CAN INFECTIONS CAUSE MENTAL ILLNESS? page 40

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Who's That?
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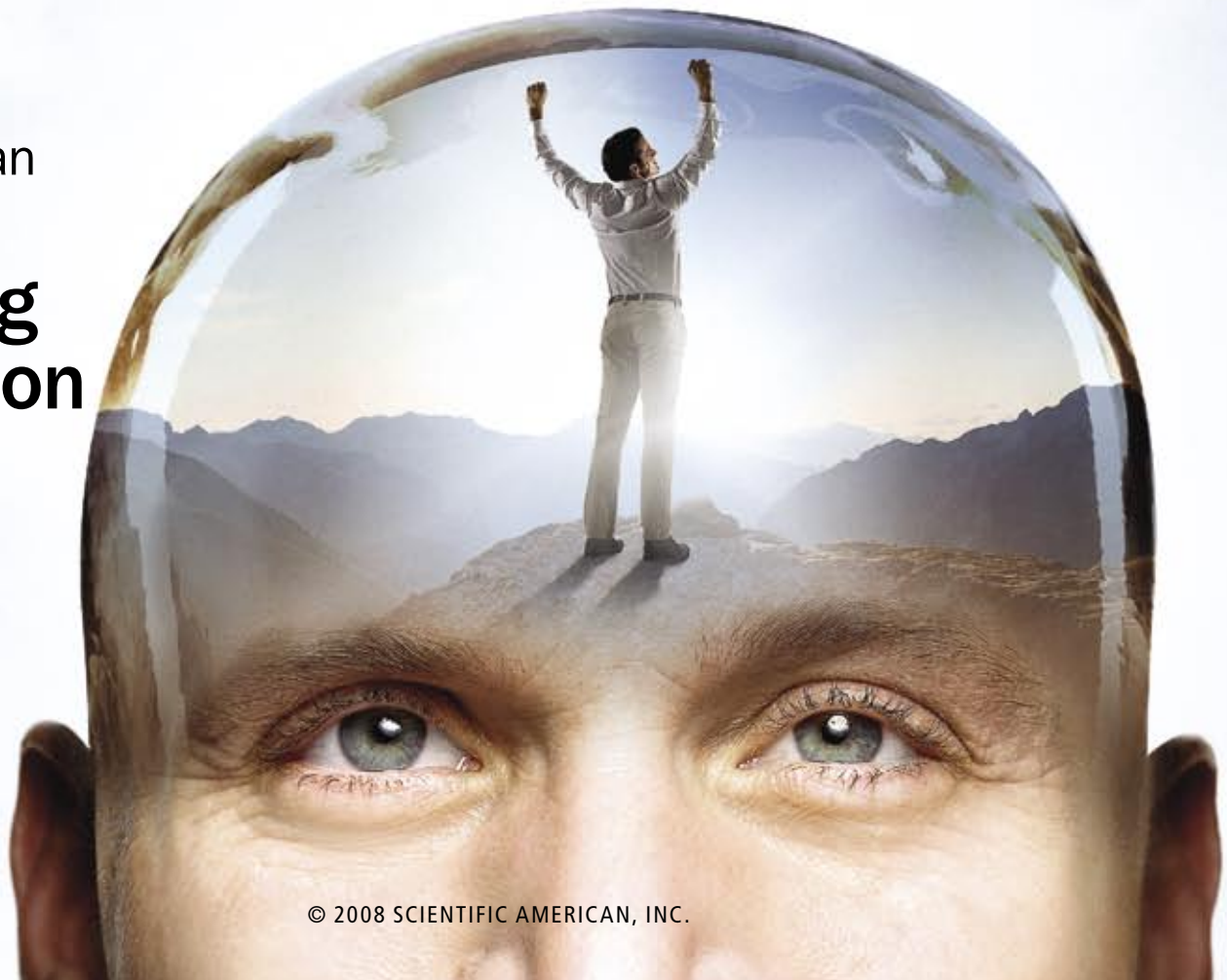

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COVER IMAGE BY AARON GOODMAN

Great Expectations

A headline in the *New York Times* drew my eye this morning: "On a Battlefield of Civil Rights, Race Fades for Some Voters." The story reported that "voters in an Alabama county that is more than 96 percent white chose a genial black man, James Fields, to represent them in the State House of Representatives." Why, you might ask, is that front-page news more than 100 years after the Civil War?

Part of the answer is that we are still using brains evolved over millions of years to prefer what social psychologists call our "in-group"—those with whom we identify, who historically could help us survive as members of our collaborative tribe or clan. Our brains use shortcuts for such social identification, swiftly categorizing others—and ourselves—to avoid the energy-intensive processing of conscious thought. Often we do not even realize how extensively subconscious stereotypes shape our reactions, as two feature articles in this issue reveal.

The first, "The Social Psychology of Success," by S. Alexander Haslam, Jessica Salvatore, Thomas Kessler and Stephen D. Reicher, looks at behavioral aspects. It explains how people's performance is shaped by awareness of stereotypes. For example, when solving math problems, Asian women who think of themselves as female (stereotypically worse at math as compared with males) will perform less well than if they think of themselves as Asian (stereotypically better at math). Turn to page 24 to learn how to throw off the yoke of expectation. The second article, "Buried Prejudice," by Siri Carpenter, digs into the neuroscience of implicit bias and how it affects cognition. Even basic visual preferences are skewed toward in-groups; studies show that we remember faces better if they match our own racial group. The article starts on page 32.

Are we stuck with our mental stereotypes? Not at all. After all, knowledge (about the brain) is power. As Haslam and company conclude, we "can learn to use stereotypes as tools of our own liberation. In short, who we think we are determines both how we perform and what we are able to become."

Mariette DiChristina
Executive Editor
editors@SciAmMind.com

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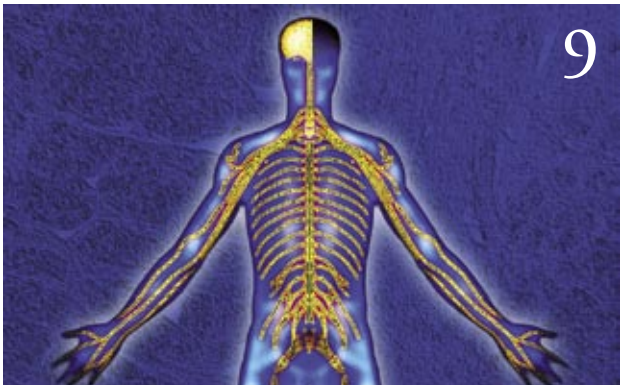
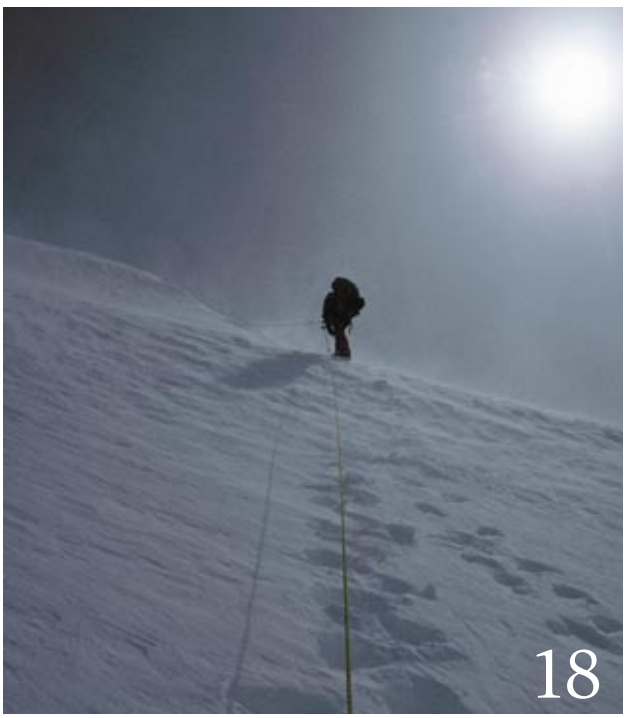
FEATURES

DEPARTMENTS





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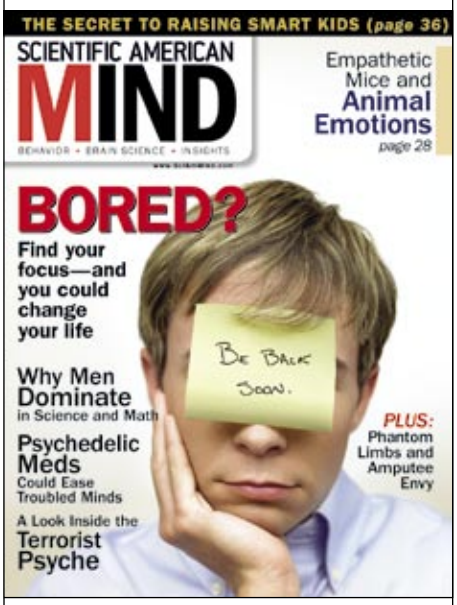


WOMEN IN SCIENCE

I was surprised that the design of math and science curricula was not addressed in the article "Sex, Math and Scientific Achievement," by Diane F. Halpern, Camilla P. Benbow, David C. Geary, Ruben C. Gur, Janet Shibley Hyde and Morton Ann Gernsbacher. Traditionally, instruction in these fields has almost exclusively used a method of thought and communication that appeals more strongly to males than females.

Your article raised the issue of differing visuospatial skills between genders. It may not be the case that male minds more easily grasp the information being disseminated; it is possible that *how* this information is presented can make a difference in skill sets. Males have dominated the fields of science and math for centuries, and the manner in which they have undertaken research, compiled educational texts and designed curricula has affected how children are taught this information and, therefore, how they respond to it.

Rachel Lindley
Edmonton, Alberta

"Sex, Math and Scientific Achievement" was very disappointing in an otherwise enjoyable publication. Your highly unscientific opinion that social psychologists have decided that "the overt sexism that existed decades ago in the U.S. and in many other countries is now rare" is simply laughable. Stating this puts the phenomenon of lower female participation in the sciences squarely on women's shoulders.

I realize that objectivity is important when reporting scientific data. Nevertheless, in playing it safe with this article, the authors provide readers with little (if any) enlightenment on the topic. And in this regard, they are no better than profoundly misogynist, ignorant and biased individuals such as Larry Summers.

Name withheld
Mountain View, Calif.

Having read more than a few articles by various researchers on the topic of the gender gap in science and math careers, I cannot sit back any longer. These researchers all seem to miss a potentially significant variable—the impact of autism spectrum disorders (ASD). Here is a sex difference for the authors to discuss: autism in general has an approximate 4 to 1 ratio of males to females. At the high-functioning end of the spectrum, such as among those of us with Asperger's syndrome, the ratio is even greater.

"Normal" people usually have an even spread of abilities, whereas those of us with high-functioning ASD tend to have a very uneven spread of abilities. Our visuospatial skills are usually better than average, whereas our social-verbal skills tend to be worse than average. Often these abilities are much better and much worse, respectively. As such, those of us "Aspies" who succeed tend to be drawn toward deterministic fields of endeavor in which solutions are black-and-white, such as engineering, computers, math and physics—and most of us are men.

Larry D. Moody
via e-mail

I would like to make a recommendation. Women typically handle the family finances and are quite gifted at managing money in hard economic

times. Working women, however, are still being paid roughly 77 percent of what men are paid for similar jobs. Given that women are acutely aware of finance, universities might consider offering their science degrees to women at a 23 percent tuition discount. An economic incentive might be the right solution.

Ola Marra Cook
Campbell, Calif.

FAMILY VALUES

In "Inside the Terrorist Mind," Annette Schaefer rightly notes that most terrorists are not mentally ill. I would like to add that there is a common family dynamic found in many individual histories of male terrorists: the authoritarian family, which I discuss in my article "'I Came with a Sword on Judgment Day': A Psychoanalytic Look at Terrorist Enactments" (*Psychoanalytic Review,* Vol. 94, No. 5; October 2007).

Some idealistic young men raised in authoritarian families may identify with the poor and needy and search to establish an equitable society. Although they may be seeking to correct social injustice, they also need to find a way to express their rage toward their fathers, who have humiliated and abused them. That rage can morph into explosive tragedies.

