—occurred at a rate of six in 10,000 among the children of the younger fathers and 32 in 10,000 among the children of the older fathers. (That is closer to five times the risk, but statistical adjustments showed the risk was actually about six times higher in the offspring of the older dads.) In the children of fathers older than 50, the risk was 52 in 10,000.

That was the study I heard about the day after my son Henry was born.

Reichenberg interprets these results as very solid findings: “In epide-

miology, you look for an odds ratio of two. Anything above that, you’re happy. When you have an odds ratio more than five, you’re excited.” The study could not absolutely rule out some effect of older mothers, but “we’re pretty confident that the paternal age risk holds no matter what the maternal age,” he says.

As these studies were being done, Malaspina asked Jay Gingrich, a psychiatrist and neuroscientist at Columbia who works with mice, whether he could look for the same effect in the offspring of older mouse fathers.

Gingrich can’t ask his mice whether they are suffering delusions or hearing voices. But he can give them tests that people with schizophrenia have difficulty passing. In one such test he looked at how mice reacted when startled by a loud sound. Mice are like people—when they hear a loud noise, they jump. And there is more similarity than that:

when mice or people hear a soft sound before being startled, they don’t jump as much. It is called prepulse inhibition; the soft pulse inhibits the reaction to the louder one. “It’s abnormal in a number of neuropsychiatric disorders, including schizophrenia, autism, obsessive-compulsive disorders and some of the others,” Gingrich says. And he found that the response was abnormal in mice with older fathers.

The results were so striking that Gingrich thought they were too good to be true. He and a postdoctoral researcher, Maria Milekic, collected data on 100 offspring of younger dads and another 100 offspring of older dads before they decided the results were correct.

One expert believes the risks for children of older fathers will come to be seen to be as noteworthy as those of older mothers: “It’s going to be more and more of an issue.”

Missing a Mechanism?

Not everyone agrees on what Malaspina’s results mean. Daniel R. Weinberger, a psychiatrist and schizophrenia expert at the National Institute of Mental Health, for instance,

Could the incessant copying required for making sperm result in genetic errors that cause an increased risk of problems in the children of older fathers?





Until we know more about the link between paternal age and dysfunction in offspring, one researcher recommends that men consider storing sperm when they are young.

accepts the findings—that the incidence of schizophrenia is higher in the children of older fathers. But he does not agree with Malaspina that this could be one of the most important causes of schizophrenia. The reason, he says, is researchers know too little about which genes conspire to cause schizophrenia: “It’s a seminal observation, but like many seminal observations, it doesn’t identify a mechanism.” Weinberger wants to know exactly how this happens before he can say what it means.

Malaspina has thought a lot about the mechanism. What happens to the sperm of men as they age that could give rise to these increased risks in their offspring? The first thought was a classic kind of genetic mutation—a typo in the DNA, a stutter or some other scramble of the code.

There is, however, another possibility. The genetic code we are familiar with is expressed in the DNA itself. But there is a second genetic code, separate from what is embedded in the DNA. To distinguish it from the genetic code, it is referred to as “epigenetic” information. It is like a bar code imprinted on the outside of a gene. The information in that bar code can turn the gene on or off—sometimes inappropriately. If it turns the wrong genes on or off, it can affect health and disease just as surely as can changes in the DNA itself.

Malaspina has not yet proved it, but she suspects that as men grow older they develop defects in the machinery that stamps this code on the genes. These imprinting defects may give rise to the increased risk of schizophrenia, autism and perhaps some of the other ailments related to paternal age.

It is not possible to poke around in people’s brains to see whether those who have schizophrenia show errors in this imprinting. But that can be done in Gingrich’s mice. He is just

now beginning to examine the imprinting in the brain tissue of his mice, and he is betting he will find errors there. That is precisely the kind of research that could address Weinberger’s concerns about the mechanism responsible for increasing the incidence of schizophrenia in the children of older dads.

This research could represent an important advance in understanding schizophrenia and autism. “This is work that we will pursue and fund, because we’re so eager to get the genetics worked out,” says Thomas R. Insel, a psychiatrist and director of the National Institute of Mental Health. “It’s a very interesting observation.” With persistence—and some luck—the research could lead to better treatments or even, one day, a cure for schizophrenia and autism.

Some researchers worry that these new findings are just among the first of the problems that might ultimately be associated with older dads. “If there is one common disease that we know is associated with older biological fathers, we can safely assume there are more remaining to be discovered,” says University of Chicago psychiatrist Elliot S. Gershon.

Gershon’s prediction has already come true. In September 2008 researchers in Sweden, in collaboration with Reichenberg, reported that the children of older fathers had an increased risk of acquiring bipolar disorder. And the risk increased as the fathers’ age rose, encouraging confidence in the results.

For now, prospective parents might want to rethink their plans about when to have children, says Herbert Meltzer, a psychiatrist and widely recognized schizophrenia expert at Vanderbilt University. He believes the risks for children of older fathers will eventually be seen to be as noteworthy as the risks facing older mothers. “It’s going to be more and more of an issue to society,” he notes. “Schizophrenia is a terrible disease, and anything that can be done to reduce it is terribly important.”

Meltzer thinks women should take a man’s age into consideration when choosing a partner to have children with. And men might want to think about having sperm stored when they are young. Because despite the advances in understanding autism and schizophrenia, treatment is limited and difficult, and a cure remains elusive.

As for Henry, that decision has been made. The question, for me, is whether I would make the same choice, knowing what I know now. Despite the increase in risks, the absolute risks “to any individual child of a man at any age are quite small,” Malaspina says.

My answer: I don’t know. **M**

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Afraid of
crumbling under
pressure?
Try not to think
so hard

Avoiding the Big Choke

By Elizabeth
Svoboda

You've practiced your big presentation a thousand times. Your last rehearsal was perfect, and you're ready to go. You tell yourself that for the real thing, you will focus on keeping your voice up, smiling, and enunciating clearly and slowly. Suddenly, at the podium, you freeze—all your preparation is for naught as you stand there like a deer in headlights. What happened?

CORBIS



You choked—

and we all have had the experience. But why do we sometimes, without warning, inexplicably screw up just when it matters most? The answer lies in the way our brains are structured. When we have practiced something so well that we no longer need to think about it, subconscious processing systems are at work. When we then slow down to focus on these “automated” actions, we can thwart those processes, tripping ourselves up. And a raft of recent research is revealing who drops the ball and when, yielding surprising insights that could help frequent flubbers leave their self-sabotaging tendencies behind.

Don't Concentrate

Since the early 1980s researchers have been studying in earnest the question of why we choke. In 1984 Florida State University psychologist Roy Baumeister officially defined “choking” as “performance decrements under pressure circumstances.” Ongoing research

Well-meaning experts often advise people to take their time, thinking that will quell nervousness, but it is actually better to just get on with things if you're well rehearsed.

in the past 25 years has established that factors such as audience pressure and high performance expectations make us especially vulnerable to choking—just as perennial chokers might surmise.

But in recent years, scientists have

started arriving at more counterintuitive insights about the circumstances that court choking. Well-meaning experts often advise performers to take their time—slowing down delivery, the thinking goes, helps to quell nervousness—but it is actually better just to get on with things if you are well rehearsed, says psychologist Sian L. Beilock of the University of Chicago.

In a 2008 study she divided novice and skilled golfers into two groups and instructed them to perform a series of golf putts. The researchers encouraged members of the first group to take their time, whereas they exhorted members of the second group to swing as quickly as they could. Novice golfers performed less accurately when speed was emphasized, but skilled golfers showed exactly the *opposite* pattern: they performed best when told to execute quickly and faltered when advised to take their time. (This result adds weight to the long-held notion, confirmed by previous studies, that some experienced golfers develop “the yips”—muscle tremors or freezing up—when they assume a position for a prolonged period before putting.)

Beilock speculates that this pattern occurs because taking extra time to perform when you have already practiced ad infinitum can encourage too much conscious thought. “These golfers were really hurt when we asked them to pay too much attention,” she says. “What happens under stress is that they do start worrying, and in response to that they start monitoring their performance.”

The idea that too much self-monitoring hinders performance aligns with the well-established theory of how the brain

FAST FACTS

Staying Cool

1 >> We choke under pressure because such conditions thwart the normal brain processing of tasks that are so well learned they have become “automatic.”

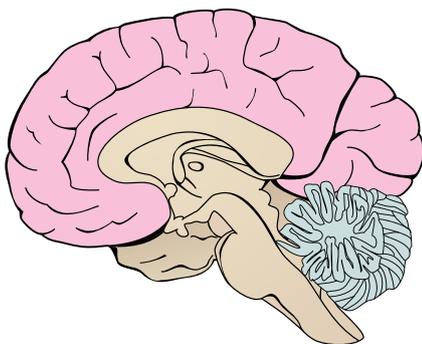
2 >> Trying to concentrate on monitoring the quality of your performance is counterproductive because the cerebellum, which controls complex motor tasks, is not consciously accessible.

3 >> Ratcheting up the pressure at your practice sessions is the best way to avoid failing when it counts.



Thinking too much about specifics such as speed or power can cause major mishaps.

learns to perform complex motor skills—anything from speaking to typing to cradling a lacrosse ball. The part of our brain that is most involved in learning a new task is the cerebral cortex, which controls higher-order, conscious thought and is adaptable to novel situations. But as we play a piece of music or practice a speech over and over again, we gradually transfer the control of that activity from the cerebral cortex to another area of the brain, the cerebellum, which orchestrates the lightning-fast motor activation needed to perform complex ac-



The cerebral cortex (*pink*) is the site of learning and conscious thought. As a skill is mastered, the cerebellum (*blue*) takes control.

tions. “The cerebral cortex is very good at general-purpose stuff but not at intricately timed things,” says Boston University neurologist Frank Guenther. “You want to get the better-equipped part of the brain doing the job for these tasks.” Thus, when people are learning something new they show high levels of activity in the cerebral cortex, whereas when they perform a task they already know well they show more activity in the cerebellum.

The wrinkle in this system is that the cerebellum, unlike the cerebral cortex, is not consciously accessible. As a result, Guenther says, it is when chokers try to check their progress as they are performing that they run into trouble. “Let’s say you’re trying to play the piano. If you were relying on your motor memory”—just letting it fly—“your motor command would automatically read out the next note in about 50 milliseconds.” But consciously monitoring your performance brings this superfast sequence of motor commands to a screeching halt, resulting in a choking incident of epic proportions. “The feedback from the first note takes 100 milliseconds just to move from

your cochlea up to your brain. So if you’re saying to yourself, ‘Okay, I just finished the C, now I have to go on to the D,’ you’re going to have problems.”

But how much monitoring is too much? Obsessing over every little detail can be perilous, but daydreaming might leave you without sufficient focus to complete a task at all. To find the happy monitoring medium, psychologists Daniel Gucciardi and James Dimmock of the University of Western Australia recruited 20 expert golfers and instructed them to perform putts in three circumstances. Players in the first group focused on three words that stood for aspects of their physical technique (such as “head,” “weight” and “arms”); the second group focused on three words that had nothing to do with the putt (for example, “red,” “blue” and “green”); and the third group focused on a single word that encapsulated the putting mo-

(The Author)

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tion (such as “smooth”). Initially, the golfers putted in a low-pressure situation, and most of them did well. During a second trial, however, Gucciardi and Dimmock ratcheted up the tension by offering the top performers cash prizes.

The players sailed through the second trial with flying colors—except the ones who focused on multiple aspects of their putt, according to the results published in the January 2008 *Psychology of Sport and Exercise*. “When they were focusing on the three representative mechanical processes, that was when their performance dropped,” Gucciardi noted. Similarly, in 1999 psychologist Lew Hardy of the University of Wales found that performers who think about a con-

Training in high-pressure situations minimizes the possibility of freezing up for the same reason that letting spiders crawl all over you makes them less frightening.



Practicing with a target is less useful than practicing in a dynamic, high-pressure situation.

crete, detailed set of rules during their moment in the spotlight (“keep skis high in the air” and “keep body streamlined” for a ski jumper, for instance) are more likely to succumb to pressure than are those who do not have such a specific set of rules in mind.

On the other hand, the golfers in Gucciardi’s study who focused on holistic single-word cues actually performed *best* in the pressure-packed putting round. Gucciardi thinks the degree of focus involved in fixating on a one-word mantra—not too much, not too little—could account for the difference between the three groups. “Our thought is that if

you use the one word, it prevents you from regressing into conscious control, but it’s still enough to activate the schematic cue to get that motor program running,” he says.

The upshot? If you scrutinize your performance too much—trying to control, for example, the natural inflections in your voice as you present an important finding to your office mates—you will be priming your cerebral cortex to trip over your cerebellum, leaving yourself at a loss for words. But if you focus on a single word or idea that sums up your entire presentation (“smooth” or “forceful,” for instance), you will be best

equipped to prevent your brain from getting in its own way.

Pressure Makes Perfect

Steering yourself away from conscious monitoring is easy enough when you are reciting a speech or playing a piece in your living room, but keeping optimum focus in front of a crowd or review board is another animal entirely.

The best way to make a performance situation feel like rehearsal, says Raoul R. D. Oudejans, a psychologist at Free University Amsterdam, is to subject yourself to the same anxiety-packed conditions during practice that you expect to encounter during your moment in the spotlight. In a 2008 study Oudejans rounded up a group of Dutch police officers and asked half of them to practice their marksmanship skills by shooting at a cardboard target; the other half trained by firing shots directly at one another (the cartridges contained soap, not bullets). After three one-hour training sessions, the “performance” was on: an officer-on-officer shoot-out using the dummy cartridges. The officers who had practiced on cardboard targets caved in this new tension-filled situation, whereas the group that had trained under the same stressful conditions thrived, notching much higher accuracy ratings than the other group did.