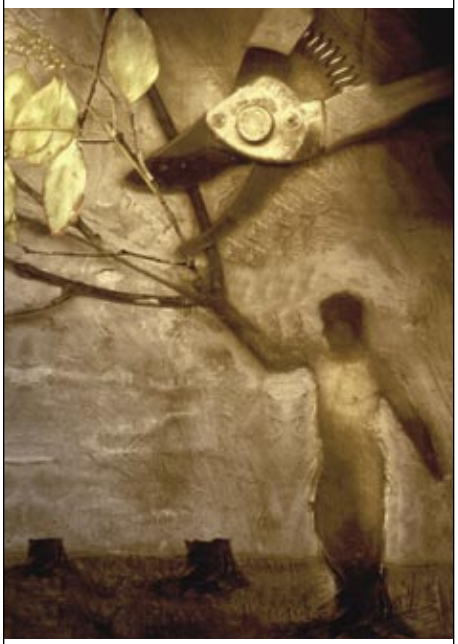
Women in these families are often deemed "soft" and incompetent, as are the peaceful methods that can be used toward establishing justice. Nonviolent means are rejected.

Lynn Somerstein
New York City

IMPAIRMENT ENVY

I was pleased to see an article about body integrity identity disorder (BIID)—"Amputee Envy," by Sabine Mueller—in *Scientific American Mind*.

As someone who has BIID, and as an advocate for BIID sufferers, I was disappointed that the author discussed only amputation as a focus of BIID, ignoring the fact that BIID sufferers may require other impairments, such as paralysis (which is my need), blindness or deafness. Michael First of Columbia University is currently conducting research that builds on his studies cited in your article. We expect him to prove that these nonamputation needs indeed exist as part of BIID.



Losing a limb may not be enough.

I have made additional, detailed comments about the article online at http://biid-info.org/Amputee_Envy. I welcome further discussion.

Sean O'Connor
via e-mail

MIRROR POWER

In "Living with Ghostly Limbs," Miguel Nicolelis generously cites our original experiments, first reported in 1994, on the use of visual feedback to treat phantom-limb pain and stroke-related paralysis. He points out correctly that although many patients report relief from phantom pain after using visual feedback (whether with mirrors or virtual reality), some do not. Several recent studies suggest, however, that a substantial number of patients in fact show striking—sometimes complete—recovery from pain.

In a study by Jack Tsao's group at Walter Reed Army Medical Center, for example, three groups of about eight patients each received one of three treatments: mirror feedback, a placebo involving guided visual imagery or a placebo using an opaque plate instead of a mirror. All patients who used mirror feedback experienced a striking reduction in pain—almost total elimination—after four weeks. The groups who received the placebo treatments showed an increase in pain. These patients were then switched to mirror feedback, and four weeks later they also felt less pain.

In 1994 we also suggested (and in 1999, with Eric Altschuler, we showed experimentally) that visual feedback can help recovery from stroke; this finding, too, was confirmed in subsequent studies, such as those by Güneş Yavuzer of Ankara University in Turkey.

A paradigm shift is under way. Instead of being composed of hardwired modules (such as a "pain module" or "vision module"), the brain is made up of highly malleable modules that are in a state of dynamic equilibrium with sensory inputs and with one another. Disease often results from shifts in this equilibrium rather than the permanent destruction of neural tissue. Sometimes equilibrium can be restored with as simple a procedure as using a mirror to hit a "reset" button.

Vilayanur S. Ramachandran and Diane Rogers-Ramachandran
University of California, San Diego

MIGRAINE'S TRIGGERS

As a neurologist, I read with interest Rodger A. Sanders's story about how his wife developed a migraine after she performed the Ramachandrans' mirror experiment ["Mirror-Induced Migraine," Letters]. Sanders asked if he and his wife had found a new cause for migraines.

Migraine triggers include odors, flashbulbs, sunlight reflecting off water, loud noises, and even striped or checkered patterns. One of my patients became violently ill when she saw her reflection in a distorting mirror. Sensory inputs are known to cause migraines; although Sanders's story is interesting, it is not news.

Karen P. Lauze
Portsmouth, N.H.

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Head Lines

KAADAA *Getty Images*

>> MEMORY

Just a Smile

Why putting on a friendly face might make you more memorable

"You're never fully dressed without a smile," sang Little Orphan Annie in the Broadway musical. It turns out Annie may have been giving some shrewd advice—studies have repeatedly shown that people remember smiling faces better than neutral ones. Now researchers at Duke University have found a physical explanation for the phenomenon. Roberto Cabeza and his colleagues "introduced" volunteers to a number of people by showing them a picture and telling them a name. Using MRI, the investigators found that both learning and recalling the names associated with smiling faces preferentially activated the orbitofrontal cortex, an area of the brain involved in reward processing. Cabeza says that although the studies are preliminary, it makes evolutionary sense that a smile would be rewarding to the onlooker. "We are sensitive to positive social signals," Cabeza explains. "We want to remember people who were kind to us, in case we interact with them in the future." —*Katherine Leitzell*

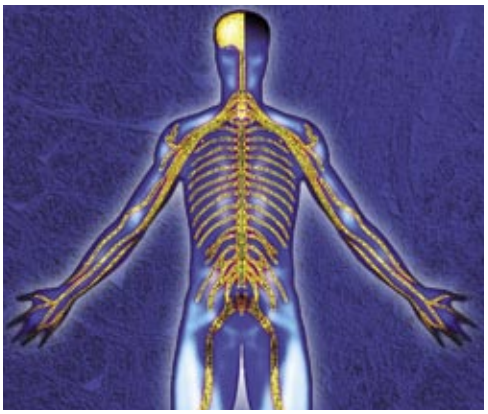
>> REHABILITATION

One Hemisphere, Two Hands

With a prosthetic, one side of the brain could control both sides of the body

One of the first things neuroscience students learn is that the brain's right hemisphere controls the left side of the body, and vice versa. Brain-computer interfaces, which employ brain signals to control an external device such as a robotic arm or a wheelchair, also utilize these opposing-side signals. Such technology is therefore unable to help victims of stroke and brain trauma, who often have one seriously damaged hemisphere that cannot be enlisted for motor commands.

But scientists now think they may be able to work around that limitation. Emerging research suggests that in addition to controlling the opposite side of the body, a given hemisphere allocates about 10 to 15 percent of its neurons to controlling the same side. A team led by neurosurgeon Eric Leuthardt of the Washington University School of Medicine in St. Louis has shown for the first time that these same-side signals can be picked up by a brain-computer interface and used to control an external device.



Leuthardt's group worked with several epileptic patients who had neural sensor grids implanted for the purpose of localizing their seizures, providing a unique opportunity for the researchers to monitor cerebral activity. Three patients learned to use neuronal signals associated with same-side movements to control a cursor on a screen and play a video game. Leuthardt hopes to one day develop a prosthetic that uses these signals to improve motor control of a dysfunctional limb—effectively allowing a stroke patient's one healthy hemisphere to control both sides of his or her body. *—Sara Goudarzi*

>> MEDICINE

Brain Injury's Toll

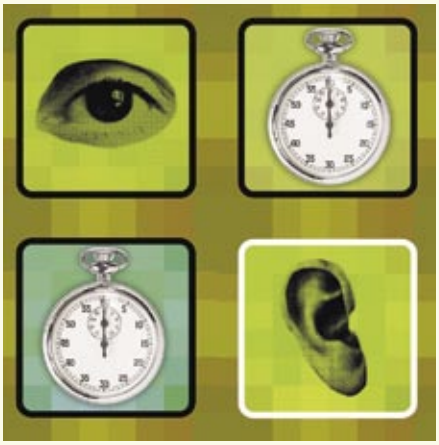
Aging veterans with head trauma experience faster cognitive decline

Traumatic brain injuries are commonplace during combat; two thirds of soldiers sent to Walter Reed Army Medical Center from Iraq suffer from such injuries. A new study of aging Vietnam veterans with head trauma paints a grim picture of the future for troops returning from Iraq with similar wounds.

Jordan Grafman, a neuroscientist at the National Institute of Neurological Disorders and Stroke, led a study of Vietnam veterans who had suffered penetrating head injuries—trauma caused in these cases by shrapnel or bullets entering the brain. His team found that as these veterans aged their cognitive function declined almost twice as fast as that of their peers. High preinjury intelligence, however, did help protect against this drop. So did education. "The more education you have, the more you're able to stave off the effects of the injury, including even effects of later decline," Grafman says. The researchers also identified genetic variants that seem to predict a more pronounced deterioration.

The findings will likely apply to Iraq veterans suffering from the same kinds of wounds, Grafman notes. These veterans should expect an accelerated cognitive decline, and their physicians should be careful not to confuse it with other neurological conditions. "We know that this is going to happen in veterans who had head injury," he says. "They need monitoring and reassurance that this is not dementia." *—Emily Anthes*

PASIEKA/SPL/PHOTO RESEARCHERS, INC. (*top*); ROBERT A. SABO *Getty Images* (*bottom*)



>> THE SENSES

Competing Clocks

In timing a short event, your eyes may deceive your ears

Your tennis partner whacks the ball, and in a split second you are lunging for it—but is it the sound of the hit or the sight of the ball that tells your brain when to react? Recent research indicates that each sense has its own clock for judging the timing and duration of fleeting stimuli, but it is unclear how these clocks interact. One new study suggests they can override and deceive one another.

Neuroscientists led by Virginie van Wassenhove of the California Institute of Technology found that a visual time-stretching illusion could alter volunteers' perception of audio stimuli, whereas an audio illusion had no such power over visual perception. The researchers flashed five gray disks paired with uniform half-second tones and asked subjects if the fourth tone was longer or shorter than the others. When the tone was paired with an expanding disk, the subjects incorrectly perceived it as being longer than the other tones, which were paired with stationary disks. But when the team tried pairing uniform disks with even tones versus tones that were rising in pitch—an audio trick that by itself causes a similar illusion of time dilation—the subjects were not fooled. They correctly perceived all disks and tones as equal in duration.

The ability of the brain's visual timekeeper to override its auditory timekeeper probably reflects our brain's tendency to give more weight to signals that might represent a threat, according to Marc Wittmann, a time researcher at the University of California, San Diego, who was not involved in the study. The expanding disk resembles an approaching object, which "has emotional value, like a dog running toward you," he says. Emotional events are stored in our memory in more detail and therefore seem to have transpired over a longer period.

It remains to be seen whether the visual clock will always trump the audio clock or whether the reverse could happen in certain situations. Nevertheless, the study is an important first step in the effort to understand the interactions among the sensory stopwatches in our brain. —*Christopher Intagliata*

What you hear is based not entirely on sound but also on what you see.

>> PARENTING

Mother's Milk

Does breast-feeding tune your brain to your baby?

Doctors agree that when it comes to feeding your baby, breast is best. Most research has focused on health advantages to the infant and, more recently, on physiological and psychological benefits for the mother. Now research highlights a mechanism by which nursing may influence the mother-infant bond: it seems the brain of a breast-feeding mother is especially receptive to signals from her baby.

Graduate student Pilyoung Kim and her colleagues at Yale University's Child Study Center used functional MRI to scan the brains of 20 women while exposing them to their baby's cry or image. Preliminary results suggest that three weeks after giving birth, breast-feeding mothers showed greater responses to indicators of their own infant (as compared with those of another baby) than formula-feeding mothers did, especially in limbic, hypothalamic and midbrain areas—brain regions involved in emotion and motivation.

Kim's team believes this difference stems mostly from oxytocin, a hormone that has received much attention for its role in social bonding. Nursing stimulates the production of oxytocin, which is thought to facilitate a mother's attentiveness to her baby.

Three to four months after they gave birth, the difference in the overall amount of brain activity between breast- and formula-feeding moms was smaller, suggesting that over time a mother's reaction to her infant may start to depend more on experience than on hormone levels. The areas of the brain more strongly activated in formula-feeding mothers, however, were different from those activated in breast-feeding mothers. They included the prefrontal cortex and other regions typically linked to social and cognitive behaviors.

Because all the subjects in this study were healthy women from similar backgrounds, Kim warns that the specific patterns of brain activation found in this study may not generalize to a more diverse population. The results may be valuable, however, for mothers who have trouble with their newborns because of depression or environmental factors such as poverty. Breast-feeding could be one way for these mothers to tap into the positive cycle involving oxytocin and the early mother-infant relationship, which has long-lasting effects on a child's development. —*Rachel Dvoskin*

AGE FOTOSTOCK (*top*); PICTURE PARTNERS/AGE FOTOSTOCK (*bottom*)

>> POLITICS

In Your Face

TV viewers are less tolerant of opposing views during extreme close-ups

JASON REED *Reuters/Landov*

They have been dubbed the "shouting heads"—television pundits who treat political discussion more as blood sport than reasoned argument. But new research suggests the problem is not just the shouting; our annoyance also comes from the apparent size of those heads.

Shouting combined with extreme close-ups tends to make viewers less tolerant of opposing political viewpoints, according to Diana Mutz, a political scientist at the University of Pennsylvania. "It takes people we would dislike regardless, and then it puts them in our faces in a way that truly intensifies our negative sentiments," she says.

When we see a magnified face on television, we react as if a real person were pushing into our comfort zone. When that face is also shouting political statements we disagree with, our dislike of the person seems to color our perception of his or her political opinions as well, Mutz observes.

Mutz filmed professional actors engaged in a mock political debate from a medium distance and in extreme close-up. She shot polite versions of the debate, as well as versions with interruptions, shouts and name-calling.

Volunteers who saw close-up shots of rude people they disagreed with were more likely to judge the opinions being expressed as illegitimate. They judged the same rudely expressed opinions as being more valid, however, when the talking heads had been filmed at a medium distance.

Mutz sees disagreement as a healthy part of democracy but worries when people feel that the opposition does not have a legitimate point of view. If these people were to see their side lose, she points out, they might begin to question the legitimacy of the government itself. —*Kurt Kleiner*

>> NEUROECONOMICS

Paying for Pleasure

Wine tastes better when we think it costs more money

Do we get more when we pay more? A new study suggests that we do—our brain seems to equate price with pleasure.

Twenty volunteers had their brains scanned using functional MRI while they tasted five supposedly different cabernet sauvignons, each identified by a different price. In fact, there were only three different wines, two of which were presented twice, once at a high price and once at a low price.

The trick worked as expected. The volunteers rated the wines according to their stated price: the "cheapest" tasted cheap, and the most "expensive" was everybody's favorite. But not only did the wine tasters report liking the pricier choices better, they also showed an increase in activity in the medial orbitofrontal cortex, an area of the brain that previous studies suggest might encode for the pleasantness of an experience.

Changing expectation by changing a marketing variable such as price can have a measurable effect on pleasure-related brain activity, says Antonio Rangel of the California Institute of Technology, an author of the study. But take note, marketers: the recipe may not be so easy—after all, now consumers know the trick.

—Graciela Flores

>> LEARNING

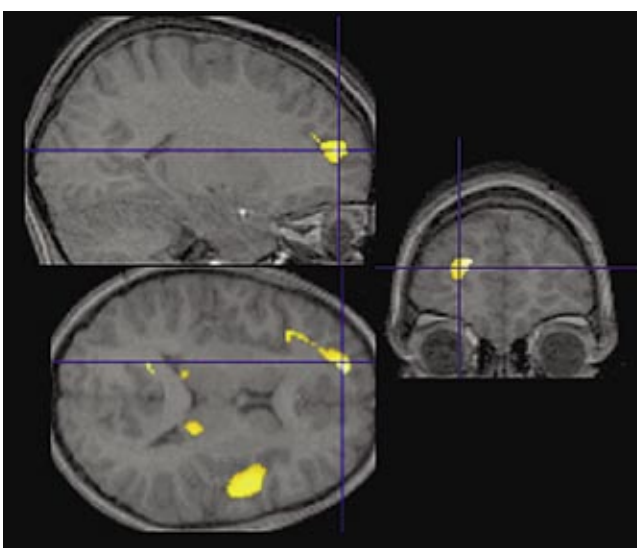
Sounding Out Dyslexia

Exercising auditory regions helps to rewire the brain

Children with dyslexia have trouble reading and writing, but the root of the problem may actually be in their brain's sound-processing regions. A new study found that targeting these areas with a workout disguised as a video game improved dyslexic children's literary skills.

Researchers at Children's Hospital Boston examined 23 typical 10-year-old readers with fMRI as they listened to rapid sound shifts common in spoken language, which elicited activity from 11 distinct areas in the children's brains. When 22 dyslexic readers of the same age took the challenge, none of these areas showed any activity at all. "This was a surprise," says lead researcher Nadine Gaab.

With practice, dyslexic children may be able to improve their brain's ability to distinguish rapid sounds.



The left prefrontal region indicated by the crosshairs is involved in distinguishing word boundaries. This area is one of many (*yellow*) that were inactive in dyslexic kids.

To activate the dysfunctional circuitry, the team had the dyslexic children play video games designed to exercise brain centers associated with rapid sound recognition. The results were dramatic: tests two months later showed that all the dyslexic children reached parity with normal readers in the critical areas of listening comprehension and word recognition. Scores in other areas such as reading comprehension fell short of those of normal readers but still represented a vast improvement.

The improvement was also reflected in brain activity. Follow-up scans showed increasing activity in the 11 areas associated with processing sound. But will the fix stick? "That's a study that still needs to be done," Gaab says.

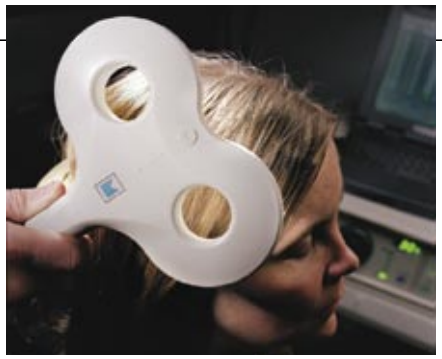
—Sandy Fritz

GETTY IMAGES (*top*); FROM "NEURAL CORRELATES OF RAPID AUDITORY PROCESSING ARE DISRUPTED IN CHILDREN WITH DEVELOPMENTAL DYSLEXIA AND AMELIORATED WITH TRAINING: AN FMRI STUDY," BY N. GAAB, J.D.E. GABRIELI, G. K. DEUTSCH, P. TALLAL AND E. TEMPLE, IN *RESTORATIVE NEUROLOGY AND NEUROSCIENCE*, VOL. 25, NOS. 3–4; 2007 (*bottom*)

>> TECHNOLOGY

A Magnetic Boost

Activating certain neurons may alleviate depression



Up to 40 percent of people with depression do not respond to antidepressant medication. For these patients, hope may come in the form of transcranial magnetic stimulation, or TMS, a technique that activates neurons by sending pulses of magnetic energy into the brain.

Although researchers have been studying the effects of TMS on depression for more than 10 years, it has been largely viewed as an experimental procedure because of concerns about safety issues, such as seizures. Now psychiatrists at the University of Pennsylvania report successful results from the largest-ever trial of TMS, countering many critics' doubts. The team tested about 300 patients with major depression who had failed to respond to medication and found that those who received about 40 minutes of TMS daily for four weeks experienced significant symptomatic improvement. No major side effects were reported, although the technique is not recommended for anyone with a history of seizures.

TMS delivers its neuron-activating magnetic field via small metallic coils attached to the scalp, which investigators can position to target specific brain areas. In this study, the team targeted a region of the prefrontal cortex previously shown to be less active in depressed subjects. Because TMS is both noninvasive and precise in aim, the technique readily lends itself to unusual research, from triggering ordinary people's inner mathematical savant to studying the root of religious experience (in its incarnation as the "God helmet" [see "Searching for God in the Brain," by David Biello; SciAmMind, October/November 2007]).

Although TMS is already available to patients in Australia and Canada, stricter regulations mean it could be several months to years before patients in the U.S. have access to the therapy, says John O'Reardon, lead author of the new study. He and other experts believe that eventually TMS will also help patients with schizophrenia, bipolar disorder and Tourette's syndrome. *—Erica Westly*

>> SPEECH

Wait, Don't Tell Me ...

The brain region responsible for that word on the tip of your tongue

We all know the maddening experience of not being able to think of a certain word that is undoubtedly in our repertoire. Now researchers have discovered an association between a specific region in the neural language system and these tip-of-the-tongue (TOT) experiences, which are a normal part of aging. Deborah Burke of Pomona College and her team found that TOT moments became more frequent as gray matter density in the left insula declined. This area of the brain has been implicated in sound processing and production. The findings support a model proposed by Burke and her colleagues, which predicts that when we do not often use a word the connections among all its various representations in the brain become weak. "Words aren't stored as a unit," Burke says. "Instead you have the sound information connected to semantic information, connected to grammatical information, and so on. But the sounds are much more vulnerable to decay over time than other kinds of information, and that leads to the TOT experience." *—Nicole Branan*

JAMES SALZANO/IMAGING BY TRILOBYTE (*top*); JUPITERIMAGES (*bottom*)

>> HUMOR

The Eyes Get It

Our pupils dilate the moment we realize a joke is funny

We have all experienced the "aha" moment when a joke suddenly makes sense, and scientists have long tried to figure out what happens in our brain during that crucial split second. Now a researcher at the University of Michigan at Ann Arbor has found a window into that state of mind: the eyes.

Humor psychologist Richard Lewis (no relation to the comedian) was intrigued by past studies showing that a person's pupils dilate in proportion to the funniness of a cartoon he or she is looking at. He took a closer look at this eye reflex by showing volunteers cartoons from the *New Yorker* magazine and using an eye-tracking device to monitor their pupil dilation and eye movements. The subjects' pupils dilated about half a second after their gaze fell on the regions of a cartoon that were critical in making it funny—a period that is very similar to the time it takes our brain to derive meaning from words we read. "The nice thing about combining pupil dilation with eye tracking," Lewis explains, "is that we can now pinpoint the 'got it' moment."

Determining this moment with pupil dilation, which Lewis thinks is most likely a basic arousal response, could aid researchers who investigate humor-related brain activity with MRI or electroencephalography. So far scientists have found several brain areas, including the reward system, to be associated more generally with our sense of humor; it appears we do not have a distinct neurological funny bone.

But why do we have a sense of humor in the first place? According to Lewis, psychologists are just beginning to discover its relation to other cognitive processes that seemingly lie outside the realm of the funny, such as our ability to gauge the thoughts of others. "This is all part of looking at the state humor puts you and your brain in and how that affects other things you do," Lewis says. "This will help us piece together the puzzle of what humor is for."

—Peter Sergo

Comedy and Culture

In another of the spate of recent studies to probe the effect of culture on information processing in the brain, Richard Lewis of the University of Michigan at Ann Arbor showed that East Asians analyze cartoons differently than Americans do. Using culturally nonspecific cartoons, he found that East Asians first take the background context into account, whereas Americans initially concentrate on objects in the foreground. This holistic-versus-pointed focus matches the findings of other comparative studies and probably results from the different cultures' outlooks. *—P.S.*

FAST FACTS

- **Cocaine, kissing** and chocolate all arouse the brain's "feel good" dopamine reward system. Now neuroscientists at Vanderbilt University suggest that aggressive behavior can provide a dopamine reward as well, a result that may explain some people's thirst to karate-chop or tackle. When the scientists suppressed the dopamine system in bellicose mice, the rodents' desire to box or bite intruders was dramatically curbed.

- **The search for** a way to predict dementia now points to telomeres, the caps on the ends of chromosomes that help to prevent damage to genes during replication. Telomeres naturally wear down as a person ages, but Harvard Medical School epidemiologists now report that women with shorter-than-average telomeres are 12 times more likely to develop mild cognitive impairment, a precursor to dementia. With this news comes yet another reason to stay active: an unrelated study showed that leading a sedentary lifestyle could speed up telomere truncation.

- **College students** and monkeys have similar math skills, according to a new study from Duke University. The subjects saw two groups of dots, then had to choose which of two larger dot clusters represented their sum. Everyone took longer to solve problems involving more dots (but the students were slightly more accurate). The research suggests that we share with other primates a common cognitive system for basic arithmetic.

GETTY IMAGES (*top*); KAZ CHIBA *Getty Images* (*bottom*)

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>> RECOGNITION

Baby in the Brain

Infant faces trigger a reward reaction in adults

Chubby cheeks, big bright eyes—the characteristics of a baby's face are thought to provoke nurturing and affectionate behavior in adults. New research suggests that a reward area of the brain initiates this response.

Neuroscientist Morten L. Kringelbach of the University of Oxford and his colleagues asked 12 adults, nine of whom were childless, to complete a computer task while infant and adult faces—comparable in expression and attractiveness—flashed onto the screen. The researchers captured the participants' neural responses with magnetoencephalography, an imaging technique that directly detects brain activity in milliseconds. (In contrast, the imaging workhorse fMRI measures changes in blood flow, an indirect indication of brain activity, in seconds.)

Although the volunteers ultimately processed the faces using the brain regions that normally handle such a task, all the participants showed an early, distinct response to the infant faces alone. Within one seventh of a second, a spike in activity occurred in the medial orbitofrontal cortex, an area above the eye sockets linked to the detection of rewarding stimuli. This activity appears to "tag" infant faces as special, Kringelbach says.

The study offers clues as to why parents with postpartum depression are less responsive to their infants, Kringelbach adds. He speculates that depressed moms are "not getting this special signal" from the medial orbitofrontal cortex because of its connection to another brain area that is implicated in depression. *—Aimee Cunningham*

>> ADDICTION

Sweeter Than Cocaine

Rats prefer a sugary drink to drugs

If the alarming statistics surrounding the so-called obesity epidemic have not convinced you of the dangers of a sugar-packed diet, a new study might have you thinking twice. Rats given a choice between highly sweetened water and intravenous cocaine overwhelmingly favored the tasty beverage. Their preference was just as intense whether the drink was sweetened with saccharin or sugar.