These results indicate that turning up the heat from the very first day of practice may be one of the most effective ways to immunize yourself against blowing it. “Performers train and train, but it’s not that common to specifically train under these kinds of psychological constraints,” Oudejans says. “They’re trained in how to play their game, but they don’t train under pressure, so they fail.” Training in such situations minimizes the possibility of freezing up for the same reason that letting spiders crawl all over you makes them less frightening: your brain gradually adapts, so that circumstances that once would have made you uneasy no longer feel novel or threatening. “The more exposure you get to these high-pressure situations, and the more you succeed [de-

WARNING: Memory Low

The discomfort of a high-stakes situation can squeeze the life out of a performance in measurable ways. When psychologist Sian L. Beilock, now at the University of Chicago, gave 93 undergraduates a tough math test in 2005, she stirred up anxiety by introducing time constraints and telling the students they were being filmed. She found—ironically—that the test takers who had earlier demonstrated the best working-memory capacity, or the ability to store and manipulate information, were the ones who bombed most spectacularly under pressure.

Beilock theorizes that stress uses up the same cognitive horsepower that would typically be devoted to mental tasks, scuttling the performance of capable people who depend on their superior reasoning abilities. “When you’ve got high levels of working memory, you actually use cognitive horsepower to do tasks, whereas if you’ve got low levels, you’re used to using shortcuts like guessing,” Beilock says. “If you’re trying to do a subtraction in your head as you’re taking the SAT and you’re thinking, ‘Crap,’ that worrying is really problem-



atic because it’s competing for the same resources as your working memory.” The solution? Try to rehearse in a situation similar to the performance scenario—for example, take timed practice tests in addition to leisurely reading over your notes—so that when the heat is on, you are not as distracted by the added pressure. —E.S.

spite them], the less likely you’re going to get that whole affective experience,” explains Art Markman, a psychologist at the University of Texas at Austin. In other words, the more comfortable you feel, the less likely you are to be affected by pressure.

The Choking Conundrum

To reap the same performance benefits the Dutch officers did from their trial-by-fire training, Oudejans recommends devising a high-tension practice regimen appropriate to your particular performance situation. If you are on deck to give an important business presentation, he says, have someone film you as you rehearse: “Your self-awareness increases that way—you get confronted with yourself in the same way you would in performance,” Oudejans observes. If you are prepping for an important sports match or musical recital, try enlisting a few friends or family members to serve as an audience during your practice sessions.

These kinds of antichoking strategies grounded in empirical data are reassuring when you are up at bat and your stomach starts to churn. Still, re-

searchers who study choking are the first to admit that figuring out who whiffs and when is far from an exact science. Many studies conducted to date focus on how and why people fall short in highly constrained situations such as making a putt or shooting a free throw. But in real-world situations, Markman points out, a plethora of factors—some under your control, some not—work together to determine whether your performance is successful. “It’s a very complex interaction,” he says. “Your performance is going to depend on whether the situation is going to reward you or not, and it’s also going to depend on the nature of the task.” In other words, if something unexpected happens (for instance, the laptop battery fails during

your PowerPoint lecture), you might still flub despite a strenuous antichoking practice regimen.

But that does not mean such a regimen is not worth undertaking. The most effective strategies, notes Trinity University psychologist Harry Wallace, are the ones that imbue performers with the assurance that they can deal with any eventuality. This mind-set proves helpful even (and perhaps especially) when something goes wrong. “Part of the key is not being overconfident in advance and recognizing that you may feel more anxiety than you expect,” Wallace says. “You want to address any concerns far in advance of performance. You don’t want to have any second thoughts about your likelihood of success.” **M**

(Further Reading)

- ◆ **Choking and Excelling under Pressure.** Arthur B. Markman, W. Todd Maddox and Darrell A. Worthy in *Psychological Science*, Vol. 17, No. 11, pages 944–948; 2006.
- ◆ **Putting in the Mind versus Putting on the Green: Expertise, Performance Time, and the Linking of Imagery and Action.** Sian L. Beilock and Sara Gonso in *Quarterly Journal of Experimental Psychology*, Vol. 61, No. 6, pages 920–932; June 2008.
- ◆ **Reality-Based Practice under Pressure Improves Handgun Shooting Performance of Police Officers.** Raoul R. D. Oudejans in *Ergonomics*, Vol. 51, No. 3, pages 261–273; March 2008.

Belief is powerful medicine, even if the treatment itself is a sham. New research shows placebos can also benefit patients who do not have faith in them

Cure in

By Maj-Britt Niemi

A man whom his doctors referred to as “Mr. Wright” was dying from cancer of the lymph nodes. Orange-size tumors had invaded his neck, groin, chest and abdomen, and his doctors had exhausted all available treatments. Nevertheless, Mr. Wright was confident that a new anticancer drug called Krebiozen would cure him, according to a 1957 report by psychologist Bruno Klopfer of the University of California, Los Angeles, entitled “Psychological Variables in Human Cancer.”

Mr. Wright was bedridden and fighting for each breath when he received his first injection. But three days later he was cheerfully ambling around the unit, joking with the nurses. Mr. Wright’s tumors had shrunk by half, and after 10 more days of treatment he was discharged from the hospital. And yet the other patients in the hospital who had received Krebiozen showed no improvement.

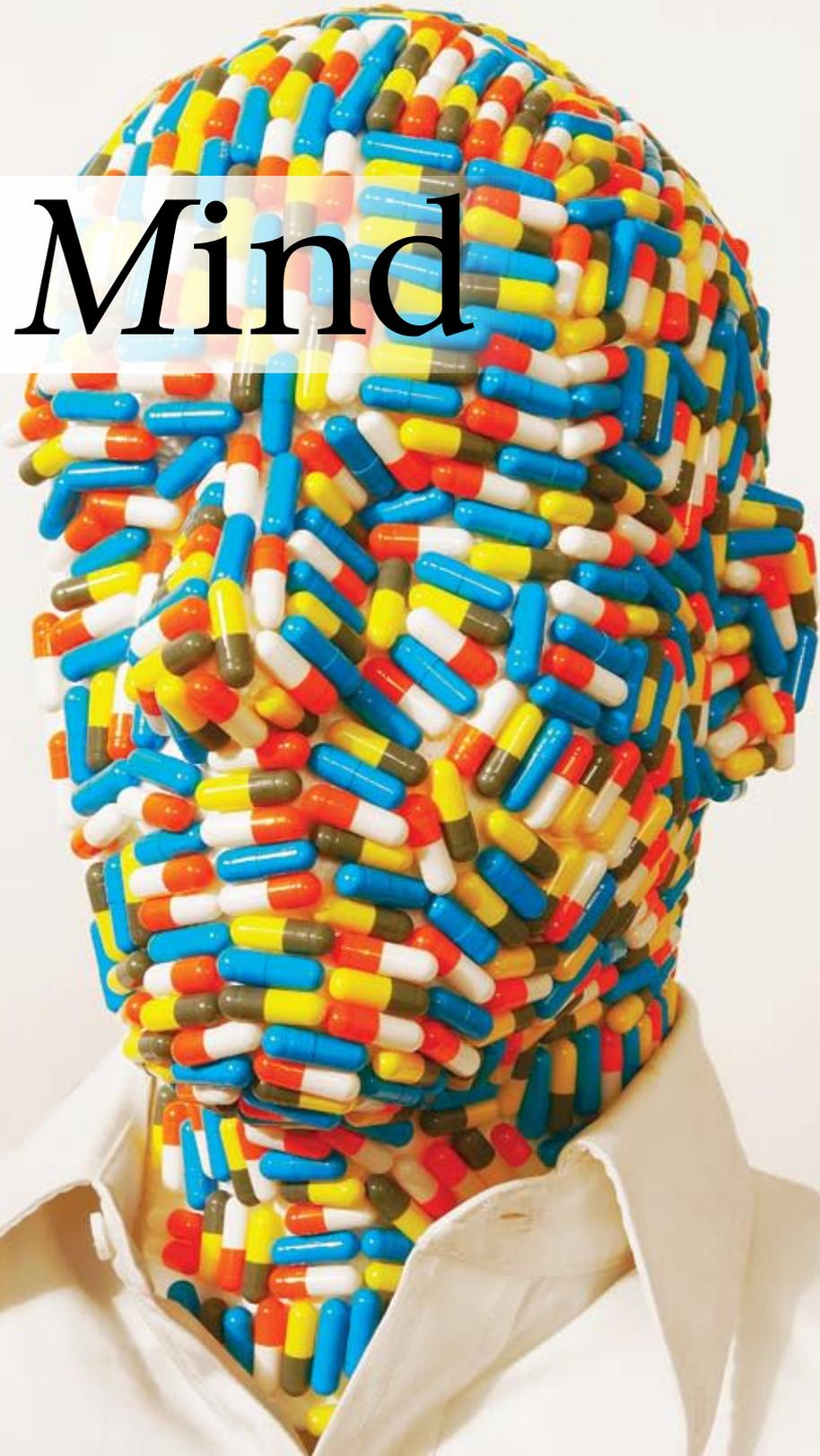
Over the next two months, however, Mr. Wright became troubled by press reports questioning the efficacy of Krebiozen and suffered a relapse. His doctors decided to lie to him: an improved, doubly effective version of the drug was due to arrive the next day, they told him. Mr. Wright was ecstatic. The doctors then gave him an injection that contained not one molecule of the drug—and he improved even more than he had the last time. Soon he walked out of the hospital symptom-free. He remained healthy until two months later, when, after reading reports that exposed Krebiozen as worthless, he died within days.

As Mr. Wright’s experience illustrates, a patient’s expectations and beliefs can greatly affect the course of an illness. When psychological factors tied to an inactive substance such as Krebiozen lead to recovery, doctors call the improvement a placebo effect.

In recent decades reports have confirmed the efficacy of such sham treat-

ANDY RYAN/Getty Images

the *Mind*



A white coat and a stethoscope can create a subconscious placebo reaction if a patient has previously associated them with feeling better.



ments in nearly all areas of medicine. Placebos can help not only to alleviate illnesses with an obvious psychological component, such as pain, depression and anxiety, but also to lessen the symptoms of Parkinson's disease and inflammatory disorders. Occasionally, as in Mr. Wright's case, placebos have shrunk tumors [see box on opposite page].

The latest research has shown that the placebo effect does not always arise from a conscious belief in a drug. Alternatively, it may grow out of subconscious associations between recovery and the experience of being treated, from the pinch of a shot to a doctor's white coat. Such subliminal conditioning can control bodily processes, including immune responses and the release of hormones. Meanwhile

researchers have decoded some of the biology of placebo responses, demonstrating that they stem from active processes in the brain.

Subconscious Cues

The placebo effect is probably as old as the healing professions themselves. In the 18th century physicians deliberately used inert pills when they had no suitable drug in their armamentarium. They spoke of supporting the healing process. After the middle of the 19th century medical scientists began viewing disease in purely physical and chemical terms. And by 1900 placebos had lost much of their previous popularity as therapy.

Indeed, modern medical investigators have often regarded the placebo response as a nuisance. But a cadre of psychologists, biologists, and other behavioral and social scientists instead view placebos as a key to understanding how the brain can control bodily processes to promote healing.

In the classic placebo effect, a person consciously believes that a substance is therapeutic, and this faith has a physiological consequence that dampens the pain or ameliorates other symptoms. Inversely, in the so-called nocebo effect, a negative attitude or expectation leads to harm or another undesirable outcome.

For several decades, however, researchers have known that placebo effects can also arise from subconscious associations as opposed to overt beliefs. Stimuli that a patient links with feeling better or with physical improvement—say, a doctor's white lab coat, a stethoscope or the smell of an examining room—may induce physiological reactions even if a patient has no explicit faith in the treatment being given. That is, simply seeing a doctor holding a sy-

FAST FACTS Fake Fixes

1 In recent decades reports have confirmed the efficacy of various sham treatments in nearly all areas of medicine. Placebos have helped alleviate pain, depression, anxiety, Parkinson's disease, inflammatory disorders and even cancer.

2 Placebo effects can arise not only from a conscious belief in a drug but also from subconscious associations between recovery and the experience of being treated—from the pinch of a shot to a doctor's white coat. Such subliminal conditioning can control bodily processes of which we are unaware, such as immune responses and the release of hormones.

3 Researchers have decoded some of the biology of placebo responses, demonstrating that they stem from active processes in the brain.

JUPITERIMAGES

Some scientists view placebos as a key to understanding how the brain can control bodily processes to promote faster healing.



ring can produce a placebo reaction if a patient has previously associated that scenario with feeling better. In such cases, the overall effect—improvement or even complete recovery—stems from a combination of the pharmacological action of the drug and the subconscious or conditioned response.

My colleague, psychologist Manfred Schedlowski, and our team at the University of Duisburg-Essen in Germany and the Swiss Federal Institute of Technology Zurich have demonstrated that such conditioning can have pharmacological effects that mimic those of the drug being given—in this case, altering immune system status. We conditioned rats by first injecting them with the immunosuppressive drug cyclosporine A, which is used to prevent the rejection of transplanted organs. At the same time, we fed the rats water sweetened with saccharin.

The rats apparently associated the cyclosporine with the sweet drink so that, later, feeding them the drink alone weakened their immune systems, presumably because their brain sent messages to the immune system that partially shut it down. Because

the rats cannot consciously believe the drink is therapeutic the way a human might, unconscious, associative learning must have depressed their immunity. These findings suggest that a placebo effect does not require that a person hope for or believe in a positive outcome.

Immune Therapy

Subsequent transplantation experiments published in the 1990s showed that such conditioning has clinical significance. Rats that received a sweet drink that previously had been paired with cyclosporine A survived with the transplanted hearts of another rat species (which the rats' immune system would have otherwise rejected) considerably longer than did nonconditioned control animals. In some of the conditioned rodents, the transplanted hearts beat for more than 100 days, which suggests their bodies had accepted the transplants. Some of this work also hinted at a mechanism for this effect: in response to behavioral conditioning, the nervous system inhibits the spleen from releasing molecules called cytokines that immune cells use to communicate with one another. Such dampened immunity thus enables the body to tolerate a foreign organ.