This finding, reported recently by graduate student Magalie Lenoir and her colleagues at the University of Bordeaux in France, fuels growing suspicions that for some people sweets could be as pleasurable and addictive as habit-forming drugs. As the theory goes, our hypersensitivity to sweet taste evolved when sugar was scarce and an indicator of a high-energy meal. Excessive sugar in today's diets may overstimulate the sweet receptors in the brain, leading to a loss of self-control mechanisms and the risk of addiction.

Indeed, drugs and food activate similar reward pathways in the brain. A separate recent study showed that rats can become dependent on sugar, exhibiting typical symptoms of addiction, including craving and both behavioral and neurochemical signs of withdrawal.

The bigger surprise, notes Serge Ahmed, who designed the preference experiment, is that rats that were already experienced cocaine "users" (they had learned to self-administer cocaine) still opted for sweetened water over the drug.

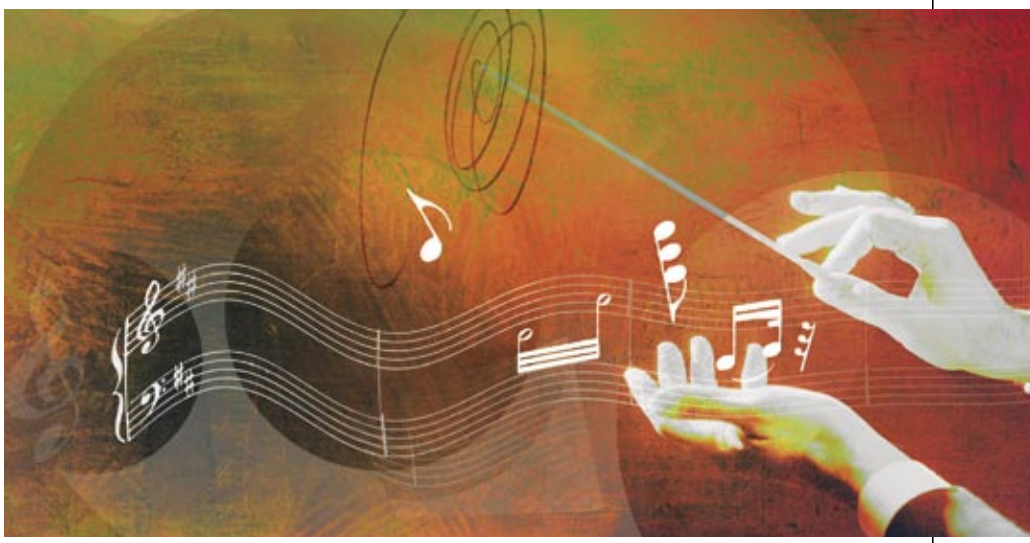
Ahmed is reluctant to generalize these results to humans just yet; rather than proving that sweets are more addictive than cocaine, his team might have discovered that rats simply cannot become addicted to drugs. This explanation, Ahmed believes, would nonetheless have important implications, suggesting that researchers should focus on the prefrontal cortex and other more recently evolved brain areas found in humans and other primates. *—Rachel Dvoskin*

ALEXANDRE JACQUES *age Fotostock (top)*; AGE FOTOSTOCK *(bottom)*

>> HEALTH

A Brighter Tune

Classical music may lift depressed patients' spirits



Add "therapist" to Beethoven's list of talents. After listening to the master's third and fifth sonatas, depressed patients in a recent study felt happier. The research, presented at the annual meeting of the Society for Neuroscience, found that classical music benefited both genders and that the music gave the biggest boost to educated and younger people.

This study supports previous findings that music therapy can be an effective and economical way to treat patients. A recently published review of the literature found that four out of five studies showed patients who had been given music therapy experienced a greater reduction in depression than those who had been randomly assigned to a different type of therapy. "Music has a specific potential that can be used therapeutically to promote well-being and alleviate symptoms like depression, anxiety, stress, anger and agitation," reports the Beethoven study's co-author, Pasadena City College neuroscientist Parvaneh Mohammadian.

—Corey Binns

>> EMOTIONS

Even Better than a Personal Best

Why showing up a peer is more satisfying than succeeding alone

If you have been trying to keep up with the Joneses, you are not alone—it seems we are all wired that way. Researchers report that the social emotions of envy and gloating are much stronger on every measure than are the sentiments of relief and regret, which are felt privately.

A team led by economist Aldo Rustichini of the University of Minnesota used skin conductance to measure volunteers' emotional arousal as they played a lottery game either alone or with a partner. The investigators found that the subjects' emotions of gloating and envy (as they compared their winnings with those of a peer) were much stronger than their emotions of relief and regret (as they played the lottery alone). The social emotions seem to elicit more response from the orbitofrontal cortex and the basal ganglia, brain regions involved in processing reward, according to preliminary data from the team's separate fMRI study.

Gloating topped all other emotions in intensity. "There is more emotional impact if you beat someone else," says Rustichini, who carried out the study with neuroscientists Nadège Bault and Giorgio Coricelli of the National Center for Scientific Research in France. The root of our delight in bragging rights could be evolutionary, Rustichini explains: "Among animals, a higher position in ranking helps in competition for food and mates, and humans may share some of this concern."

—Karen A. Frenkel

Our brain is wired to compare our successes and failures with those of the people around us.

GETTY IMAGES (*top*); EMILY SHUR Getty Images (*bottom*)

Brain Cells into Thin Air

The neural cost of high-altitude mountaineering

BY R. DOUGLAS FIELDS

> Three attributes of a good mountaineer are high pain threshold, bad memory, and … I forget the third.
>
> —*Joke in a mountaineering Internet chat room*

GALEN ROWELL *Corbis*

IN THE LATE 1890s in a laboratory atop a 4,554-meter peak in the Monta Rosa range in the Italian Alps, physiologist Angelo Mosso made the first direct observations of the effects of high altitude on the human brain: by eye and with an apparatus he designed, Mosso peeked into the skull of a man whose brain had been partly exposed in an accident, observing changes in swelling and pulsation.

Now a similar experiment has been done with noninvasive brain imaging, and for those of us who love to climb the results are not elevating. Neurologist Nicolás Fayed and his colleagues in Zaragoza, Spain, performed MRI brain scans on 35 climbers (12 professionals and 23 amateurs) who had returned from high-altitude expeditions, including 13 who had attempted Everest. They found brain damage in virtually every Everest climber but also in many climbers of lesser peaks who returned unaware that they had injured their brain. It seems that climbers of high mountains, whether weekend warrior or seasoned professional, face returning from the high peaks with a brain that is not in the same condition it was in beforehand.

What Gives in a Climber's Brain?

Although a person's tolerance to hypoxia (lack of oxygen) varies according to differences in innate physiology and physical conditioning, no one is immune. Those effects can be acute, affecting you only while you are at altitude, or—as the Fayed study found—they can be longer-lasting.

The first acute stage is called, naturally enough, acute mountain sickness. It can cause headache, insomnia, dizziness, fatigue, nausea and vomiting. The next, more serious stage is high-altitude cerebral edema, also known as HACE, brain swelling that is potentially fatal.

Lack of oxygen can directly damage brain cells. In addition, the walls of blood capillaries begin to leak at high altitudes, and the leaked fluid can cause dangerous swelling, pressing the brain outward against the rigid skull. Sometimes the optic nerves swell so badly they bulge into the back of the eye, degrading vision and causing retinal hemorrhages. Meanwhile blood, concentrated from dehydration and thickened by increased numbers of red blood cells, clots more easily. This clotting, along with the hemorrhage from the thinned capillaries, can cause a stroke. A climber with HACE may experience amnesia, confusion, delusions, emotional disturbance, personality changes and loss of consciousness.

Severe cases of acute high-altitude disease have long been known to cause brain damage. But one of the sobering things about the Fayed study is that even when climbers showed no signs of acute sickness, the scans still found brain damage.

The results in the Everest climbers were the starkest. Of the 13 climbers,

Each week in Mind Matters, www.SciAmMind.com's expert-written "blog seminar," researchers of mind and brain explain and discuss their disciplines' most notable recent findings. In this installment, neuroscientist and climber R. Douglas Fields considers a study about brain damage in climbers.

Mind Matters examines a new finding every week. Join the discussion at www.SciAmMind.com

three had made the 8,848-meter summit, three had reached 8,100 meters, and seven had topped out between 6,500 and 7,500 meters. The expedition had no major mishaps, and none of the 12 professional climbers evinced any obvious signs of high-altitude illness; the only acute case of mountain sickness was a mild one in the expedition's amateur climber. Yet only one of the 13 climbers (a professional) returned with a normal brain scan. All the scans of the other 12 showed cortical atrophy or enlargement of the Virchow-Robin (VR) spaces. These spaces surround the blood vessels that drain brain fluid and communicate with the lymph system; widening of these VR spaces is seen in the elderly but rarely in the young. The amateur climber's brain had also suffered subcortical lesions in the frontal lobes.

> Even when climbers showed no signs of acute sickness, the scans still found **brain damage**.

How High Is Too High?

Of course, Everest is extreme. Fayed and his colleagues also studied an eight-person team that attempted Aconcagua, a 6,962-meter summit in the Argentine Andes. Two climbers reached the summit, five climbed to between 6,000 and 6,400 meters, and one reached 5,500 meters. Yet three members experienced acute mountain sickness, and two displayed symptoms of brain edema—probably because they ascended more rapidly from lower altitudes than the Everest climbers did.

All eight Aconcagua climbers showed cortical atrophy on MRI scans. Seven showed enlarged VR spaces, and four showed numerous subcortical lesions. Some needed no scan to tell them their brains had been injured. One climber suffered aphasia (problems with speech), from which he recovered six months later. Two complained of transient memory loss after returning, and three others struggled with bradypsychia (slowed mental function).

The body is remarkably resilient: Does the brain recover from these mountaineering wounds? To answer this question, the researchers reexamined the same climbers three years after the expedition, with no other high-altitude climbing intervening. In all cases, the damage was still apparent on the second set of scans.

Still, Aconcagua is one of the world's highest mountains. Mont Blanc in the western Alps is less extreme. Its 4,810-meter summit is climbed every year by thousands of mountaineers who probably do not expect injury to their "second favorite organ," to use Woody Allen's nomenclature for the brain. Yet the researchers found that of seven climbers who reached Mont Blanc's summit, two returned with enlarged VR spaces.

Because Why?

The study suggests that chronic exposure to high altitudes is not required to experience irreversible brain damage. In fact, amateurs seem to be at greater risk, because they are more likely to suffer acute mountain sickness or high-altitude cerebral edema. At the same time, the experience required to become well acclimated seems to take an ever increasing cumulative toll; compared with the amateurs, professional climbers in this study had greater cortical atrophy overall. They felt stronger but showed more brain damage.

Mountain climbing is growing in popularity—and with good reason. It can provide experiences of a lifetime; a communion with nature and with friends that feeds the soul; intense and enduring rewards surpassing those found within the bounds of routine; and adventure and challenge that build courage, stamina and fortitude. It also gets you into incomparable mountain wilderness—although that is vanishing. Many sense that the singular "it" residing in George Mallory's pithy *raison d'ascent*—"Because it's there!"—may soon be gone.

Some 5,000 climbers ascend Himalayan peaks every year. Thousands more climb peaks in the Alps and Andes. Many of these people spend liberally to mount expeditions or to be guided to the summit. But it is increasingly clear that these climbers are paying for the privilege with something more than hard-earned cash. They're paying with brain tissue. M

R. DOUGLAS FIELDS is a developmental neurobiologist who writes frequently for *Scientific American* and *Scientific American Mind* and serves on *Mind*'s advisory board.

(Further Reading)

◆ **Evidence of Brain Damage after High-Altitude Climbing by Means of Magnetic Resonance Imaging.** Nicholás Fayed, Pedro J. Modrego and Humberto Morales in *American Journal of Medicine,* Vol. 19, No. 2, pages 168.e1–168.e6; February 2006.