Immune conditioning with cyclosporine works in humans as well. In 2002 Schedlowski, psychologist Marion U. Goebel of the University of Duisburg-Essen and their colleagues reported giving 18 healthy men a cyclosporine A capsule four times over three days, along with a greenish strawberry milk shake that smelled of lavender. Not surprisingly, their immune systems showed signs of reduced function. Five days later, when the subjects took just a dummy capsule (but no active drug) with the strange drink, the beverage similarly weakened their immune system, though somewhat less than cyclosporine had. In contrast, no such effect was seen in 16 men who received a dummy pill throughout the experiment. "This study demonstrates for

Placebo Medicine

Disease	Average percentage of patients in whom placebo therapy worked	Number of studies; total number of participants
Cancer	2–7 (tumors reduced in size)	10; 464
Crohn's disease	19	32; 1,047
Chronic fatigue syndrome	19.6	29; 1,016
Duodenal ulcer	Healing in 36.2–44.2	79; 3,325
Irritable bowel syndrome	40	45; 3,193
Multiple sclerosis	11–50 (fewer episodes after two to three years)	6; 264

Subliminal suggestions can manipulate involuntary physiological responses, such as hormone release, more than conscious beliefs can.



the first time in humans in a double-blind, placebo-controlled design that behavioral conditioning is able to mimic the immunological effects of an immunosuppressive drug,” the authors wrote.

Subconscious placebo responses can also dampen the overactive immune responses that give rise to allergies. In 2008 Goebel and her colleagues reported conditioning 30 people who were allergic to dust mites by giving them, on five consecutive days, an unusual drink followed by a tablet of the allergy treatment desloratadine. This drug blocks the ac-

tion of histamines, which mediate allergic reactions. Later, 11 of the patients received the novel drink, along with a placebo pill that looked like desloratadine, whereas the others received plain water and either a placebo or the drug.

The subjects who later sipped the strange beverage, but not those who drank water, showed a reduction in their allergy symptoms, accompanied by lowered immunological reactivity comparable to that seen in those who took the desloratadine in the second phase of the experiment. Thus, the placebo treatment measurably attenuated the subjects’ immune response.

But what is the neurological basis for conditioned placebos? In a 2005 study Schedlowski and I, along with our colleagues, identified several areas of the brain that play a role in cyclosporine-saccharin conditioning in rats. We selectively damaged the brains of rats in each of three areas—the insular cortex, the amygdala and the ventromedial nucleus of the hypothalamus—before or after the rats underwent the first phase of conditioning in which they were exposed to cyclosporine paired with saccharin [*see box below*].

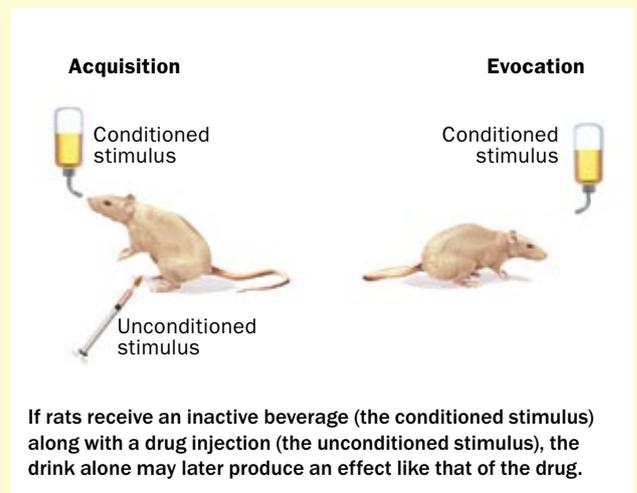
We found that the insular cortex—an area that modulates sensory experiences such as taste along with emotions and the physiological state of the body—is essential for conditioning at all times. Animals with a damaged insular cortex exhibited no conditioned immune response, no matter when

Training the Subconscious

A person can experience a placebo effect even if he or she has no explicit faith in a therapy. Subconscious conditioning can do the trick. During such conditioning, a person or animal inadvertently associates a stimulus, such as an injection, with a pharmacological consequence. In medical offices, this may happen, say, when a patient associates a doctor’s white coat or syringe with feeling better. In research laboratories, investigators can deliberately condition animals to respond to an inert substance.

Such intentional conditioning involves two phases. In the first step, called the acquisition phase, an animal such as a rat receives an active drug—say, an immunosuppressant—over several consecutive days. Scientists call the drug the unconditioned stimulus. At the same time, the rat is given a neutral stimulus such as water sweetened with saccharin. This inert substance becomes a so-called conditioned stimulus by being paired with the drug.

In the second phase of conditioning, called evocation, the animal is given the inactive beverage without the drug, and the



drink alone produces a pharmacological effect similar to that of the drug. In our experiments, the drink produces a weakened immune response. —M.-B.N.

MUSTAFA DELIORMANLI / Stockphoto (stethoscope); COURTESY OF MAJ.-BRITT NIEMI (rat experiment)



Along with subconscious cues, dummy pills can dampen overactive immune responses and thereby thwart allergies.

the experimental lesion was made. Yet an intact amygdala, which is involved in emotional learning, was indispensable only for immune conditioning during the first, so-called acquisition phase of conditioning, suggesting that the amygdala governs the input of visceral information, including the status of the immune system, during learning. Lesions to the hypothalamus, in contrast, had an effect only if they were made after the initial acquisition phase of conditioning, indicating that this almond-size neural structure participates in relaying information from the brain to the immune system to evoke the conditioned response.

Expecting Relief

Given the power of conditioned placebo effects, scientists have wondered whether conditioning might account for most such phenomena, leaving only a minor role for expectation. Data suggest, however, that expectation does often contribute but that its influence extends mainly to symptoms that humans can perceive, such as pain.

In 2003 neuroscientist Fabrizio Benedetti of the University of Turin Medical School in Italy and his team tested the relative influence of expectation and conditioning in 60 volunteers who underwent a procedure that caused severe arm pain. They gave some of the participants a saline injection and told them the shot would intensify their pain; other volunteers were also given the placebo pain promoter but in addition underwent conditioning to decrease pain in which the saline shot was preceded by injections of the nonsteroidal anti-inflammatory drug (NSAID) ketorolac. In both groups pain increased, demonstrating that

negative expectation is a powerful nocebo in the case of pain. What is more, anticipating more pain led to increased agony despite conditioning to an analgesic, showing that expectation influences pain more than conditioning does.

On the other hand, suggestion is relatively impotent when it comes to involuntary bodily responses. In another experiment in the same study, Benedetti's team told participants that a saline shot would alter levels (either up or down, depending on the group) of growth hormone or the stress hormone cortisol. But the suggestions had no effect on either hormone. In contrast, a saline injection did alter hormone concentrations when the researchers conditioned subjects with sumatriptan, a drug that influences their secretion. These placebo-induced biological changes occurred even if the participants were told the saline injection would have an effect opposite to that of sumatriptan. Thus, conditioning can manipulate involuntary physiological processes more than conscious beliefs can.

Expectation and conditioning placebos also work through separate biological mechanisms. In an experiment conducted by Benedetti and Turin neuroscientist Martina Amanzio, volunteers who received a shot of saline touted to be a pain reliever could bear more pain in their arms than they could without the shot. No pain relief was evident, however, when the saline was replaced by naloxone, a

(The Author)

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Dummy-Drug Doping?

Researchers have shown that placebos can activate the body's own painkilling opioids. In particular, saline injections can dampen pain if a person has recently received shots of morphine, a powerful analgesic, and has thereby associated such injections with pain relief. Could such a procedure be used to boost pain tolerance during athletic competitions?

According to the prohibited drugs list of the World Anti-Doping Agency, morphine is illegal during athletic competition but not during training. So an athlete might legally inject herself with morphine before competition, only to replace that injection with a placebo on the day of the event. To be effective, however, such a strategy requires that the morphine be taken several days before the placebo so that no trace of the drug would exist on competition day, and until recently, researchers were not sure whether the conditioned response would still be effective after an interval longer than a day or so.

In 2007 neuroscientist Fabrizio Benedetti of the University of Turin Medical School in Italy and his colleagues reported simulating a sports competition in which four teams of 10 young males competed with one another in a test of pain endurance. During the training, two of the teams were given morphine injections once a week for two weeks. Then, a week later, just before the pain tolerance test, members of one morphine-exposed team were injected with saline they thought was morphine. Indeed, that combination produced the greatest pain tolerance as compared with no injection, an injection of saline



New research suggests that athletes could use placebos to legally enhance their performance at competitive events such as track meets.

without previous exposure to morphine or a shot of an opioid-blocking drug.

These results show that only two shots of morphine, separated in time by as long as a week, are enough to induce a strong and long-lasting placebo response, which could significantly boost pain tolerance in an athlete on the day of a competition. Because an athlete who took morphine a week earlier is not likely to test positive for the drug, such a placebo procedure would be legal. But given the placebo's power, doping agency officials might start asking whether it should be.

—Ingrid Wickelgren, staff editor

substance that blocks the function of the body's natural painkillers, endogenous opioids. This result suggests that the expectation effect works through the release of these opioids.

Then researchers conditioned subjects by preceding a saline injection with doses of the NSAID ketorolac. But in this case, the resulting placebo effect was *not* blocked by naloxone. What is more, naloxone only abbreviated the placebo response from saline paired with ketorolac when the participants also believed that the saline was a pain-blocking agent. In other words, naloxone exclusively impinged on the conscious part of that pain-reducing response. The scientists conclude that the placebo effect can consist of two components: the expectation effect, which is mediated by opioids and abolished by naloxone, and the conditioned effect, which seems to work in the same manner as whatever analgesic is used in the conditioning—and is therefore not generally sensitive to naloxone.

Additional support for the notion that endogenous opioids are behind the expectation effect comes from psychiatrist Jon-Kar Zubieta and his co-workers at the University of Michigan at Ann Arbor. In 2005 the investigators reported using molecular imaging techniques to measure opioid-mediated neuronal activity in the brain while they induced sustained muscle pain in volunteers. During one of the scans, the investigators gave the volunteers a placebo infusion of plain saline that doctors described as a medication “thought to have analgesic effects.” Compared with the trial in which no infusion was given, the saline produced increased activity precisely in those brain regions that inhibit pain and stress through endogenous opioid neurotransmission, the researchers found. In addition, the volunteers reported lower ratings of pain intensity in the saline-injection trial, suggesting that a placebo with expected painkilling properties relieves pain by acting on the brain's endogenous opioid system.

TOSHIO HOSHI/Jupiterimages

Along with a flurry of activity from brain opioids, placebo analgesia is also accompanied by a quieting of brain regions responsible for processing painful sensations. In a 2007 study neuroscientist Donald Price of the University of Florida and his colleagues used magnetic resonance imaging to scan the brains of patients with irritable bowel syndrome while they underwent a painful procedure. Price's team showed that when patients believed they were receiving an analgesic, not only did their pain diminish but neuronal activity also declined significantly in five pain-sensing brain regions as compared with trials in which they were not given a fake painkiller.

Placebo Performance

Despite the proved power of suggestion, investigators have been unable to identify personality traits that increase susceptibility to placebos. Personality, after all, has little effect on subconscious conditioning. For such subliminal responses, presentation matters more than personality does. Giving a medication a popular brand name or prescribing more frequent doses can boost the efficacy of a placebo. Similarly, a physician can maximize a placebo effect by radiating confidence or spending more time with the patient. Such tactics may subconsciously build a patient's trust in a therapy.

A high price tag on the drug can apparently help, too. In one study, placebos reported to cost \$0.10 worked considerably less well in relieving pain than did those priced at \$2.50 per pill. Test subjects evidently distrusted the less expensive medication. Patients are also liable to benefit more from placebos that involve elaborate medical procedures than from those requiring simple measures. Thus, the most effective sham treatments may extend beyond dispensing inactive pills to a simulation of a multistep therapeutic regimen.

As evidence of this idea, counseling psychologist Cynthia McRae of the University of Denver and her colleagues reported in 2004 the surprising success of a sham brain surgery in improving the quality of life of patients with advanced Parkinson's disease. Surgeons performed the sham operation to compare its efficacy with that of implanting human embryonic dopamine neurons into the brains of Parkinson's patients, who suffer from a lack of dopamine. In McRae's follow-up study, which assessed the patients' quality of life up to a year later, the researchers found that the patients who received the sham surgery were doing just as well physically, socially and emotionally as were the patients who had received the new cells. What mattered was not

Giving a medication a well-known name, prescribing more frequent doses or indicating that it is expensive can boost the efficacy of a placebo.

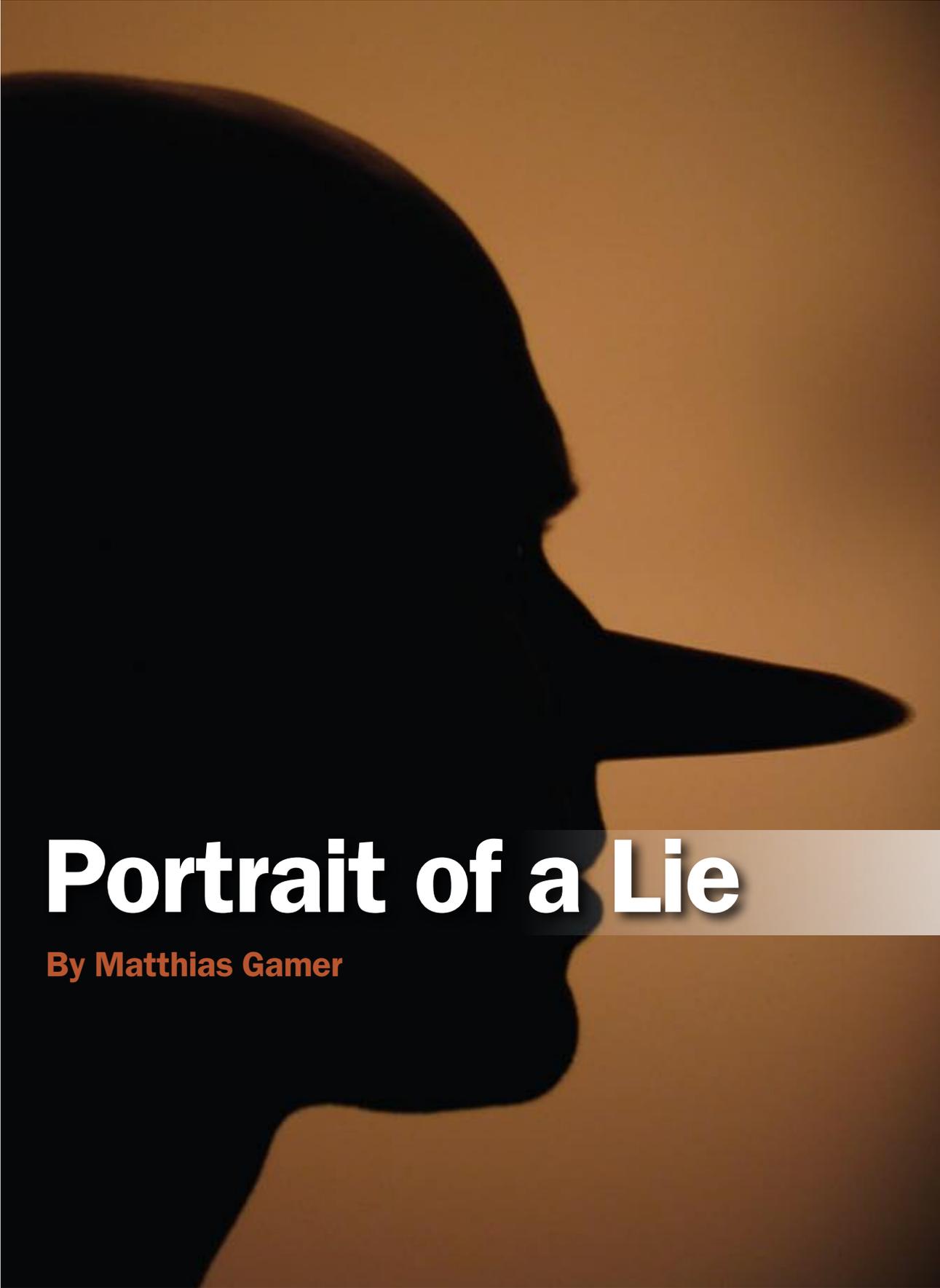


the transplant itself but whether a patient thought he or she had received it.

In recent years extensive research revealing the many medical applications, types and mechanisms of placebo effects has given credence to this once orphaned phenomenon. Doctors are now considering placebo pills and procedures as a way of enhancing the effectiveness of drugs and surgery. Such uses may elicit new controversies and questions such as the use of placebos to boost athletic performance [see box on opposite page]. In the meantime, sophisticated doctors might decide to manipulate the conscious and subconscious mind in ways that could cure—or at least, do no harm. **M**

(Further Reading)

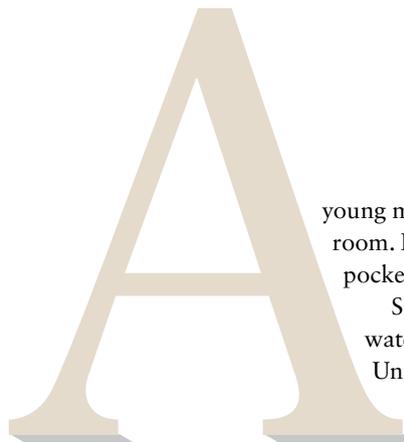
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Portrait of a Lie

By Matthias Gamer

MICHEL DE NIJS / iStockphoto



young man steals across the hallway, slips through a door and scans the room. He opens a drawer, snatches a wristwatch inside and puts it in his pocket. Then he hurries out the door.

Sixty more people perform the same drill, half of them filching a watch and the others, a ring. Psychiatrist F. Andrew Kozel, now at the University of Texas Southwestern Medical Center at Dallas, and his colleagues promised to give a bonus payment to anyone who could conceal the deed from the scientists, who planned to look into their brains for signs of a cover-up.

Kozel and his co-workers scanned the volunteers' brains using functional magnetic resonance imaging, which provides a measure of neural activity in different brain areas. During the scans, the subjects answered questions about the theft such as "Did you steal a watch?" or "Did you steal a ring?" The researchers also asked neutral yes/no queries as well as questions about minor wrongful acts. Each participant could truthfully deny stealing one of the objects but had to lie about the other to conceal the deed. (The volunteers were supposed to answer the unrelated questions truthfully.)

Kozel and his team initially identified typical neural activity patterns for true and false statements. Then, in the first use of fMRI to detect deception in individuals, the researchers used the patterns they identified to correctly determine whether each of the subjects had taken a watch or a ring 90 percent of the time.

In search of a better lie detector, scientists are peering into the brain to probe the origins of deception

The use of fMRI represents the cutting edge of lie-detection technology. As far as we know, no region of the brain specializes in lies. But investigators have found that lying activates brain regions involved in suppressing information and in resolving conflicts—such as that between the impulse to describe reality and the wish to contradict it. The use of fMRI combined with a clever questioning strategy could lead to a better method for detecting lies or, more precisely, for getting at the truth despite a person's attempts to hide it.

Improved ability to detect falsehoods would be of significant use in solving crimes, for example, and perhaps also in ferreting out military spies. Unraveling the neurocircuitry of deception, moreover, might help doctors better understand, diagnose and treat patients with disorders in which compulsive lying is a prominent component, including antisocial personality disorder and substance dependence.

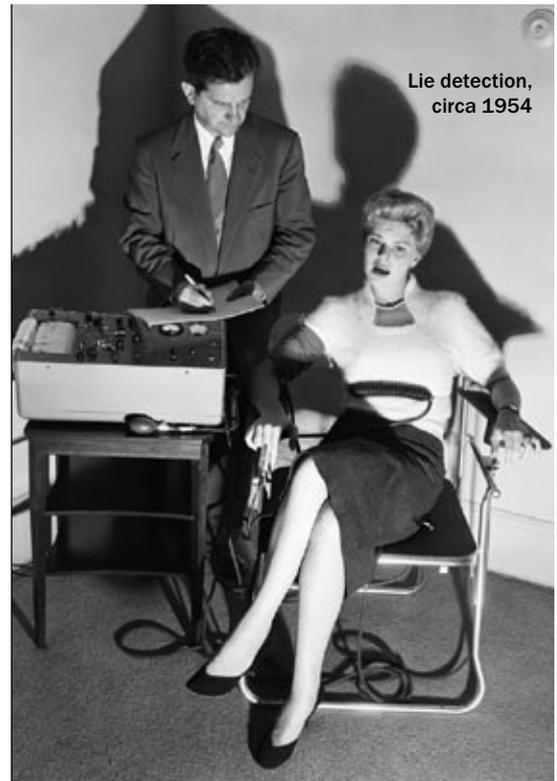
In contrast to Pinocchio's infamous nose, the "tells" that betray dishonest intent in humans are more nonspecific.

Questioning the Truth

Virtually everybody lies. Indeed, the ability to fabricate, at least to some extent, is important for normal social interactions and the maintenance of a healthy state of mind [see "Natural-Born Liars," by David Livingstone Smith; *SCIENTIFIC AMERICAN MIND*, Vol. 16, No. 2; June 2005]. Nevertheless, law-enforcement officials and employers, among others, often want to know whether someone is lying—either to cover up a crime or to simply make himself or herself look better.

Laypeople and psychologists alike have thus looked for behavioral clues such as slight hesitations or mistakes in speech, awkward gestures or lack of eye contact. These signs do not reliably indicate untruthfulness, however. We cannot distinguish a fabrication from the facts by observation alone. We are correct only 45 to 60 percent of the time, a rate barely better than chance.

Similarly, researchers have not found any specific verbal, behavioral or physiological cue that uniquely indicates lying. In contrast to Pinocchio, whose nose grows whenever he lies, the "tells" that betray dishonest intent in humans are more nonspecific. In the early 20th century psychologist William Moulton Marston invented the first polygraph, popularly known as a lie detector, to pick up some of these nonspecific signals. The polygraph measures physiological activity from a subject that may help an examiner glean the truth from his or her



reactions to questions and statements. The instrument records such physical signs as heart rate dips, blood pressure boosts, slowed breathing and increased sweating on separate tracks in a graphical printout [see box on opposite page].

The polygraph picks up emotional and peripheral nervous system arousal that is not specific to lying. Thus, blips on a polygraph can reflect fear or agitation resulting from just being hooked up to a machine and having to answer probing questions. To minimize that problem, researchers have designed questioning strategies that compare physical reactions to questions or answer choices that are connected to a crime with those of questions or choices that have nothing to do with the deed.

In the Control Question Test, for example, a practitioner compares the physiological responses to crime-linked inquiries such as the direct "Did you do it?" with the responses to incriminatory control questions about past acts such as minor traffic violations or lying to parents. In a pretest interview, an examiner leads subjects to believe that the control questions are important indicators of dishonesty so that they will trigger large physiological re-

FAST FACTS

Detecting Deception

1» There is no telltale sign that reliably shows someone is a liar, although investigators have long used physical indications of arousal such as sweating and changes in heart rate.

2» More recently, researchers have probed the brain for a neural signature of a fib. They found that lying activates brain regions involved in suppressing information and in resolving conflicts—such as that between the impulse to describe reality and the wish to contradict it.

3» The use of brain imaging combined with physiological measures, along with a clever questioning strategy, could lead to an improved method for detecting lies.

sponses when subjects lie about them in an attempt to appear respectable. In theory, a perpetrator should still react more strongly to crime-related queries than to the control questions. In contrast, innocent individuals should respond less vigorously to the crime questions, which they can deny with a clear conscience. Thus, the results of a polygraph test are supposed to point to guilt or innocence—and, indirectly, to deception by perpetrators trying to hide their ties to a misdeed.

Guilty Knowledge

Such tactics are imperfect, however. When combined with a Control Question Test, a polygraph may detect a reaction pattern in an innocent person that is very similar to that of the perpetrator if the blameless individual merely thinks he or she is being accused of a crime. Some researchers say that this combination wrongly implicates the innocent in up to 30 percent of cases. Conversely, if a person can remain calm, he or she could beat the test and successfully hide falsehoods.

Another questioning strategy, developed by the late psychologist David T. Lykken of the University of Minnesota, reduces such misplaced anxiety by not prodding a suspect directly about guilt. Instead of asking, “Did you steal the watch?” Lykken’s Guilty Knowledge Test probes a person for inside information about the crime. It compares physiological responses to different multiple-choice answers, one of which contains information only the investigators and criminal would know. For the misdeed described above, one such inquiry might read, “Where did the thief find a watch? Did he find it (a) on the table, (b) in the jewelry box, (c) in the drawer or (d) in a shopping bag?”

If the person being interrogated responds systematically differently to the correct answer (“in the drawer”), he has an insider’s knowledge of the crime, indicating guilt. In contrast, an innocent person should not react differently to the theft-related answers. The Guilty Knowledge Test relies on recognition, which is hard to suppress, rather than on fear or comprehension of culpability. It accurately detects concealed recognition of crime details 80 to 90 percent of the time. What is more, it incriminates the innocent in only 0 to 10 percent of cases, far fewer than the Control Question Test does.

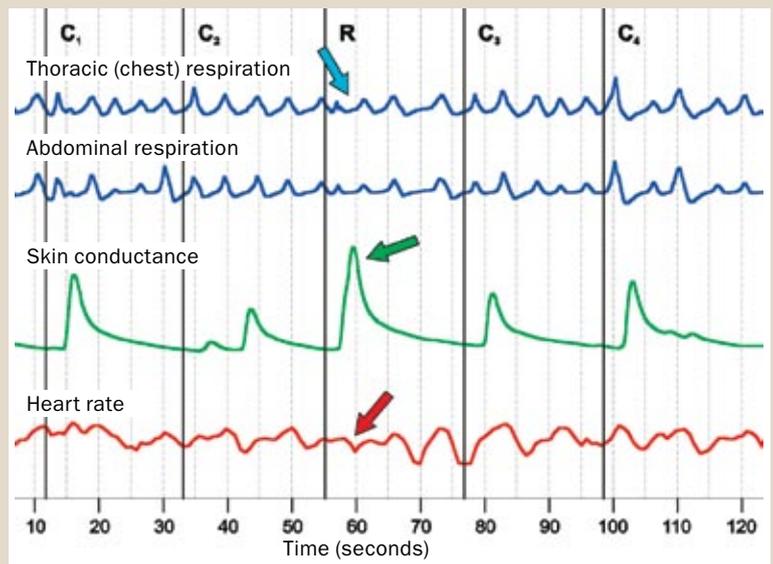
As a practical matter, the Guilty Knowledge Test requires that investigators have several pieces of insider information so that conclusions are based on more than just one or two deviant responses. Furthermore, interrogators must make certain that the general public is not privy to facts about the

Body Language

Can your body betray a lie? The so-called Guilty Knowledge Test is based on the idea that people react physiologically to information they recognize but are trying to conceal—such as that connected to a crime. When someone recognizes a crime-related detail, for example, he or she typically breaks out in a sweat and shows a brief heart rate drop, a reaction that might relate to enhanced attention. A polygraph (aka lie detector) tracks such responses. Tubes placed around the chest and stomach record respiratory rate (through chest and abdominal movement); two small metal plates on the fingers measure skin conductivity, which indicates the amount of sweat on the fingertips; and an electrocardiogram picks up the heart rate.

In the case shown here, the examiner compared a suspect’s physiological responses when she heard a multiple-choice answer that was related to a crime (R) to her bodily reactions to four plausible control answers (C₁–C₄). Physiological aberrations that occur in connection with the crime facts may indicate involvement in an illegal activity. The reaction profile suggests that the person being interrogated has knowledge of the crime: when a crime detail is mentioned, her breathing slows (blue arrow); she sweats more, indicated by increased skin conductivity (green arrow); and her heart rate momentarily drops (red arrow).

—M.G.



circumstances of the crime; otherwise innocent suspects might distinguish these facts from the neutral alternatives and react as a perpetrator would.