Transparently Obvious

How the brain sees through the perceptual hurdles of tinted glass, shadows and all things transparent

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

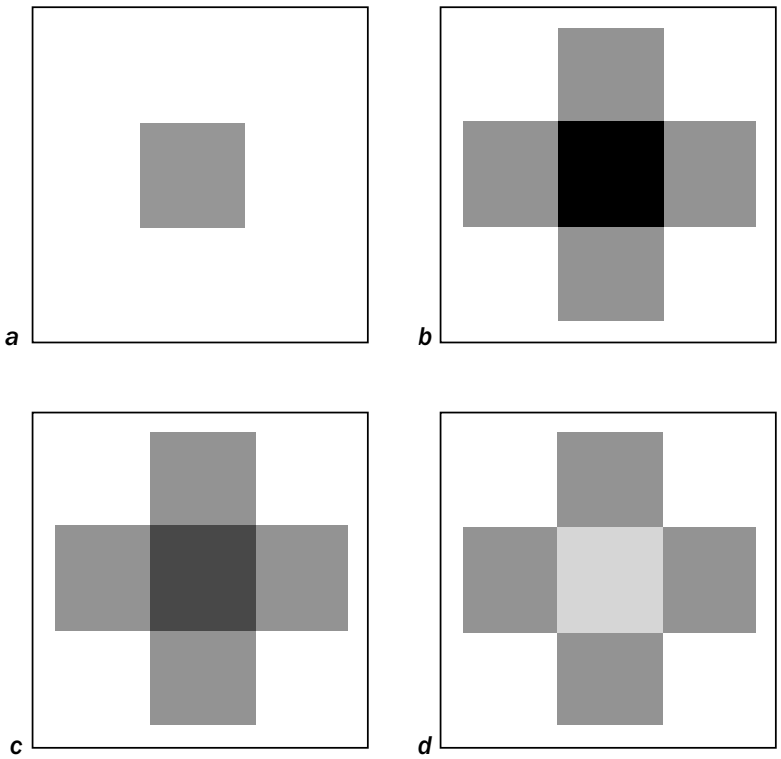
OUR ABILITY to perceive visual scenes effortlessly depends on intelligent deployment of built-in knowledge about the external world. The key word here is "intelligent," which raises the questions: Just how smart is the visual system? What is its IQ? For example, does the visual system know the laws of physics? Does it use inductive logic only (as many suspect), or can it perform deductions as well? How does it deal with paradoxes, conflicts or incomplete information? How adaptable is it?

Some insight into perceptual intelligence comes from the study of transparency, a phenomenon explored by Gestalt psychologist Fabio Metelli. He first drew attention to the fact that compelling illusions of transparency can be produced by using relatively simple displays.

The word "transparency" is used loosely. Sometimes it refers to seeing an object, such as a sunglass lens, and the objects visible through that object, and sometimes it means seeing something through frosted glass, known as translucency. In this column we will restrict ourselves to the former, because the physical and perceptual laws pertaining to it are simpler.

Physics of Transparency

First let us consider the physics of transparency. If you put a rectangular neutral-density filter, such as dark glasses, on a sheet of white paper, the filter allows only a certain proportion of light through—say, 50 percent. Put another way, if the paper has a brightness, or luminance, of 100 candelas (cd) per square meter, the portion covered by the filter will have a luminance of 50 cd. If you then add a second such filter so that it partially overlaps the first, the overlapping region will receive 50 percent of the original 50 percent of the light—that is, 25 percent. The relation is always multiplicative.



So much for physics. What about perception? If, as in *a*, you simply have a dark square in the middle of a light square (with the former being 50 cd and the latter 100 cd), the inner square could be either a filter that cuts light by 50 percent or a darker square that reflects only 50 percent as much of the incident light as does the surrounding background. Without additional information, there is no way the visual system could know which condition exists; because the latter case is far more common in nature, that is what you will always see.

But now consider two rectangles that form a cross with an overlapping region in the middle. In this case it is not inconceivable—and, indeed, it is more probable—that this configuration really does consist of two overlapping rectangular pieces of filters rather than five blocks arranged to form a cross. But if it is the former, then the luminance ratios must be such that the central square (the overlapping region) should be darker than the other squares and, of course, darker than the background. In particular, the central square's luminance should

Does the visual system know the **laws of physics**? How does it deal with paradoxes and incomplete information?

The visual system may have evolved to **discover and react** appropriately to shadows rather than to transparency filters.

be a multiplicative function in terms of a percentage of the two filters. If the nonoverlapping regions of the two rectangles are, for instance, 66 and 50 percent of the background, respectively, then the inner rectangle should be 50 percent of that 66 percent—or roughly 33 percent (that is, 33 cd assuming the white paper is 100 cd).

Now the question is: Does the visual system have tacit "knowledge" of all these factors? We can find out by using a series of displays (*b, c, d*) in which the background and rectangles are of a fixed luminance (such as 100 and 50 cd, respectively) while the luminance of the inner square alone changes. In terms of the luminance that would exist with physical transparency, the inner square is set to be too dark (*b*), appropriately dark (*c*) or too light (*d*). If you look at these figures without knowing anything about physics, you see the rectangles as transparent in *c* but not in *b* or in *d*. It is almost as if your visual system knows what you do not know (or did not know until you read this column).

This experiment suggests that two conditions must be fulfilled for transparency to be seen. First, there must be figural complexity and segmentation to justify this interpretation (hence no transparency in *a*). Second, the luminance ratios have to be right (no transparency is visible in *b* or *d*).

Shadowy Influences

Transparency is infrequent in nature, but shadows are not. It is possible that the "laws" of perception we have explored so far evolved mainly to deal with shadows and to distinguish them from "real" objects, which would also produce luminance differences in the visual scene as a result of differences in reflectance (for instance, a zebra's stripes or a white cat on a black mat).

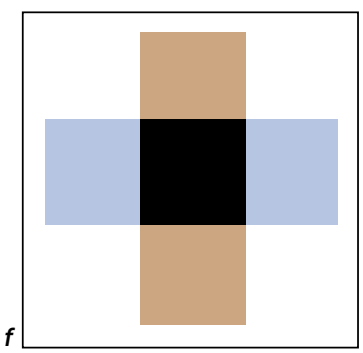
The shadow cast by an object such as a tree could, in theory, be pitch black if there were a single distant light

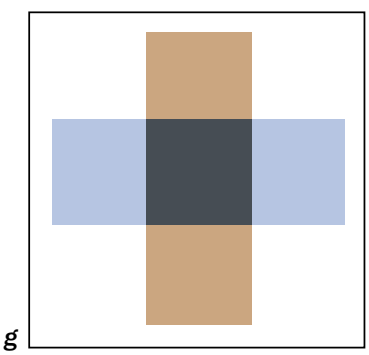
source, without scattering or reflections. Ordinarily, however, ambient light from the environment falls on the shadow so that a dark, but not black, shadow results. If the tree shadow falls on a sidewalk and darker grass (*e*), the manner in which the magnitude and sign of luminance vary along the shadow's boundary would be identical on both sides of the boundary, the shadow side and the light side. This covariation of luminance clues the brain that it is a shadow, not an object or texture.

It turns out that the luminance changes in transparency mimic those seen in shadows. The visual system may have evolved to discover and react appropriately to shadows rather than to transparent filters. If it could not, you might try to grab a shadow or gingerly step over it to avoid tripping, not realizing that it is not an object at all.

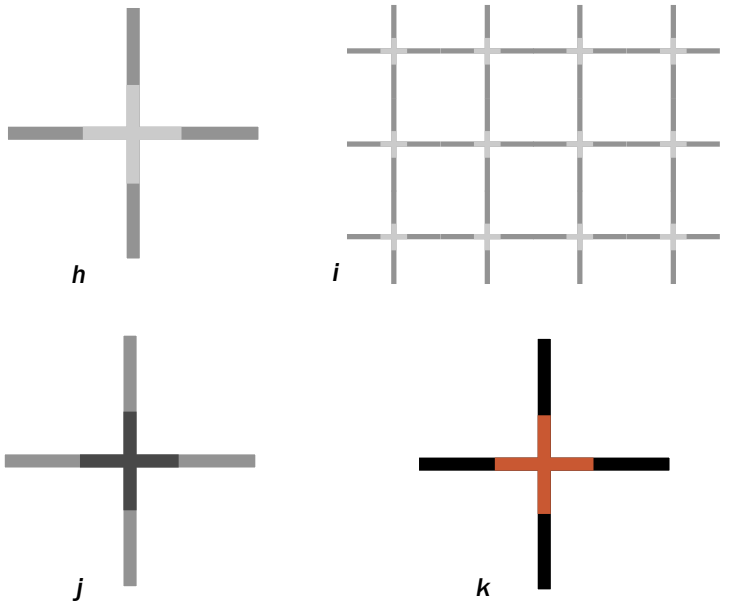
Interestingly, although our perceptual mechanisms seem to be aware of the physics of transparency pertaining to luminance, they appear to be blind to the laws pertaining to color "transparency." In *f* and *g*, we have two bars crossing each other, both with luminance of, say, 50 percent of the background. We have contrived it so that in *g* the overlapping region has 25 percent of the background luminance, as it should be if we were dealing just with luminance. But if the colors of the two filters are different—as they are—the overlap zone should be pitch black, not gray. The reason is that the red filter transmits only long ("red") wavelengths when white light shines through it and the blue filter transmits only short ("blue") wavelengths. So if you cross the filters, *no* light passes through; the overlap zone would be black. In fact, transparency is seen not when the midzone is black but when it is 25 percent (*g*). Apparently, the visual system continues to follow the luminance rule and ignores the color incompatibilities.

A curious effect occurs if you place a gray cross on a white background when the middle of the cross is a lighter shade of gray (*h*). Instead of seeing the lighter cross for what it is, the brain prefers to see it as if there were a circu-





GETTY IMAGES (*top*); SCIENTIFIC AMERICAN MIND (*bottom*)

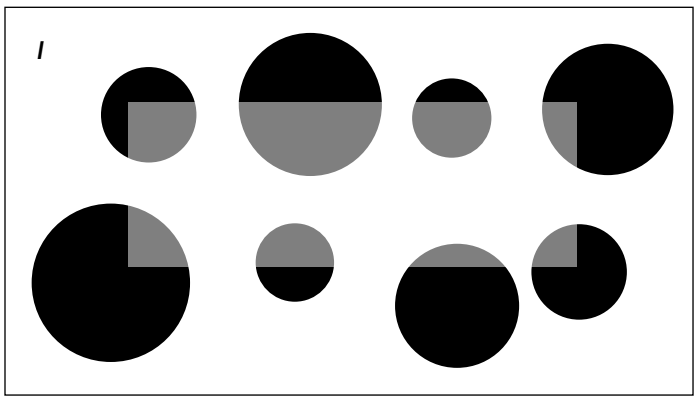


lar piece of frosted glass or vellum superimposed on the larger gray cross. To achieve this perception, the brain has to "hallucinate" an illusory frosted glass spreading, even in the area surrounding the central region of the cross. The effect is especially compelling if you have a patch of several such crosses (*i*).

Once again the luminance ratios between the surround (white), the cross (dark gray) and the central region (light gray) have to be just right for the effect to occur; if they are wrong, the effect disappears (*j*). In other words, the ratios must be compatible with what would occur with actual translucent surfaces (for example, fog or frosted glass). The effect is even more striking if there is a chromatic component to the display (*k*).

Thus, even though the visual system does not know about color subtraction, if the luminance ratios are right, then the colors are "dragged along" with the spread of luminance.

Another intriguing effect is seen in *l*, invented by Italian psychologist Gaetano Kanizsa: the Swiss cheese effect. When you glance at it casually, you see a large opaque rectangle with holes in it superimposed on a smaller gray rectangle sitting on a black background. But with some mental effort, you can start to imagine the light-gray rectangle behind the holes as actually a translucent white rectangle in front of the holes and then start to perceive a transparent rectangle through which you see black spots in the background. This illusion demonstrates the profound effect of "top down" influences on perception of surfaces; the transparency you see is not entirely driven bottom up through serial hierarchical processing of the physical input on the retina.



Taken collectively, these demonstrations allow us to conclude that a remarkable degree of "wisdom" about the statistics and physical laws of transparency are wired into visual processing, through a combination of natural selection and learning. Yet there are limits to this wisdom. The visual system seems tolerant of incompatible colors. It is incapable of applying the physics of color subtraction, partly because color perception evolved much later in primates and did not get wired in adequately and partly because in the luminance domain color overlap is much less common in the natural world than transparency and translucency are.

We may conclude that even though the visual system can make sophisticated use of such abstract properties as the physics of luminance ratios and the statistics of segmentation required for transparency, it is "dumb" with regard to other characteristics such as color because of the happenstance manner in which its hardware (or "squishyware") evolved through natural selection—strong evidence against "intelligent design." M

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. They serve on *Scientific American Mind*'s board of advisers.

With fond memories of Daniel J. Plummer (1966–2006), a dear friend and brilliant student of transparency and other phenomena.

(Further Reading)

- **The Perception of Transparency.** Fabio Metelli in *Scientific American,* Vol. 230, No. 4, pages 90–98; April 1974.
- **On the Role of Figural Organization in Perception of Transparency.** J. Beck and R. Ivry in *Perception and Psychophysics,* Vol. 44, pages 585–594; 1988.
- **Perception of Transparency in Stationary and Moving Images.** D. J. Plummer and V. S. Ramachandran in *Spatial Vision,* Vol. 7, pages 113–123; 1993.