But in addition to trying to improve such interrogation procedures, many scientists are looking for a more precise physiological measure of deception. In particular, psychologists have been trying

(The Author)

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to outline the signature of a lie in the brain. Deception is, after all, a cognitive event, so it ought to leave a trace in the neural machinery that underlies the ability to deceive.

Early efforts to perform brain “fingerprinting” involved attaching electrodes to a subject’s head and recording his or her brain waves on an electroencephalogram. A characteristic brain wave called the P300 shows up when a person recognizes something familiar, which could indicate that he or she



Telling the Truth

Finding the facts of a criminal case does not necessarily require fancy machinery. A method called Criteria-Based Content Analysis relies on evaluating the retelling of an incident for a set of defined narrative features that hint at whether it is a true account. The method is based on research indicating that a story of a real recollection differs from a fabrication in specific ways, according to a 2005 analysis by psychologist Aldert Vrij of the University of Portsmouth in England.

This idea suggests that descriptions of actual experiences have the following properties:

- They are coherent and consistent but generally not in chronological order.
- They contain a lot of detail and include unusual and superfluous elements.
- They depict personal interactions and reiterate speech and conversation.
- They describe feelings and thoughts—the narrator’s and in many cases those the storyteller ascribes to the perpetrator.
- They contain spontaneous corrections, the admission of memory gaps and doubts about the believability of the story.

These criteria may be used in cases of suspected sexual abuse in children to assess the believability of the events as described by the underage victims. Some studies suggest, however, that testimony gained in this manner is somewhat less valid than that derived from polygraph tests. Indeed, the error rate of the method in experimental settings is as high as 30 percent. —M.G.

has an insider’s knowledge of a crime, although such familiarity does not necessarily mean an individual is guilty [see “Exposing Lies,” by Thomas Metzinger; *SCIENTIFIC AMERICAN MIND*, October/November 2006].

Patterns of Deceit

More recently, researchers have used sophisticated brain scanning to search for a neural portrait indicative of a lie. In one of the first attempts to employ fMRI for this purpose, reported in 2002, psychiatrist Daniel D. Langleben of the University of Pennsylvania and his colleagues gave 18 men and women a playing card to put in their pocket and told them to lie about having that card when asked if they had it during a brain scan. The subjects were supposed to tell the truth when they were queried about possessing other playing cards.

When a subject was fibbing, the scientists noted a burst of activity in a strip of brain tissue at the top of the head that is involved in motor control and sensory feedback and in the anterior cingulate, which performs cognitive tasks such as detecting discrepancies that could result in errors [see “Minding Mistakes,” by Markus Ullsperger; *SCIENTIFIC AMERICAN MIND*, August/September 2008]. Langleben’s team suggests that this neural pattern reflects the mental conflict that arises in the telling of a lie and the increased demand for motor control when suppressing the truth. Such inhibition of the truth, the authors state, may be a basic component of intentional deception. Because no brain regions were *less* active during deceit, the researchers contend that truth is the baseline cognitive state.

Other studies have similarly associated dishonesty with activation in the anterior cingulate. In their 2005 study, described earlier, Kozel and his colleagues showed that they could use an activation pattern in the brain that included this area to determine whether individuals had “stolen” a watch or a ring. The scientists theorize that the anterior cingulate monitors the incorrect and deceptive response to a question and then spurs other frontal brain regions to produce a falsehood. The ability to recognize a mark of deception in the brain further suggests that brain imaging might work as a lie detector in the courtroom and in other applications.

In a study published in 2007 my colleagues at the University of Mainz in Germany and I found additional support for the role of frontal brain regions in concealing knowledge. We asked 14 men to choose one of three envelopes containing money and a playing card and to keep them secret. While the men were in an MRI scanner, we gave them a

Researchers may eventually find a combination of brain images and body signals that accurately depicts deception.

Guilty Knowledge Test that included images of the contents of the envelope and of various other objects. In addition, we recorded skin conductivity to determine whether activity in the brain regions involved in concealing information is linked to the response of sweat glands to questions about crime details.

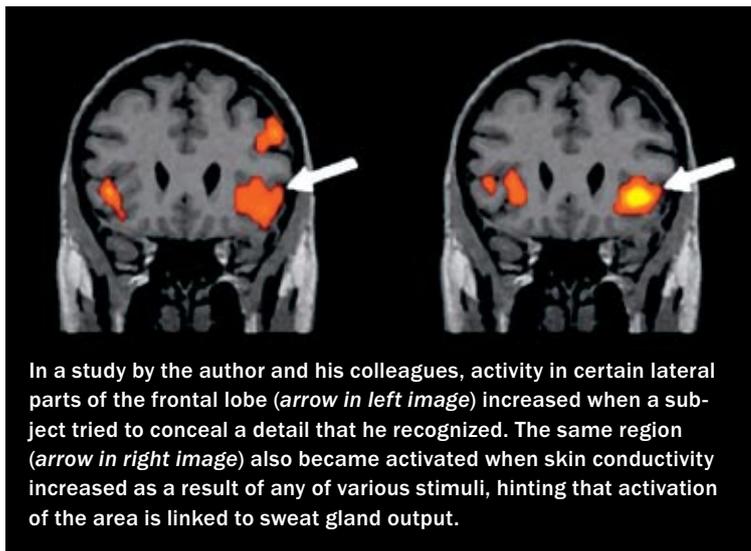
As expected, skin conductivity increased more when subjects saw the information they were trying to conceal than when they looked at the other options. The same held true for activity in certain regions of the frontal lobe, which plays a key role in memory and attention [see illustration at right]. Apparently, our volunteers recognized the secret information and mobilized additional brain resources to conceal their knowledge of it. In fact, we found that activity in inferior frontal regions and in the right anterior insula, which interprets bodily states as emotions, directly paralleled sweat gland productivity, lending credence to both brain and skin responses as indicators of fibbing.

Imaging on Trial

Still, many questions remain about the use of brain imaging to detect lies in real-world settings such as law enforcement. For one, experimental tests of the technology typically involve normal adults whose brains may be substantially different from those of individuals who have frequent problems with the law. Studies of people with antisocial personality disorders, for example, indicate that such patients may have damaged frontal lobes. Because of these discrepancies, a sociopath, psychopath or someone who is simply a good liar might well be able to suppress any suspicious neural responses to the “insider” choices and thus avoid detection. [For more on the use of brain scans in the courtroom, see “Brain Scans Go Legal,” by Scott T. Grafton et al.; SCIENTIFIC AMERICAN MIND, December 2006/January 2007.]

And of course, the consequences of being caught in a lie in experimental settings are typically low: the subjects are usually asked to lie, after all. The brain activity recorded in such studies therefore is not necessarily the same as that which occurs in real-world scenarios in which people deceive to avoid severe social, emotional or monetary repercussions.

Functional MRIs of brain activity are far more



In a study by the author and his colleagues, activity in certain lateral parts of the frontal lobe (arrow in left image) increased when a subject tried to conceal a detail that he recognized. The same region (arrow in right image) also became activated when skin conductivity increased as a result of any of various stimuli, hinting that activation of the area is linked to sweat gland output.

expensive than polygraph exams, too, and we do not yet know whether they are really more sensitive and accurate than these traditional tests are. We can be fairly certain that neither polygraphs nor fMRI can identify responses that are exclusive to lying or identify the guilty with 100 percent confidence. Nevertheless, researchers may eventually identify a combination of brain images and signals from the body that comes much closer than do current methods to providing an accurate depiction of deception. **M**

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- ◆ **Detecting Deception Using Functional Magnetic Resonance Imaging.** F. Andrew Kozel et al. in *Biological Psychiatry*, Vol. 58, No. 8, pages 605-613; October 15, 2005.
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Adapted from the book *The Instant Egghead Guide to the Mind*, by Emily Anthes and *Scientific American*. © 2008 by *Scientific American*. Published by arrangement with St. Martin's Press.

Six Ways to Boost Brainpower

The adult human brain is surprisingly malleable: it can rewire itself and even grow new cells. Here are some habits that can fine-tune your mind

By Emily Anthes

Amputees sometimes experience phantom limb sensations, feeling pain, itching or other impulses coming from limbs that no longer exist. Neuroscientist Vilayanur S. Ramachandran worked with patients who had so-called phantom limbs, including Tom, a man who had lost one of his arms.

Ramachandran discovered that if he stroked Tom's face, Tom felt like his missing fingers were also being touched. Each part of the body is represented by a different region of the somatosensory cortex, and, as it happens, the region for the hand is adjacent to the region for the face. The neuroscientist deduced that a remarkable change had taken place in Tom's somatosensory cortex.

Ramachandran concluded that because Tom's cortex was no longer getting input from his missing hand, the region processing sensation from his face had slowly taken over the hand's territory. So touching Tom's face produced sensation in his nonexistent fingers.

This kind of rewiring is an example of neuroplasticity, the adult brain's ability to change and remold itself. Scientists are finding that the adult brain is far more malleable than they once thought. Our behavior and environment can cause substantial rewiring of the brain or a re-

organization of its functions and where they are located. Some believe that even our patterns of thinking alone are enough to reshape the brain.

Researchers now know that neurogenesis (the birth of new neurons) is a normal feature of the adult brain. Studies have shown that one of the most active regions for neurogenesis is the hippocampus, a structure that is vitally important for learning and long-term memory.

Neurogenesis also takes place in the olfactory bulb, which is involved in processing smells. But not all the neurons that are born survive; in fact, most of them die. To survive, the new cells need nutrients and connections with other neurons that are already thriving. Scientists are currently identifying the factors that affect the rate of neurogenesis and the survival of new cells. Mental and physical exercise, for instance, both boost neuron survival.

IMAGE COMPOSITION BY SCIENTIFIC AMERICAN MIND; JULIE FELTON
iStockphoto (brain on opposite and following pages); DEAN TURNER /iStockphoto
(background on opposite page and in brain icons on following pages)



Exercise can improve the brain's executive functions: planning, organizing, multitasking and more. Physical activity improves the delivery of oxygen and nutrients to brain cells.

METHOD 1: EXERCISE

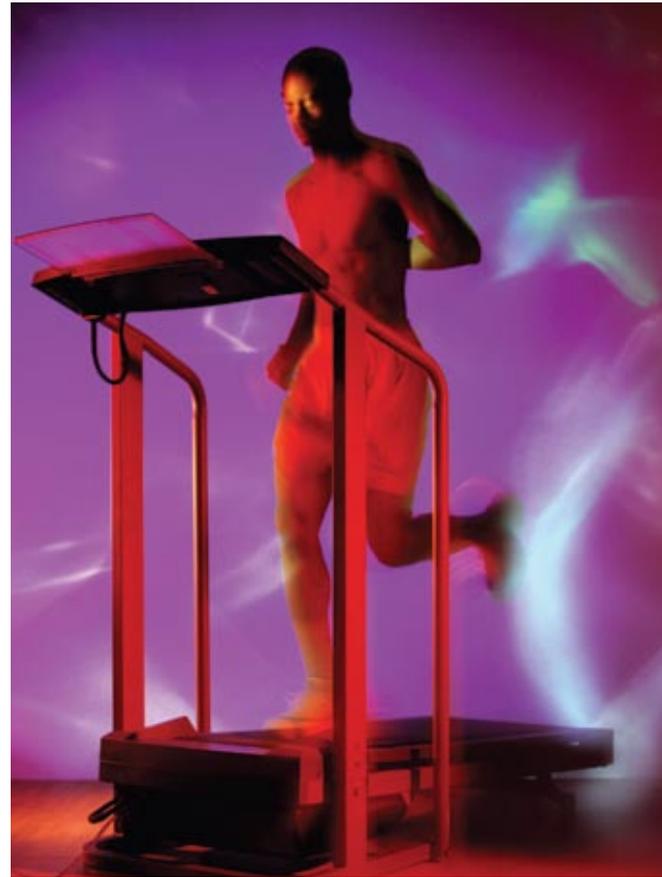


Mice that run on wheels increase the number of neurons in their hippocampus and perform better on tests of learning and memory. Studies of humans have revealed that exercise can improve the brain's executive functions (planning, organizing, multitasking, and more). Exercise is also well known for its mood-boosting effects, and people who exercise are less likely to get dementia as they age. Among those who are already

aged, athletic senior citizens have better executive function than do those who are sedentary; even seniors who have spent their entire lives on the couch can improve these abilities just by starting to move more in their golden years.

A variety of mechanisms might be responsible for this brain boost. Exercise increases blood flow to the brain, which also increases the delivery of oxygen, fuel and nutrients to those hard-working neurons. Research has shown that exercise can increase levels of a substance called brain-derived neurotrophic factor (BDNF), which encourages growth, communication and survival of neurons.

Of course, all this research does nothing to help explain dumb jocks.



ON THE FRONTIER

New research suggests a little music can make your workout better yet. Volunteers completed two workout sessions. In one, they sweated to the sweet sound of silence; in the other, they listened to Vivaldi's *Four Seasons*. After each workout, participants completed assessments of their mood and verbal skills.

Exercise alone was enough to boost both, but verbal scores improved twice as much when the exercisers had tunes to listen to. Maybe you can get your insurance company to pay for a new iPod.

COCKTAIL PARTY TIDBITS

>> Exercise also improves sleep quality, a pile of studies suggests. And immune function. Is there anything it can't do?

>> You don't need to be Chuck Norris (thankfully) to get the brain benefits of exercise. Studies of senior citizens have shown that as little as 20 minutes of walking a day can do the trick.

FAST FACTS

Changing Your Mind

1>> Scientists are finding that the adult human brain is far more malleable than they once thought. Your behavior and environment can cause substantial rewiring of your brain or a reorganization of its functions.

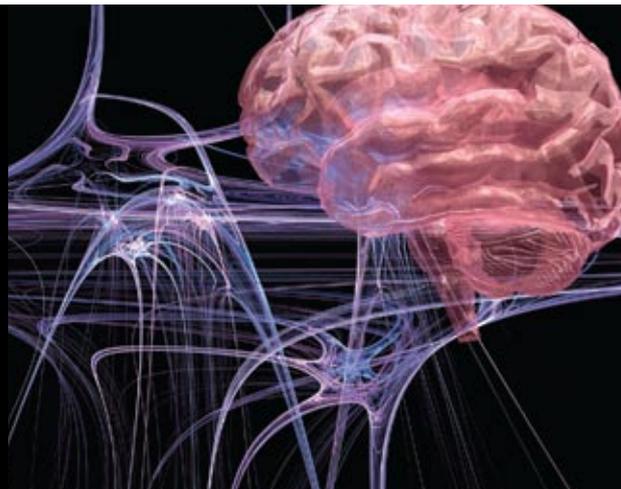
2>> Studies have shown that exercise can improve the brain's executive skills, which include planning, organizing and multitasking. What you eat can also influence how effectively your brain operates.

3>> Activities such as listening to music, playing video games and meditating may boost cognitive performance as well.

ISTOCKPHOTO (legs in icon); PETER BEAVIS/Getty Images (man on treadmill); HENNING DALHOFF/Bonnier Publications/SPL/Photo Researchers, Inc. (neurogenesis on opposite page, top left)



Neurogenesis, or the birth of new neurons (left) is a normal feature of the adult brain. To survive, a new neuron needs nutrients and connections with other neurons (right). Mental and physical exercise both boost neuron survival.



METHOD 2: DIET



The brain needs fuel just as the body does. So what will really boost your brainpower, and what will make you lose your mind? Saturated fat, that familiar culprit, is no better for the brain than it is for the body. Rats fed diets high in saturated fat underperformed on tests of learning and memory, and humans who live on such diets seem to be at increased risk for dementia.

Not all fat is bad news, however. The brain is mostly fat—all those cell membranes and myelin coverings require fatty acids—so it is important to eat certain fats, particularly omega-3 fats, which are found in fish, nuts and seeds. Alzheimer's disease, depression, schizophrenia and other disorders may be associated with low levels of omega-3 fatty acids.

Fruits and vegetables also appear to be brain superfoods. Produce is high in substances called antioxidants, which counteract atoms that can damage brain cells. Researchers have found that high-antioxidant diets keep learning and memory sharp in aging rats and even reduce the brain damage caused by strokes. That's food for thought.

ON THE FRONTIER

It's not just what you eat that affects the brain. It's also how much. Research has shown that laboratory animals fed calorie-restricted diets—anywhere from 25 to 50 percent less than normal—live longer than other animals do. And it turns out they also have improved brain function, performing better on tests of memory and coordination. Rodents on calorie-restricted diets are also better able to resist the damage that accompanies Alzheimer's, Parkinson's and Huntington's disease.

COCKTAIL PARTY TIDBITS

- >> Some of the best brain foods: walnuts, blueberries and spinach.
- >> It is especially important that babies get enough fat. Babies who don't get enough of the stuff have trouble creating the fatty myelin insulation that helps neurons transmit signals. Luckily for babies, breast milk is 50 percent fat.
- >> Populations that traditionally eat diets high in omega-3 fatty acids tend to have lower rates of disorders of the central nervous system.



Video games can improve mental dexterity, while boosting

METHOD 3: STIMULANTS



Stimulants are substances that rev up the nervous system, increasing heart rate, blood pressure, energy, breathing and more. Caffeine is probably the most famous of the group. (It is actually the most widely used “drug” in the world.) By activating the central nervous system, caffeine boosts arousal and alertness. In high doses, though, this stimulation can go too far, causing jitters, anxiety and insomnia.

Cocaine and amphetamines are less benign. Although they work on the brain through different mechanisms, they have similar effects. Taking them increases the release of some of the brain’s feel-good neurotransmitters—including dopamine and serotonin—and produces a rush of euphoria. They also increase alertness and energy.

That all sounds pretty good, but cocaine and amphetamines are extremely addictive drugs and in high doses they can cause psychosis and withdrawal. The withdrawal symptoms are nasty and can lead to depression, the opposite of that euphoric feeling. And of course, an overdose can kill you.

ON THE FRONTIER

Although high doses of caffeine can undoubtedly have unpleasant effects (ranging from irritability to the most unpleasant of all: death in rare cases), small to moderate amounts can boost our mental

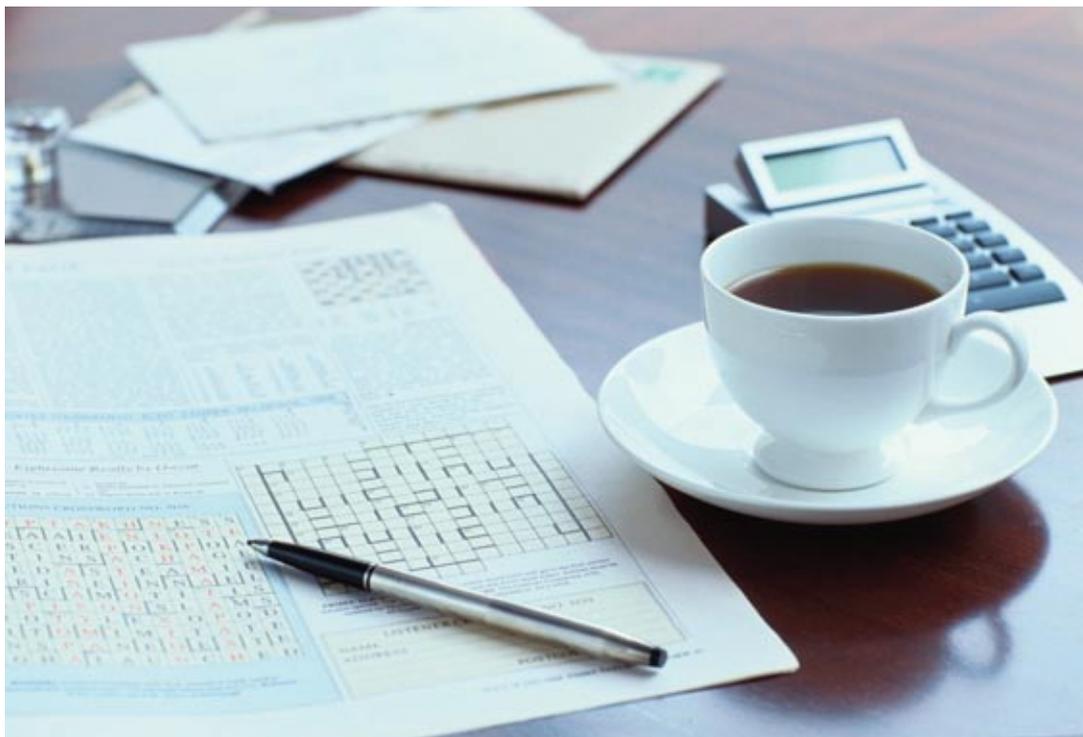
functioning in ways researchers are now measuring.

One study showed that the equivalent of two cups of coffee can boost short-term memory and reaction time. Functional MRI scans taken during the study also revealed that volunteers who had been given caffeine had increased activity in the brain regions involving attention. In addition, research suggests caffeine can protect against age-related memory decline in older women.

COCKTAIL PARTY TIDBITS

>> Three quarters of the caffeine we ingest comes from coffee. Try to limit yourself to fewer than 100 cups a day. That much coffee contains about 10 grams of caffeine, enough to cause fatal complications.

>> One of fiction’s most famous stimulant users is the great caper cracker Sherlock Holmes. Many of the detective’s capers include descriptions of the relief he found from injecting cocaine. It must be tough to make sure justice is done.



ISTOCKPHOTO (coffee cup in icon); RYOICHI UTSUMI/Getty Images (coffee on table)

hand-eye coordination, depth perception and pattern recognition.

METHOD 4: VIDEO GAMES



Video games could save your life. Surgeons who spend at least a few hours a week playing video games make one-third fewer errors in the operating room than nongaming doctors do. Indeed, research has shown that video games can improve mental dexterity, while boosting hand-eye coordination, depth perception and pattern recognition. Gamers also have better attention spans and information-

processing skills than the average Joe has. When nongamers agree to spend a week playing video games (in the name of science, of course), their visual-perception skills improve. And strike your notions of gamers as outcasts: one researcher found that white-collar professionals who play video games are more confident and social.

Of course, we cannot talk about the effects of video games without mentioning the popular theory that they are responsible for increasing real-world violence. A number of studies have reinforced this link. Young men who play a lot of violent video games have brains that are less responsive to graphic images, suggesting that these gamers have become desensitized to such depictions. Another study revealed that gamers had patterns of brain activity consistent with aggression while playing first-person shooter games.

This does not necessarily mean these players will actually be violent in real life. The connections are worth exploring, but so far the data do not support the idea that the rise of video games is responsible for increased youth violence.

ON THE FRONTIER

Video games activate the brain's reward circuits but do so much more in men than in women, according to a new study. Researchers hooked men and women up to functional MRI machines while the participants played a video game designed for the study. Both groups performed well, but the men showed more activity in the limbic system, which is associated with reward processing. What is more, the men showed greater connectivity between the structures that make up the reward circuit, and the better this connection was in a particular player, the better he performed. There was no such correlation in women. Men are more than twice as likely as women are to say they feel addicted to video games.

COCKTAIL PARTY TIDBITS

- >> Video games are a \$10-billion industry in the U.S.
- >> In 2003 a 16-year-old boy shot and killed two police



officers and a police dispatcher. Two years later the families of the victims filed suit against the company that made the massively popular video game *Grand Theft Auto*. The lawsuit alleges that the perpetrator was inspired by his obsession with the controversial video game.

(The Author)

EMILY ANTHES is a freelance science and health writer living in Brooklyn. Her work has appeared in *Seed*, *Discover*, *Slate*, *New York* and the *Boston Globe*, among other publications.

METHOD 5: MUSIC



When you turn on Queen's *Greatest Hits*, the auditory cortex analyzes the many components of the music: volume, pitch, timbre, melody and rhythm. But there's more to music's interaction with the brain than just the raw sound. Music can also activate your brain's reward centers and depress activity in the amygdala, reducing fear and other negative emotions.

A highly publicized study suggested that listening to Mozart could boost cognitive performance, inspiring parents everywhere to go out and buy classical CDs for their children. The idea of a "Mozart effect" remains popular, but the original study has been somewhat discredited, and any intellectual boost that comes from listening to music seems to be tiny and temporary. Nevertheless, music does seem to possess some good vibrations. It can treat anxiety and insomnia, lower blood pressure, soothe

patients with dementia, and help premature babies to gain weight and leave the hospital sooner.

Music training can bolster the brain. The motor cortex, cerebellum and corpus callosum (which connects the brain's two sides) are all bigger in musicians than in nonmusicians. And string players have more of their sensory cortices devoted to their fingers than do those who don't play the instruments. There is no agreement yet on whether musical training makes you smarter, but some studies

have indeed shown that music lessons can improve the spatial abilities of young kids.

ON THE FRONTIER

Music lessons and practice during childhood increase the sensitivity of the brain stem to the sounds of human speech. According to a recent study, the brain stem is involved in very basic encoding of sound, and lots of exposure to music can help fine-tune this system, even in kids without particular musical gifts.

So buck up, tone-deaf children of the world! Think of it like eating vegetables: chewing on that clarinet is good for you.

COCKTAIL PARTY TIDBITS

>> The auditory cortex is activated by singing a song in your head. The visual cortex is activated by merely imagining a musical score.

>> Playing classical and soothing music can increase the milk yield of dairy cows.



Music can activate your brain's reward centers and depress activity in the amygdala, the hub of emotional memory, reducing fear and other negative feelings.



METHOD 6: MEDITATION



Forget apples. If reams of scientific studies are to be believed (and such studies usually are), an om a day can keep the doctor away. Meditation, or the turning of the mind inward for contemplation and relaxation, seems to help all types of conditions—*anxiety disorders, sure, but it can also reduce pain and treat high blood pressure, asthma, insomnia, diabetes, depression and even skin conditions.*

And regular meditators say they feel more at ease and more creative than nonmeditators do.

Researchers are now illuminating the actual brain changes caused by meditation by sticking meditators into brain-imaging machines. For one, although the brain's cells typically fire at all different times, during meditation they fire in synchrony. Expert meditators also show spikes of brain activity in the left prefrontal cortex, an area of the brain that has generally been associated with positive emotions. And those who had the most activity in this area during meditation also had big boosts in immune system functioning.

Meditation can increase the thickness of the cerebral cortex, particularly in regions associated with attention and sensation. (The growth does not seem to result from the cortex growing new neurons, though—it appears that the neurons already there make more connections, the number of support cells increases, and blood vessels in that area get bigger.)

ON THE FRONTIER

Meditation can increase focus and attention, improving performance on cognitive tasks. Researchers spent three months training volunteers in the practice of Vipassana meditation, which centers on minimizing distractions.

Then the volunteers were asked to perform a task in which they had to pick a few numbers out of a stream of letters. People who had undergone meditation training were much better at identifying numbers that briefly flashed onto a computer screen. They also seemed to be able to do this without exerting as much mental energy.

COCKTAIL PARTY TIDBITS

» Monks who take part in these scientific studies have typically spent more than 10,000 hours in meditation. That's more than a year.

» In 2005 the Dalai Lama was a distinguished speaker at the Society for Neuroscience's annual conference, the world's largest gathering of brain researchers. **M**

Lunacy and the Full Moon

Does a full moon really trigger strange behavior?

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ



"It is the very error of the moon. She comes more near the earth than she was wont. And makes men mad."

—William Shakespeare, *Othello*

ACROSS THE CENTURIES, many a person has uttered the phrase “There must be a full moon out there” in an attempt to explain weird happenings at night. Indeed, the Roman goddess of the moon bore a name that remains familiar to us today: *Luna*, prefix of the word “lunatic.” Greek philosopher Aristotle and Roman historian Pliny the Elder suggested that the brain was the “moistest” organ in the body and thereby most susceptible to the pernicious influences of the moon, which triggers the tides. Belief in the “lunar lunacy effect,” or “Transylvania effect,” as it is sometimes called, persisted in Europe through the Middle Ages, when humans were widely reputed to transmogrify into werewolves or vampires during a full moon.