(calendar)

April

1 Science is in the spotlight at the Ensemble Studio Theatre's **First Light Festival**, a month of science-themed plays, readings, workshops and other theatrical activities. In a partnership with the Alfred P. Sloan Foundation, which promotes connections between science and popular culture, the acclaimed theater company investigates topics from the emotional dynamics of working in a research lab to the eccentric brilliance of Alan Turing, the father of artificial intelligence.
New York City
www.ensemblestudiotheatre.org

CAROL ROSEGG (*Ensemble Studio Theatre*); COURTESY OF HAGGERTY MUSEUM (*lithograph*); ISM/PHOTOTAKE (*brain*)

2 This year marks the first annual **World Autism Awareness Day**, as designated by the United Nations with the goal of fostering international cooperation in research and educational campaigns. In the U.S. the date coincides with **Autism Awareness Month**, during which many organizations host fund-raising and educational events. One popular destination is the beach of Lake Erie on the Presque Isle peninsula, where the Northwestern Pennsylvania chapter of the Autism Society of America holds its **Annual Walk for Autism** on April 26.
Erie, Pa.
www.autism-society.org

3 Explore the sociology of late 19th-century America—including racial and ethnic prejudice and the limited roles of women and children—through lithographic illustrations at Marquette University's Haggerty Museum of Art. Running through June 18, the exhibit ***Harper's Weekly:* Illustrated Themes of the Nineteenth Century** offers a vivid and accessible glimpse of language and culture in the U.S. during the newsmagazine's entire run, from 1857 through 1916.
Milwaukee, Wis.
www.marquette.edu/haggerty

12–19 Join more than 10,000 neurologists and neuroscientists at the **American Academy of Neurology's 60th Annual Meeting**, one of the world's largest showcases of brain-related scientific research. In addition to the usual educational activities, this year's meeting features a 60th-birthday bash complete with a quiz show about neurological diagnosis, two off-Broadway plays dramatizing neurological disorders, and a special brainy performance by the Chicago comedy troupe Second City.
Chicago
www.aan.com/go/am

14 Neuroscientist **John Donoghue** of Brown University lectures as part of the National Institutes of Health's Neuroscience Seminar Series. Donoghue's lab developed BrainGate, the revolutionary brain-computer interface that allowed a paralyzed man in 2006 to use a computer with his thoughts alone. Tune in live at noon or download the podcast after the lecture is over.
Bethesda, Md.
http://videocast.nih.gov

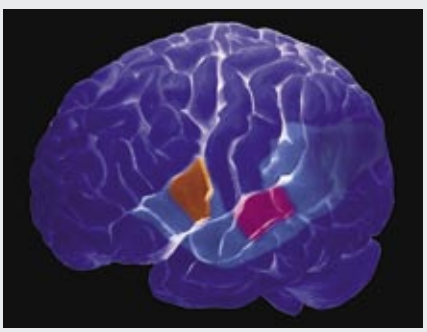
May

2 What happens when a naturally creative child finds his imagination stifled by his strict upbringing? In the movie ***Son of Rambow***, set in 1982, 11-year-old Will has never been exposed to television, movies or books other than the Bible—until he accidentally sees a pirated copy of *First Blood,* the inaugural "Rambo" movie. Will is entranced, and he embarks on a mission to shoot his own film, despite the direct conflict with his family's beliefs.
Paramount Vantage
www.sonoframbow.com

In History: Speech in the Brain

April 18

On this date in 1861 French physician **Paul Broca** performed an autopsy on the brain of a patient who had suffered from aphasia, the inability to produce speech. Broca discovered a lesion in the left frontal lobe and asserted that this area was responsible for articulation. Further research bore out his hypothesis: damage to this part of the brain, now called Broca's area, impairs or destroys the ability to speak clearly and use complex grammar.



The orange region is Broca's area, and Wernicke's area is pink.

May 15

On this date in 1848 **Carl Wernicke** was born in what is now the city of Tarnowskie Góry, Poland. Intrigued by Paul Broca's findings on language deficits caused by damage to the brain, Wernicke began his own research in neuropathology. In 1874 he discovered that an area of the brain located posterior to Broca's area is also crucial for speech—but for language comprehension, rather than for articulate speaking. People with damage to Wernicke's area, as the region is now called, can form words normally, but they string those words together without meaning.

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

The Social Psychology of SUCCESS

By S. Alexander Haslam, Jessica Salvatore, Thomas Kessler and Stephen D. Reicher

You tried so hard. But you failed. You did not pass the test, you performed poorly in the interview or you missed your project goal at the office. Why? Is it that you were not capable? Or could something more subtle—and worrisome—also be at work?

As it turns out, research shows that such performance failures cannot always be attributed simply to inherent lack of ability or incompetence. Although some have jumped to the highly controversial conclusion that differences in attainment reflect natural differences between groups, the roots of many handicaps actually lie in the stereotypes, or preconceptions, that others hold about the groups to which we belong. For instance, a woman who knows that women as a group are believed to do worse than men in math will, indeed, tend to perform less well on math tests as a result.

The same is true for any member of a group who is aware that his or her group is considered to be inferior to others in a given domain of performance—whether it is one that appears to tap intellectual and academic ability or one that is designed to establish athletic and sporting prowess. Just as women's performance on spatial and mathematical tasks is created by, and appears to "prove," the stereotype of their spatial and mathematical inferiority, so, too, the sporting performance of a team of long-failing underdogs will tend to live up (or, in fact, down) to its low expectations.

The social psychological research that has uncovered these effects is an important development of theoretical work initiated in the 1970s that focused on issues of social identity—looking at how people see themselves as members of a particular group and what the implications of this are. More important, however, social identity research examines not only how we both take on (internalize) and live out (externalize) identities that are shared with our peers—other members of our ingroup—but also how these things can change. This research helps us to understand the debilitating consequences of sexism, racism, homophobia and the like, as well as to identify ways of addressing the problems they cause so that human talent and potential are not neglected or squandered.

Part of the story here involves recognizing not only that stereotypes can promote failure but that they can also *lift* a person's or group's performance and be tools that promote social progress. Understanding these dynamics—and the processes that underpin them—enables us to think more productively about the conditions that allow ability to be expressed rather than repressed and that foster success rather than failure.

Stereotype Threat

In the past decade such issues have been put on center stage by social psychologists who have been researching the phenomenon of "stereotype threat." The impressive body of work they have built up demonstrates not only that such underperformance occurs but also that it is especially common for individuals who are aware that their group is considered inferior to others with which it is compared. Pioneering studies conducted at Stanford University by Claude Steele and Joshua Aronson are particularly illuminating in this respect.

Steele and Aronson's classic demonstration of stereotype threat emerged from a series of studies in the mid-1990s in which high-achieving African-American students at Stanford completed questions from the verbal

People's performance on intellectual and athletic tasks is shaped by awareness of stereotypes about the groups to which they belong. New research explains why—and how we can break free from the expectations of others

AARON GOODMAN

Although awareness of negative perceptions about others' expectations can keep us down, group membership can also provide support for success.

Graduate Record Examinations (GRE) under conditions where they thought either that the test was measuring intelligence or that it was not a test of ability at all. Intriguingly, these participants' performance was much worse when they were told that the test was a measure of intelligence [*see box on opposite page*]. This slide, the researchers argued, occurred because "in situations where the stereotype is applicable, one is at risk of confirming it as a self-characterization, both to one's self and to others who know the stereotype."

This pattern of findings has been replicated with many different groups on many different dimensions of stereotype content. For example, Sian L. Beilock of the University of Chicago and her colleagues reported in a 2007 issue of the *Journal of Experimental Psychology* that if female students are made aware of the stereotype that men have greater mathematical ability than women do, they tend to perform worse on complex mathematical tasks than they do if they are not alerted to this stereotype. Likewise, elderly people have been found to perform worse on memory tests if they take them after being made aware of stereotypes that associate aging with deteriorating cognitive ability.

In the domain of athletic performance, studies of golf putting have shown that expert golfers tend to leave their putts farther from a target than they would otherwise do if they are exposed to a stereotype that members of their sex are worse at putting than members of the opposite sex. It seems unlikely that Greg Norman choked in the 1996 Masters Tournament, when he blew an early lead and ultimately lost, because he was mindful of this stereotype, but other relevant stereotypes (for instance, that Australians underperform in the Masters—with no one from that country ever having won the tournament) may have interfered with the flow of his game at the critical juncture. Along similar lines, it seems entirely plausible that England's poor performance on penalty shoot-outs in World Cup soccer matches has something to do with a lack of self-belief associated with a team history of performing poorly in such contests (of seven shoot-outs in major tournaments, the team has won only one).

Understanding Process

What, though, is the "something" that is responsible for the effects of stereotype threat? Recent work has argued that one core factor is enhanced cognitive load. For example, a 2005 study by social psychologists Mara Cadinu, Anne Maass and colleagues at the University of Padua in Italy showed that when women perform mathematical tasks after being

DANIEL BOSLER Getty Images

FAST FACTS

Sterotypes and Success

1» Faults in performance do not necessarily signify a dearth of skills or abilities, social scientists have found. Instead the failures may arise from awareness of stereotypes that others hold about the groups to which we belong.

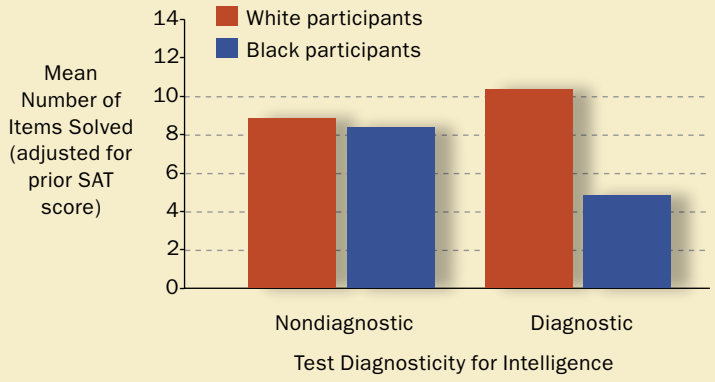
2» Social identity research examines not only how we both take on (internalize) and live out (externalize) identities that are shared with our peers but also how these things can change.

3» This research can help us identify ways of responding to others' stereotypes so that human talent and potential are not squandered. Although stereotypes can promote failure, they can also *lift* a person's or group's performance and be tools that promote social progress.

Beliefs Cut Both Ways

When taking the Graduate Record Examinations (GRE), black participants do significantly worse if they are led to believe that testing reveals a person's level of intelligence. Such findings are evidence of the powerful impact of "stereotype threat," whereby (in this case for black participants) a sense that behavior may confirm stereotypes of inferiority about a group to which we belong can disrupt otherwise competent performance. The pattern of findings also provides some indication of "stereotype lift," in which white participants' performance is enhanced when they believe the GRE assesses intelligence, because, for them, the relevant stereotype is associated with in-group superiority.

—S.A.H., J.S., T.K. and S.D.R.



SOURCE: "STEREOTYPE THREAT AND THE INTELLECTUAL TEST PERFORMANCE OF AFRICAN-AMERICANS," BY CLAUDE M. STEELE AND JOSHUA ARONSON, IN *JOURNAL OF PERSONALITY AND SOCIAL PSYCHOLOGY*, VOL. 69; 1995

exposed to the stereotype that they are worse at math than men, they report entertaining more intrusive negative thoughts about their own mathematical ability. That is, they find themselves thinking things such as "These exercises are too difficult for me" and "I am not good at math." Likewise, a number of studies have indicated that exposing people to negative stereotypes about groups to which they belong increases their anxiety and stress when performing tasks related to that stereotype.

Evidence from work by Beilock and others also suggests that such anxieties can use up information-processing resources that are required to carry out the tasks at hand. For example, when people perform complex math tasks, this cognitive burden places heavy demands on working memory, using the brain areas that briefly store and manipulate information.

The 2007 article by Beilock and her colleagues attempts to explore and integrate these ideas by delving deeply into the cognitive dynamics of stereotype threat. Working in the domain of women's performance on mathematical tasks, a series of experiments replicates the standard stereotype threat effect: it shows that the effect is most pronounced on tasks that place demands on phonological resources (such as those requiring verbal reasoning); demonstrates that the presence of stereotype threat increases verbal reports of worry associated with either the task or the stereotype; and suggests that the debilitating consequences of stereotype threat can be avoided if participants learn to perform tasks in such a way that they are mentally undemanding. The last insight is based on evidence that women do not succumb to the effects of stereotype threat if they learn answers to math problems by rote (as one does when learning one's times tables) so that their production relies only on long-term memory.