Even today many people think the mystical powers of the full moon induce erratic behaviors, psychiatric hospital admissions, suicides, homicides, emergency room calls, traffic accidents, fights at professional hockey games, dog bites and all manner of strange events. One survey revealed that 45 percent of college students believe moonstruck humans are prone to unusual behaviors, and other surveys suggest that mental health professionals may be still more likely than laypeople to hold this conviction. In 2007 several police departments in the U.K. even added officers on full-



moon nights in an effort to cope with presumed higher crime rates.

Water at Work?

Following Aristotle and Pliny the Elder, some contemporary authors, such as Miami psychiatrist Arnold Lieber, have conjectured that the full moon’s supposed effects on behavior arise from its influence on water. The human body, after all, is about 80 percent water, so perhaps the moon works its mischievous magic by somehow disrupting the alignment of water molecules in the nervous system.

But there are at least three reasons why this explanation doesn’t “hold water,” pardon the pun. First, the gravitational effects of the moon are far too minuscule to generate any meaningful effects on brain activity, let alone behavior. As the late astronomer George Abell of

the University of California, Los Angeles, noted, a mosquito sitting on our arm exerts a more powerful gravitational pull on us than the moon does. Yet to the best of our knowledge, there have been no reports of a “mosquito lunacy effect.” Second, the moon’s gravitational force affects only open bodies of water, such as oceans and lakes, but not contained sources of water, such as the human brain. Third, the gravitational effect of the moon is just as potent during new moons—when the moon is invisible to us—as it is during full moons.

There is a more serious problem for fervent believers in the lunar lunacy effect: no evidence that it exists. Florida International University psychologist James Rotton, Colorado State University astronomer Roger Culver and University of Saskatchewan psychologist Ivan

Some authors have conjectured that the full moon’s supposed effects arise from its **influence on water** in the body.

COURTESY OF SCOTT O. LILIENFELD (left); COURTESY OF HAL ARKOWITZ (right); GEORGE ROBINSON age fotostock (moon and silhouette)

(The lunar lunacy effect appears to be **no better supported** than the idea that the moon is made of green cheese.)

W. Kelly have searched far and wide for any consistent behavioral effects of the full moon. In all cases, they have come up empty-handed. By combining the results of multiple studies and treating them as though they were one huge study—a statistical procedure called meta-analysis—they have found that full moons are entirely unrelated to a host of events, including crimes, suicides, psychiatric problems and crisis center calls. In their 1985 review of 37 studies entitled “Much Ado about the Full Moon,” which appeared in one of psychology’s premier journals, *Psychological Bulletin*, Rotton and Kelly humorously bid adieu to the full-moon effect and concluded that further research on it was unnecessary.

Persistent critics have disagreed with this conclusion, pointing to a few positive findings that emerge in scattered studies. Still, even the handful of research claims that seem to support full-moon effects have collapsed on closer investigation. In one study published in 1982 an author team reported that traffic accidents were more frequent on full-moon nights than on other nights. Yet a fatal flaw marred these findings: in the period under consideration, full moons were more common on weekends, when more people drive. When the authors reanalyzed their data to eliminate this confounding factor, the lunar effect vanished.

Where Belief Begins

So if the lunar lunacy effect is merely an astronomical and psychological urban legend, why is it so widespread? There are several probable reasons. Media coverage almost surely plays a role. Scores of Hollywood horror flicks portray full-moon nights as peak times of spooky occurrences such as stabbings, shootings and psychotic behaviors.

Perhaps more important, research demonstrates that many people fall prey to a phenomenon that University of Wis-



Legend has it that werewolves emerge during full moons.

consin-Madison psychologists Loren and Jean Chapman termed “illusory correlation”—the perception of an association that does not in fact exist. For example, many people who have joint pain insist that their pain increases during rainy weather, although research disconfirms this assertion. Much like the watery mirages we observe on freeways during hot summer days, illusory correlations can fool us into perceiving phenomena in their absence.

Illusory correlations result in part from our mind’s propensity to attend to—and recall—most events better than nonevents. When there is a full moon and something decidedly odd happens, we usually notice it, tell others about it and remember it. We do so because such co-occurrences fit with our preconceptions. Indeed, one study showed that psychiatric nurses who believed in the lunar effect wrote more notes about patients’ peculiar behavior than did nurses who did not believe in this effect. In contrast, when there is a full moon and nothing odd happens, this nonevent quickly fades from our memory. As a result of our selective recall, we erroneously

perceive an association between full moons and myriad bizarre events.

Still, the illusory correlation explanation, though probably a crucial piece of the puzzle, does not account for how the full-moon notion got started. One intriguing idea for its origins comes to us courtesy of psychiatrist Charles L. Raison, now at Emory University, and several of his colleagues. According to Raison, the lunar lunacy effect may possess a small kernel of truth in that it may once have been genuine. Raison conjectures that before the advent of outdoor lighting in modern times, the bright light of the full moon deprived people who were living outside—including many who had severe mental disorders—of sleep. Because sleep deprivation often triggers erratic behavior in people with certain psychological conditions, such as bipolar disorder (formerly called manic depression), the full moon may have been linked to a heightened rate of bizarre behaviors in long-bygone eras. So the lunar lunacy effect is, in Raison and his colleagues’ terms, a “cultural fossil.”

We may never know whether this ingenious explanation is correct. But in today’s world at least, the lunar lunacy effect appears to be no better supported than is the idea that the moon is made of green cheese. **M**

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

(Further Reading)

- ◆ **Much Ado about the Full Moon: A Meta-analysis of Lunar-Lunacy Research.** James Rotton and Ivan W. Kelly in *Psychological Bulletin*, Vol. 97, No. 2, pages 286–306; March 1985.
- ◆ **The Moon and Madness Reconsidered.** Charles L. Raison, Haven M. Klein and Morgan Steckler in *Journal of Affective Disorders*, Vol. 53, No. 1, pages 99–106; April 1999.
- ◆ **Pseudoscience and the Paranormal.** Second edition. Terence Hines. Prometheus Books, 2003.

(we're only human)

A Recipe for Motivation

Exercise routine. Gourmet cooking. If it's easy to read about, it must be a cinch to do

BY WRAY HERBERT



ONE OF THE MOST FAMOUS

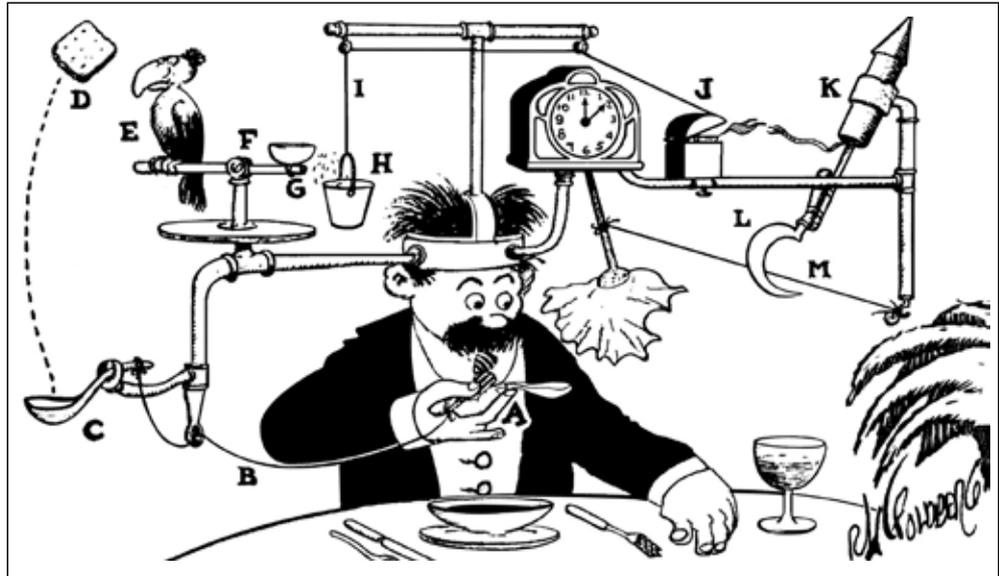
American cartoonists of the 20th century was Rube Goldberg, who was widely known for his “Goldberg machines.” Each of these comical inventions depicted a complex set of “instructions” for completing what should have been a fairly simple everyday task. His Self-Operating Napkin, for example, required 13 sequential steps involving a parrot, a cigar lighter, a rocket and a sickle—along with various strings, springs and pendulums.

The cartoons were funny because they poked good-natured fun at a fundamental irony of human psychology.

People will make even the simplest task much more complicated than it needs to be, yet all this overexplaining rarely helps. Indeed, the opposite is often true: Goldberg’s convoluted “how-to” instructions may make us laugh, but they also leave us feeling exhausted. If that is what it takes to use a napkin, why would we bother?

How Things “Feel”

Psychologists are very interested in the complex interplay of effort, motivation and cognitive crunching—the ease with which we think about a task in our mind. Is it possible that the simplicity (or complexity) of how a task is described and processed—whether it feels “fluid” or “difficult”—actually affects our attitude toward the task itself and ultimately our willingness to put our head down and work?



Rube Goldberg’s Self-Operating Napkin, with its multiple, convoluted steps, poked fun at how people will tend to make simple tasks unnecessarily complicated.

Two psychologists at the University of Michigan at Ann Arbor decided to investigate this idea in their lab. Hyunjin Song and Norbert Schwarz wanted to see if they could motivate a group of 20-year-old college students to exercise regularly. They gave all the students written instructions for a regular exercise routine, but they used a simple yet ingenious method to make the how-to instructions either cognitively palatable or challenging: some received instructions printed in Arial typeface, a plain font designed for easy reading; others got their instructions printed in a Brush font, which basically looks as if it has been written by hand with a Japanese paintbrush—it is unfamiliar and much harder to read.

There are many ways to make something mentally palatable—or not. You

can use clear, straightforward language or arcane vocabulary words; simple sentences or convoluted sentences with lots of clauses.

The psychologists chose to vary the font, because it is easy to manipulate in the lab. After the students had all read the instructions, the researchers asked them some questions about the exercise regimen: how long they thought it would take, whether it would flow naturally or drag on endlessly, whether it would be boring, and so forth. They also queried the students about whether they were likely to make exercise a routine part of their day.

Give It to Me Plain

The findings were remarkable. Those who had read the exercise instructions in an unadorned, accessible typeface

(There are many ways in which to make something seem **mentally palatable**—or not.)

MATT MENDELSON (Herbert); RUBE GOLDBERG IS THE © AND © OF RUBE GOLDBERG, INC. (Self-Operating Napkin)

If unchecked, our tendency to confuse thoughts and actions can make **dubious choices** seem desirable.



The ease of reading about making sushi rolls or doing exercise tricked students' brains into thinking those tasks were also easy to do.

were much more open to the prospect of exercising: they believed that the regimen would take less time and that it would feel more fluid and easy. Most important, they were more willing to make exercise part of their day.

Apparently the students' brains mistook the ease of reading about exercise for the ease of actually doing push-ups and crunches, and this misunderstanding motivated them to think about a life change. Those who struggled through the Japanese brushstrokes had no intention of heading to the gym; the reading alone tired them out.

Song and Schwarz decided to double-check these results with another experiment, this one involving a completely unrelated activity: cooking.

Again they used easy-and hard-to-read typefaces, but in this case the instructions were for making a Japanese sushi roll. After the volunteers had read the recipe, they estimated how long it would

take them to make the dish and whether they were inclined to do it. They were also asked how much skill a professional cook would need to prepare the sushi roll.

The results were basically the same as before. As reported in the October 2008 issue of the journal *Psychological Science*, those who read the instructions in the mentally challenging script saw the task as time-consuming and requiring a high level of culinary skill; they were not apt to try it themselves. They, in effect, viewed the alien writing as a proxy for the actual task and as a result ended up avoiding it. Those who received the more digestible instructions were much more likely to head for the kitchen and sharpen their knives.

Our brains employ all kinds of tricks

and shortcuts to get us through the day with the least mental and physical effort, but it is good to be wary of these automatic judgments. If unchecked, our tendency to confuse thoughts and actions can make dubious choices seem easier and more desirable than they ought to be, or it can discourage us from healthy habits and creative exploration. After all, most of the time using a "self-operating" napkin is just as simple as it appears to be. **M**

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

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

(Further Reading)

- ◆ **If It's Hard to Read, It's Hard to Do: Processing Fluency Affects Effort Prediction and Motivation.** Hyunjin Song and Norbert Schwarz in *Psychological Science*, Vol. 19, No. 10, pages 986-988; October 2008.

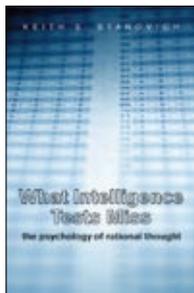
books

MORE THAN IQ

What Intelligence Tests Miss: The Psychology of Rational Thought

by Keith E. Stanovich. Yale University Press, 2009 (\$30)

Clumsy speech, immense overconfidence, heavy reliance on intuition rather than factual evidence: many people associate these attributes with George W. Bush, and some believe, based on these traits, that the former president is a man of inferior intelligence. That is why so many people were stunned when, during the 2004 presidential campaign, Bush's IQ score was estimated to be 120—well above average and about the same as that of his opponent John Kerry. Psychologist Keith Stanovich of the University of Toronto, however, was not surprised at all by Bush's IQ. In his new book he explains why.



Stanovich is convinced that intelligence is different from the ability to make rational decisions and that the two traits do not always co-exist. IQ tests measure only part of our cognitive qualities, he argues, and critical thinking is not included. As a result “some people can have very high IQs but be

remarkably weak when it comes to the ability to think rationally,” he writes. Yet our society is “fixated on assessing intelligence” and completely ignores rationality. Parents and teachers place great emphasis on trying to raise more intelligent children, but teaching kids to become rational human beings receives much less attention—even though critical thinking would be easy to teach, Stanovich says. This oversight is a serious problem because “societal consequences of irrational thinking are profound,” Stanovich adds. For example, jurors have admit-

ted to having made their decisions based on astrology, and Americans waste billions of dollars a year on quack medical remedies.