On the basis of these studies, the researchers make the case that their work advances our understanding of stereotype threat by revealing what is responsible for its effects (for instance, anxiety-related demands on short-term verbal memory) and then using this understanding to suggest how this impact can be overcome. In this regard, there is no doubt that their work contributes substantially to our understanding of specific cognitive aspects of the phenomenon, and in particular the role that memory processes can play in the dynamics of particular threat-related effects. Yet despite its internal coherence, there are reasons for believing that an exclusively cognitive analysis is limited both theoretically and practically.

Stereotypes That Help

A sense that the theoretical analysis by Beilock and her colleagues is incomplete derives from other research inspired by Steele and Aronson's original demonstration of the effects of stereotype threat. Exposure to stereotypes, researchers have found, can have welcome as well as unwelcome consequences. That is, under certain circumstances, exposure to stereotypes about one's group can serve to *elevate* performance instead of compromising it [*see box at left*].

Studies conducted at Harvard University in 1999 by Margaret Shih and her co-investigators provide particularly good demonstrations of this point. The participants in this research were Asian women. In different conditions of the studies they were required to focus on the fact either that they were women (who are stereotypically worse at math than men) or that they were Asian (stereotypically better at math than members of other ethnic groups). As in

Beilock and her colleagues' work, in the former case the women performed worse than they did when no group membership was made salient. Yet in the latter case they did *better*.

Other studies reveal similar effects, finding that women display superior ability on spatial tests if reminded that they attend a college whose students perform well on such tasks and that golfers putt more accurately if exposed to a stereotype that members of their sex are better at putting than those of the opposite sex. Jeff Stone of the University of Arizona and fellow psychologists also found that when white golfers are told that their golfing performance will be compared with that of black golfers they perform worse if they believe this is a test of "natural athletic ability" (because here the comparison poses a threat), but that they perform better if they believe it to be a test of "sport strategic intelligence" (because this comparison suggests the in-group's superiority).

A meta-analysis of similar studies published in 2003 by social psychologists Gregory Walton and Geoffrey Cohen, then at Yale University, has shown that if people are exposed to stereotypes about the inferiority of an out-group (those who are not part of the individual's in-group) in a given domain, then their performance is typically elevated—a phenomenon they refer to as stereotype lift. In this way, just as a sense of in-group inferiority can impair performance, an ideology of superiority can give members of high-status groups a performance boost.

Such elevated performance cannot easily be explained in terms of cognitive load—because it is hard to see how the salience of a positive in-group stereotype (as in "we are good") could *increase* the memory resources available to participants (relative to those in control conditions). Ideally, then, a parsimonious explanation of the effects of stereotypes should be capable of accounting for both upward and downward change. It should also be able to explain a host of other effects reported in the research literature—including evidence that such effects are apparent in domains where cognitive capacity is not critical (golf or basketball, say); are diminished if people are exposed to stereotypes about multiple groups; are weaker if one's in-group is not exposed to generalized hostility (for example, if one is male or white); and vary depending on whether participants are encouraged to focus on promoting positive outcomes or on preventing negative ones.

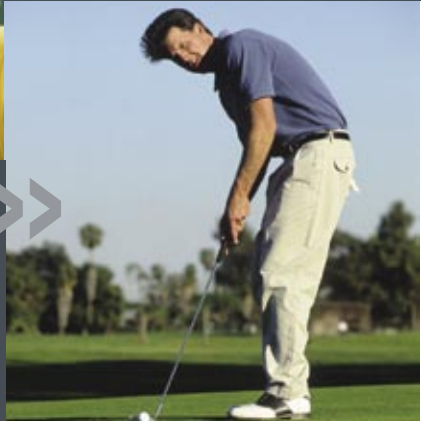
More important, an explanation of effects arising from stereotype threat also needs to explain why these influences are not as generalized as a cursory reading of Beilock and her colleagues' work might suggest. Because it is certainly not the case that *all* members of a given group succumb to the perils of threat.

On the contrary, effects are restricted to individuals who value the domain in question and who have high levels of basic competence (for instance, those who, in the abstract, have *less* to worry about). To be selected to participate in Beilock and her colleagues' first study of mathematical performance, for example, women had to perform baseline tasks with greater than 75 percent accuracy, and they had to agree with the statements "I am good at math" and "It is important to me that I am good at math." Why do these things matter?

Self and Identity

One answer to the preceding question is that, fundamentally, stereotype threat is not so much an issue of cognition per se as one of self and identity. This point has been made by a number of researchers working in the stereotype domain, including Steele and Aronson themselves. Along these lines, in a recent major review of work in this area, they, together with social psychologist Steven Spencer of the University of Waterloo in Ontario, argue that stereotype threat can be understood as a phenomenon that centers on a person's social identity. That is, stereotype threat (and lift) effects come about because, and to the extent that, people are encouraged to think of themselves in terms of a particular group membership (such as Asian or female; white or male).

Asian or female? Research at Harvard University by Margaret Shih and her colleagues suggests that Asian women perform better on math tests if they think of themselves as Asians rather than as women.

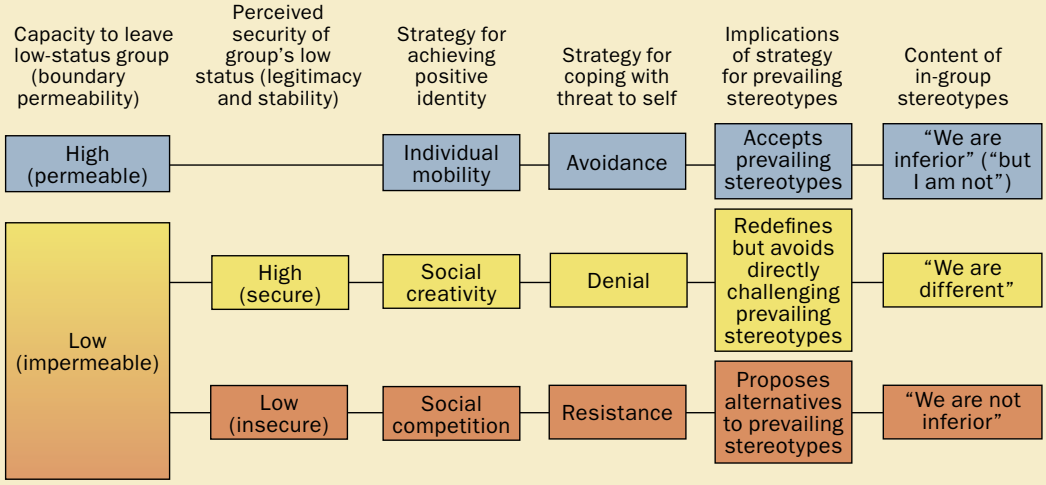


Strategy or athletic ability? Research by Jeff Stone and his colleagues at the University of Arizona indicates that if white golfers believe they are being compared with black golfers, they perform better if they think golf tests strategy but worse if they think it tests athletic prowess.

AGE FOTOSTOCK (*student and golfer*)

Coping with Stress: Three Strategies

Being a member of a low-status group can be a threat to a person's self-esteem and a source of stress. How do people deal with this? According to social identity theory, the answer depends on an interplay between social psychological and social structural factors. In particular, willingness to engage in social competition with a high-status group and to resist stress collectively depend on accessing cognitive alternatives that point to the illegitimacy and instability of existing conditions and envisioning ways in which these unfavorable conditions could be improved. *—S.A.H., J.S., T.K. and S.D.R.*



As specified by the social identity theory that Henri Tajfel and John Turner developed at the University of Bristol in England, when people define themselves as group members (as "we" rather than "I"), behavior is shaped by the stereotypic norms that define in-group membership in any given context [see "The Psychology of Tyranny," by S. Alexander Haslam and Stephen D. Reicher; Scientific American Mind, Vol. 16, No. 3; 2005]. Here people are generally motivated to advance the interests of their in-group and to see it positively. They are, for example, more inclined to agree with stereotypes that suggest "we are good" than with those that say "we are bad." Yet under conditions in which broad consensus exists about an in-group's low status and in which status appears to be stable and legitimate (that is, uncontestable), members of that group often accept and internalize their group's inferiority on status-defining dimensions ("We are poor at math …") and seek to achieve a positive in-group identity in other areas ("… but we are more verbally skilled, more sociable, more musical, and so on").

Thus, when the content of a salient social identity conflicts with a person's motivations to do well in a given domain (to be good at math, for instance), he or she will experience identity-related psychological conflict. This conflict tends to interfere with performance in the way that studies of stereotype threat reveal. As the work of Cadinu and others shows, it creates anxiety, self-consciousness and self-doubt. In short, people will tend to perform relatively poorly in situations where they have a conflicted sense of self—wherein their sense of what they are (and want to be) as individuals appears incompatible with what they are seen to be as group members.

On the other hand, if the content of a salient social identity is compatible with a person's aspirations (perhaps because they suggest superior ability), this circumstance will tend to motivate and energize the individual and thereby improve performance in the manner suggested by demonstrations of stereotype lift. We experience

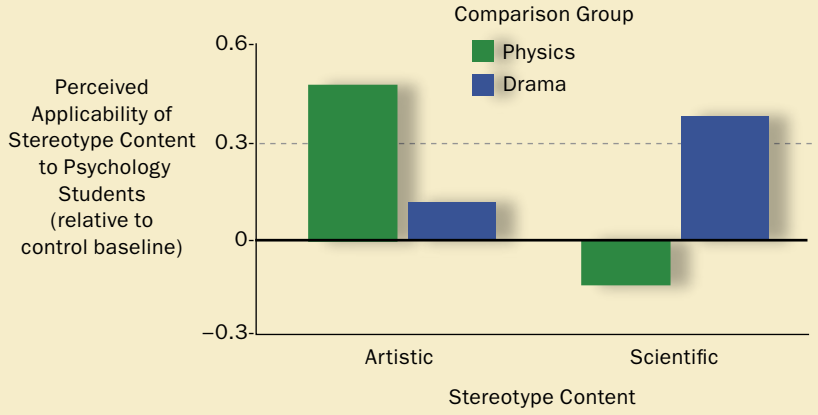
(The Authors)

S. ALEXANDER HASLAM is professor of social psychology at the University of Exeter in England and serves on the board of advisers for *Scientific American Mind*. JESSICA SALVATORE is a postdoctoral fellow at Exeter who recently completed her Ph.D. at Princeton University. THOMAS KESSLER recently moved from the University of Jena in Germany to take up a position as professor of social psychology at Exeter. STEPHEN D. REICHER is professor of social psychology at the University of St. Andrews in Scotland and serves on the board of advisers for *Scientific American Mind*.

ADAPTED FROM "STRESSING THE GROUP: SOCIAL IDENTITY AND THE UNFOLDING DYNAMICS OF RESPONSES TO STRESS," BY S. ALEXANDER HASLAM AND STEPHEN D. REICHER, IN *JOURNAL OF APPLIED PSYCHOLOGY*, VOL. 91; 2006

Who Do We Think We Are?

Psychology students stereotype themselves as a group depending on what group they compare themselves against. When psychology students compare themselves with physics students, for example, they are more likely to describe themselves as artistic than when they compare themselves with drama students. Yet in the former case, they are less likely to describe themselves as scientific. Such findings point to the flexibility of self-stereotypes and also to general motivations to think of one's membership group positively. *—S.A.H., J.S., T.K. and S.D.R.*



a facility of self and "flow" when what we are and want to be as individuals is fully compatible with what we appear to be as group members.

Overcoming Stereotypes

One final question, though, is whether the phenomenon of stereotype threat (or lift) means that people are destined always to reproduce existing stereotypes and social structures. Are we inevitably condemned to act in ways that reinforce existing stereotypes of superiority and inferiority? Not at all. Indeed, one important lesson to be learned from theorizing about social identity is that when individuals are confronted with obstacles to self-enhancement associated with the apparent inferiority of their in-group, they can deal with these obstacles in multiple ways. These strategic responses do more or less to reproduce the status quo [*see box on preceding page*].

The first is to adopt a strategy of "social mobility," which involves individual-level activities that serve to downplay the impact of the group on the self. In effect, this is the kind of strategy that Beilock and her colleagues recommend when they encourage participants to work hard to learn solutions to problems by rote so they will no longer be handicapped by stereotype threat. The limitation of this solution is that it protects the individual by working *around* the problem but, in the process, leaves the problem itself unresolved. As two of us (Haslam and Reicher) note in a 2006 article in the *Journal of Applied Psychology*, such activities thus involve attempting to cope with the stress of threats to self through a strategy of personal avoidance. This approach may be cognitively sophisticated but politically naive.