In *What Intelligence Tests Miss*, Stanovich shows that we have enough knowledge and the right tests to assess rationality as systematically as we determine IQ. So why aren't we doing it? He thinks the reason is a “historical accident.” Because we had measures of intelligence first, IQ tests became ubiquitous early on and have pushed any interest in other cognitive abilities out of our minds ever since.

Stanovich makes a compelling argument that we need to put more emphasis on measuring and teaching critical thinking skills. His clear writing and his many interesting examples make the book accessible and engaging. *What Intelligence Tests Miss* illuminates the actions of everyone who affects our lives, from our family members to our co-workers to former president Bush. —Nicole Branan

Beyond Pets



Made for Each Other: The Biology of the Human-Animal Bond

by Meg Daley Olmert. Da Capo Press, 2009 (\$26)

In 1980 Brooklyn College health scientist Erika Friedmann designed a survey to assess how

social support affects survival after a heart attack. Just for fun, she threw in a question about pet ownership. When she analyzed her results months later, she was startled to find that pets—more

than support from family and friends—kept people alive. Patients who owned pets were 22 percent more likely to be alive a year after their heart attack than those who did not.

No one knew at the time why pets were such excellent “medicine.” But in the decades since, research has revealed that animals and people share a special bond that is based not only on emotions but also on biology—and that relationships with animals keep us healthier and happier. As Meg Daley Olmert writes in her heartwarming and fascinating book *Made for Each Other*, the human-animal bond, which developed over the course of several millennia, shaped our

evolution and that of the animals we love.

About 100,000 years ago, the theory goes, an ice age forced our herbivore hominid ancestors to expand their diet to include meat. Those who had the courage to draw near to the animals they feared probably had some help from oxytocin, a hormone that Olmert argues is key to the animal-human bond. Oxytocin—best known as the hormone that facilitates the mother-child bond—is also important for overcoming fear. The first hominids to approach animals most likely had higher-than-normal levels of oxytocin in their brains. And oxytocin has other effects: it promotes social bonding, reduces stress levels, increases antioxidant production

Creature Kin: Three recent titles also delve into the social and emotional lives of animals.

>> Alex, the famous African grey parrot, surprised people time and time again with his sophisticated understanding of language and numbers. Irene M. Pepperberg reveals the emotional ties to the famous bird behind her research in *Alex & Me:*

How a Scientist and a Parrot Discovered a Hidden World of Animal Intelligence—and Formed a Deep Bond in the Process (Collins, 2008).

>> In *The Social Behavior of Older Animals* (Johns Hopkins University Press, 2008), animal behaviorist Anne Innis Dagg details some common concerns: How does aging affect our

relationships and how others perceive us? By examining the social dynamics of aging mammals and birds, she reveals insights about humans as well.



>> Farm animals are more similar to us than most of us would like to think. Writer Amy Hatkoff explores the remarkable emotions and intelligence of cows, chickens and other barnyard brethren in *The Inner World of Farm Animals: Their Amazing Intellectual, Emotional, and Social Capacities* (Stewart, Tabori & Chang, 2009).

—Compiled by Rachel Mahan

CYRIL RUOSO Minden Pictures (horses)

► **READING FACES**

Lie to Me

FOX, Wednesdays at 9 P.M. EST

"If you see this microexpression in your spouse's face, your marriage is coming to an end," announces Dr. Cal Lightman to a room full of skeptical FBI agents as they watch a recording of a neo-Nazi skinhead accused of planning arson. Lightman, played by Tim Roth in the new TV series *Lie to Me*, has seen something in the convict's face the rest of us might miss, a snarl that flashes by in a split second, called a microexpression. When he freezes the video, the agents and the television audience can recognize the fleeting grimace of anger and scorn.

Lightman's abilities to read faces and solve crimes are based on the real-life work of the field's pioneer, psychologist Paul Ekman, professor emeritus at the University of California, San Francisco. "The big difference between us is that he's pretty cocky, and I'm not," Ekman says. "Lightman tells people what he sees even when he hasn't been asked. I wouldn't want him as my friend." But if Ekman's skills are as impressive as his alter ego's, he has every right to boast. According to Ekman, his



the rest of us, the series provides lessons seamlessly written into each plot on how to tell if someone is prevaricating. "Some of these clues you can learn easily," Ekman promises. "You'll see it on the show once and you'll never miss it again."

Every week he will blog at www.fox.com/lietome about the science behind each episode, such as how experts read the emotions underlying arched eyebrows and dilated pupils. Close-up shots of expressions, such as that of an accused teen as he breaks eye contact to honestly recall events, give the audience an eerie insight into what experts such as Ekman catch us doing all the time. As Lightman says, "The truth is written on all our faces."
—Corey Binns

► **WAR-TORN MEMORY**

Waltz with Bashir

Sony Pictures Classics, 2008

If our brain has built-in mechanisms to block out traumatic memories and if memories are the source of our personalities, then what role do traumatic events play in shaping who we are? That question, along with many others about the nature of memory and personality, underpins the new animated documentary *Waltz with Bashir*.

The movie details Israeli director Ari Folman's quest to unlock memories of his involvement in the massacre of Palestinian civilians during the Lebanese Civil War. After Folman undergoes his first flashback to the war, he contacts a psychiatrist friend to help him determine if his flashback represents a real event or a manufactured memory created by Folman's subconscious.

Folman's choice to use animation rather than live action for this autobiographical work may strike documentary buffs as odd at first, but it ends up serving his subject matter well. A live-action movie might have struggled to represent Folman's intangible psychological experiences visually, whereas animation allows *Waltz with Bashir* to communicate the experience of vivid flashbacks, falsified memories and the alienation induced by post-traumatic stress disorder. The movie mixes recreations of actual events with impressionistic fantasy sequences and interviews with Folman's friends, comrades and psychiatrists.

At the movie's U.S. premiere at the New York Film Festival, Folman said he was inspired by research that described a repressed memory as a nut in a shell. Although other memories fade over time, the repressed memories remain fresh but inaccessible within their casing. Folman made *Waltz with Bashir* for the specific purpose of cracking that shell, exhuming those memories and exploring his subconscious to find out who he really is. In doing so, he created a rare glimpse into the psychological effects of war. —Stuart Fox



and promotes happiness. So when oxytocin-rich hominids started focusing on animals, even though their intention was to hunt them, they probably also started bonding with them. This emotional connection then released more oxytocin, building a self-propagating cycle.

Over the course of the next 100,000 years, human-animal relationships solidified. According to Olmert, women occasionally breast-fed wolf pups and children sometimes suckled milk from cows' udders. This bond started influencing the evolution of both humans and animals as we lived together and learned from one another. The surges of oxytocin our ancestors enjoyed also kept them healthy and happy. We needed animals, and they needed us.

Today in our urban and technological culture, we have only the faintest memories of these incredible ties. But our continued love for pets is evidence that we have not forgotten entirely. Still, only 63 percent of Americans own pets. As a population, we may not be getting the same oxytocin doses we used to, which could have negative effects on our well-being. Olmert makes a convincing case that we are better off with them in our lives.

"Clinically speaking, animals are a homeostatic necessity," she writes. "Like breathing, they can only be denied for so long."
—Melinda Wenner

asktheBrains

Is it true that people can have a midlife crisis, or is it a myth?

—Paul Graham, Pleasantville, N.Y.



David Almeida, professor of human development and family studies at Pennsylvania State University, responds:

MANY PEOPLE EXPECT that midlife brings forth inevitable crisis, but that idea is not supported by social science. In fact, only 26 percent of adults older than 40 reported having a crisis, according to a recent study. That is not to say that the middle-aged do not experience challenges and psychological distress, but these feelings tend to be brought on by stressful events, such as health problems or losing a parent—not by age alone.

The notion of the midlife crisis began with followers of Sigmund Freud, who thought that during middle age everyone's thoughts were driven by the fear of impending death. Although plenty of aging people try to cling to their youth, my research shows that the middle-aged are actually happier and more satisfied with their daily life than younger adults are. They have found their way in the world, they are settled into their job, and their kids are older. On average, midlife is a happy time.

Midlife crises are often defined by someone else's perception rather than our own. A lot of the stereotypical hallmarks, such as the sudden purchase of an expensive sports car, probably have more to do with improved financial status than with a search for youth. People can finally afford some finer, more expensive pleasures.

We also do not see many genuine midlife crises because middle-aged adults simply do not have time for a crisis. In this period they are often responsible for their children and their aging parents. They also move into management positions and have additional responsibilities at work.

The concept of the midlife crisis sometimes serves as a convenient excuse for behaviors that just happen to take place in one's 40s or 50s. Dissatisfaction in your job? Relationship problems? There are a multitude of explanations for these experiences—and although it may seem easy to blame a midlife crisis, age most likely has nothing to do with it.

Why does listening to music make it so much easier for me to complete a challenging workout?

—Rachel Birkey, San Francisco



Mark A. W. Andrews, professor of physiology and director of the Independent Study Pathway at the Lake Erie College of Osteopathic Medicine, replies:

MOST OF US have experienced the boost music brings to a workout—increased motivation, distraction from fatigue and the perception that time is passing more quickly. Indeed, working out with music has been proved to increase physical performance and levels of alertness, and it may aid the release of brain chemicals that influence mood.

Recent research confirms that listening to music is especially advantageous in boosting physical performance among those needing to exercise to help with obesity or heart problems. Music has been found to increase physical performance by more than 20 percent in many such individuals because they perceive their workout to be easier.

Prehistoric evidence suggests that making and listening to music is one of the basic actions of humans. Even infants react to upbeat music by moving their arms and legs rhythmically. Like music, aerobic exercise and basic physiological functions such as heartbeat and respiration involve rhythmic activity. Because the body is used to rhythms, the

Although plenty of aging people try to cling to their youth, my research shows that the middle-aged are actually happier and more satisfied with daily life than younger adults are.

influence of a beat helps us to readily organize our physical movements.

In the case of aerobic exercise, a straightforward, high-paced rhythm seems to be an important aspect. Research indicates that genres such as heavy metal, fast pop and hip-hop are best able to excite the nervous system and aid physical behavior and self-expression. Although evidence is incomplete, such music may also help generate the fast-paced beta waves in the brain, which are characteristic of a strongly engaged, aroused and, most important, motivated mind. In addition, music and rhythmic motion may encourage the brain to release opioids, chemicals related to pleasure and euphoria.

On the other hand, although hard rock has an appropriate speed of rhythm, some hard rock appears to destroy the symmetry between the cerebral hemispheres and induce alarm, causing performance to decrease, possibly because of irregular beats and shrill frequencies. And weight training differs from rhythmic aerobic exercise in that it is not so dependent on a fast pace—performance seems to benefit from medium tempo music coupled with inspirational lyrics. **M**

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

Head Games

Match wits with the Mensa puzzlers

1 HIDE-A-WORD

Form six 9-letter words by arranging the 3-letter blocks correctly in the grid. What "brainy" bonus word now appears in one of the vertical columns?

						U	C	K
						H	A	L
						I	N	K
						C	H	E
						O	N	E
						O	U	S

A	N	K	B	E	T	O	X	I
D	C	H	E	R	L	R	O	T
H	E	A	H	Y	P	R	T	A
L	E	B	O	B	N	W	O	O

2 SIGNS IN DISGUISE

These phrases started as common road signs, but one letter in each word has been changed, and sometimes the resulting words have been rearranged. What did the signs say?

- a) TEN WORD AD
- b) FILL SHEEP
- c) MIGHT GO IN BED
- d) PAW DOLL

5 SNOOTS

The folks of Snooterville have some strong likes and dislikes. For example, Cora likes mice and rats but dislikes kittens and dogs. And Enos likes wine and women, but he can't abide song. Figure out what these other snooty people like and dislike.

- Does Ringo like the beautiful or the grotesque?
- Does Randy like Mary or Sandra?
- Does Sandra like berries or grapes?
- Does Justin like Randy or Ringo?
- Does the football team's halfback like Flaherty or Mahoney?

3 SUBTRACTION

Fill in each row with a 5-letter word and three smaller words found inside it. Subtract the first letter to make the first 4-letter word. Subtract the last letter to make the second 4-letter word. Subtract both letters to make the final 3-letter word. Use the definitions as clues for the first and last words.

dirt _____ edge
 sudden rush/ _____ gentle tap
 increase _____
 world _____ easy throw

4 PLACE YOUR BET

Three gamblers are playing a subtraction game. They each pick a different number between 1 and 100, then subtract the numbers from one another until someone hits 0 and has to pay up.

Assume Andy has the highest number, Beth the middle number and Charlie the lowest number. First Beth subtracts her number from Andy's. This result is Andy's new number. Then Charlie subtracts his number from Beth's, and the result is Beth's new number. Then Andy subtracts his new number from Charlie's number. This routine goes on until one player ends up with 0 or a negative number. That player loses and has to pay the other two.

In their first game Andy picked 100, Beth picked 60, and Charlie picked 40. Here's how the action went:

A	B	C
100	60	40
40	20	0 and Charlie is the loser.

In their second game Andy picked 100 again, and Charlie picked 50. Beth's number was less than 75 but greater than 50. Who lost?

Answers

5. Read each name as a statement: Cora likes "c," or "a," and Enos likes "e" but not "s." Ringo ("r" in "go") likes the grotesque. Randy ("r" and "y") likes Mary. Sandra ("s" and "ra") likes grapes. Justin (just "in") likes Ringo. Halfback ("half" back) likes Flaherty.

2. a) Men at work
 b) Steep hill
 c) No right on red
 d) Pay toll
 3. Grime, rime, grim, rim; Spate, pate, spat, pat; Globe, lobe, glob, lob.
 4. No matter which number between 75 and 50 Beth picked, she lost.

S	U	O	I	X	O	N	B	O
E	N	O	B	E	L	K	N	A
E	H	C	A	R	T	A	E	H
K	N	I	L	R	E	P	Y	H
L	A	O	T	R	O	T	H	B
K	C	H	U	C	D	O	O	W

1. CORTEX.