A second strategy is one of "social creativity," which invokes different in-group stereotypes that deflect the impact of belonging to a disadvantaged group. Traditionally, researchers and laypeople alike have tended to think of stereotypes as fixed and invariant representations of social groups that are impervious to change. In fact, however, the large body of evidence reviewed in the mid-1990s by Penelope Oakes and her fellow social identity researchers at the Australian National University suggests that stereotypes—of both ourselves and others—are inherently flexible.

For example, the degree to which psychology students think of themselves as "scientific" or "artistic" has been shown to vary considerably depending on whether they compare themselves with drama students or with physical scientists. In comparison with physical scientists they are more inclined to stereotype themselves as artistic, but in comparison with people who work in the theater they are more inclined to stereotype themselves as scientific [*see box at left*]. Psychology students should experience stereotype threat if they are asked to perform a scientific task when compared with physicists or an artistic task when compared with artists, but they should experience stereotype lift if asked to perform an artistic task when compared with physicists or a scientific task when compared with artists.

Leaders and other agents of change are thus able to promote changes to in-group stereotypes by altering the dimensions of comparison, the comparative frame of reference or the meaning of particular attributes. There is a sense, however, in which these strategies of social creativity still work within a prevailing consensus rather than doing anything directly to change features of the social world that give rise to a group's stigmatization and disadvantage. In this respect, they can still be seen as strategies of threat denial rather than threat removal.

A third alternative, then, is to advocate group-based opposition to the status quo through a strategy of so-

SOURCE: "THE EFFECT OF COMPARATIVE CONTEXT ON CENTRAL TENDENCY AND VARIABILITY JUDGMENTS AND THE EVALUATION OF GROUP CHARACTERISTICS," BY BERTJAN DOOSJE, S. ALEXANDER HASLAM, RUSSELL SPEARS, PENELOPE J. OAKES AND WILLEM KOOMEN, IN *EUROPEAN JOURNAL OF SOCIAL PSYCHOLOGY*, VOL. 28; 1998

cial competition that involves engaging in active resistance. Here group members work together to challenge the legitimacy of the conditions (and associated stereotypes) that define them as inferior—trying to change the world that oppresses them rather than their reactions to the existing world. They work to counter the stereotypes that are tools of their repression with stereotypes that are tools of emancipation. This strategy was precisely what activists such as Steve Biko and Emmeline Pankhurst achieved through black consciousness and feminism, respectively. They challenged the legitimacy of those comparisons and stereotypes that defined their groups as inferior and replaced them with expressions of group pride. They were (as one supporter said of Pankhurst) "self-dedicated reshaper[s]of the world." And the more their opponents invoked stereotypes against them, the more they acted collectively to contradict those stereotypes and reveal their claims to legitimacy as a lie.

To quote from the evidence that Biko gave at his trial in South Africa in 1976: "The basic tenet of black consciousness is that the black man must reject all value systems that seek to make him a foreigner in the country of his birth and reduce his basic human dignity."

Which of these three strategies individuals choose to pursue, social identity theory argues, depends on a range of factors that are structural and political as well as cognitive and psychological [*see box on page 29*]. In particular, whether or not people seek to change an unequal world rather than adapting to it depends partly on whether they are exposed to social-change belief systems that engage their imagination and articulate cognitive alternatives to the prevailing orthodoxy. In this respect, the significance of established methods for measuring differences between groups (for example, in various forms of ability) derives from their capacity to limit the potential for people to conceive of such alternatives by presenting data as objective and uncontestable "fact." That is, they do not so much measure "real" difference as contribute to making measured differences "real." In this regard, too, the success of leaders of emancipatory movements typically derives from their capacity to create a sense of shared social identity that centers on challenges to the stereotypes and received forms of understanding that define their group as inferior.

Group members can work together to challenge the legitimacy of stereotypes—a strategy employed in the 1970s by Steve Biko in South Africa to combat racism (*left*) and in the late 1800s by Emmeline Pankhurst, a founder of the British suffragette movement (*center in image at right*).

Resistance, of course, is not always successful. Yet it is rarely entirely futile either. Indeed, history teaches us that change is as much a part of social reality as is stability. And when they are in our own hands, stereotypes can be essential to mobilizing the group for success as much as, when in the hands of others, they can be used as forces of restraint and failure.

Thus, the literature on stereotype threat delivers two fundamental lessons. The first is to beware of equating performance and ability, especially when dealing with differences between groups, and to understand the power that the expectations of others has over what we do. The second is to realize that we are not doomed to be victims of oppressive stereotypes but can learn to use stereotypes as tools of our own liberation. In short, who we think we are determines both how we perform and what we are able to become. M

(Further Reading)

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- **Stereotype Susceptibility: Identity Salience and Shifts in Quantitative Performance.** Margaret Shih, Todd Pittinsky and Nalini Ambady in *Psychological Science,* Vol. 10, pages 80–83; January 1999.
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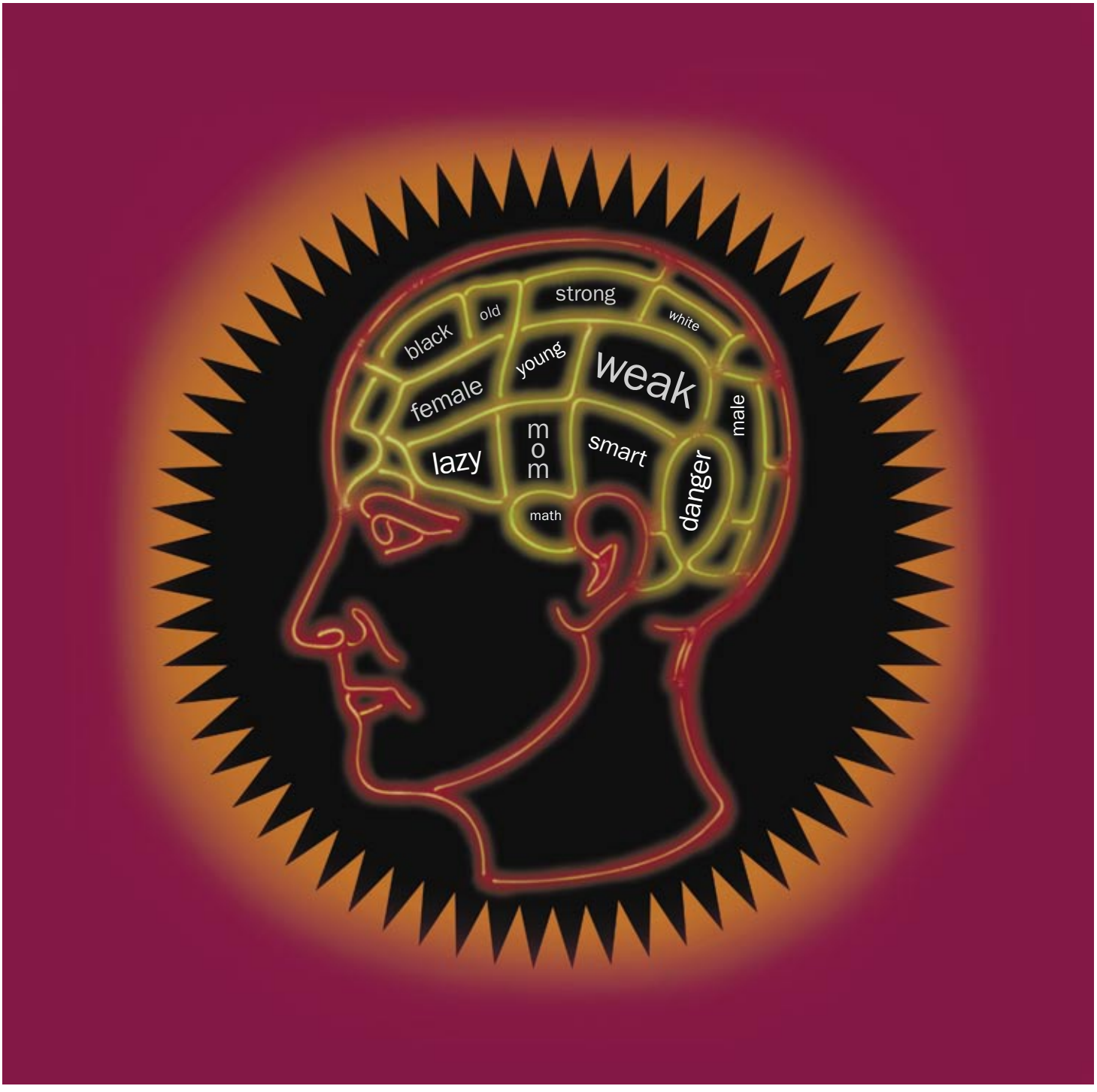
AFP/GETTY IMAGES (*left*); HULTON-DEUTSCH COLLECTION/CORBIS (*right*)



Buried Prejudice

Deep within our subconscious, all of us harbor biases that we consciously abhor. And the worst part is: **we act on them**

By Siri Carpenter

"There is nothing more painful to me at this stage in my life," Jesse Jackson once told an audience, "than to walk down the street and hear footsteps and start thinking about robbery—then look around and see somebody white and feel relieved."

Jackson's remark illustrates a basic fact of our social existence, one that even a committed black civil-rights leader cannot escape: ideas that we may not endorse—for example, that a black stranger might harm us but a white one probably would not—can nonetheless lodge themselves in our minds and, without our permission or awareness, color our perceptions, expectations and judgments.

Using a variety of sophisticated methods, psychologists have established that people unwittingly hold an astounding assortment of stereotypical beliefs and attitudes about social groups: black and white, female and male, elderly and young, gay and straight, fat and thin. Although these implicit biases inhabit us all, we vary in the particulars, depending on our own group membership, our conscious desire to avoid bias and the contours of our everyday environments. For instance, about two thirds of whites have an implicit preference for whites over blacks, whereas blacks show no average preference for one race over the other.

Such bias is far more prevalent than the more overt, or explicit, prejudice that we associate with, say, the Ku Klux Klan or the Nazis. That is emphatically *not* to say that explicit prejudice and discrimination have evaporated nor that they are of lesser importance than implicit bias. According to a 2005 federal report, almost 200,000 hate crimes—84 percent of them violent—occur in the U.S. every year.

The persistence of explicit bias in contemporary culture has led some critics to maintain that implicit bias is of secondary concern. But hundreds of studies of implicit bias show that its effects can be equally insidious. Most social psychologists believe that certain scenarios can automatically activate implicit stereotypes and attitudes, which then can affect our perceptions, judgments and behavior. "The data on that are incontrovertible," concludes psychologist Russell H. Fazio of Ohio State University.

Now researchers are probing deeper. They want to know: Where exactly do such biases come from? How much do they influence our outward behavior? And if stereotypes and prejudiced attitudes are burned into our psyches, can learning more about them help to tell each of us how to override them?

Sticking Together

Implicit biases grow out of normal and necessary features of human cognition, such as our tendency to categorize, to form cliques and to absorb social messages and cues. To make sense of the world around us, we put things into groups and remember relations between objects and actions or adjectives: for instance, people automatically note that cars move fast, cookies taste sweet and mosquitoes bite. Without such deductions, we would have a lot more trouble navigating our environment and surviving in it.

Such associations often reside outside conscious understanding; thus, to measure them, psychologists rely on indirect tests that do not depend on people's ability or willingness to reflect on their feelings and thoughts. Several commonly used methods gauge the speed at which people associate words or pictures representing social groups—young and old, female and male, black and white, fat and thin, Democrat and Republican, and so on—with positive or negative words or with particular stereotypic traits [*for one example, see box on page 39*].

Because closely associated concepts are essentially linked together in a person's mind, a person will be faster to respond to a related pair of concepts—say, "hammer and nail"—than to an uncoupled pair, such as "hammer and cotton ball." The timing of a person's responses, therefore, can reveal hidden associations such as "black and danger" or "female and frail" that form the basis of implicit prejudice. "One of the questions that people often ask is, 'Can we get rid of implicit associations?'" says psychologist Brian A. Nosek of the University of Virginia. "The answer is no, and we wouldn't want to. If we got rid of them, we would lose a very useful tool that we need for our everyday lives."

The problem arises when we form associations that contradict our intentions, beliefs and values. That is, many people unwittingly associate "female" with "weak," "Arab" with "terrorist," or "black" with "criminal," even though such stereotypes undermine values such as fairness and equality that many of us hold dear.

Self-interest often shores up implicit biases. To bolster our own status, we are predisposed to ascribe superior characteristics to the groups to which we belong, or in-groups, and to exaggerate differences between our own group and outsiders [see "The New Psychology of Leadership," by Stephen D. Reicher, S. Alexander Haslam and Michael J. Platow; SCIENTIFIC AMERICAN MIND, August/September 2007].

Even our basic visual perceptions are skewed toward our in-groups. Many studies have shown that people more readily remember faces of their own race than of other races. In recent years, scientists have begun to probe the neural basis for this phenomenon, known as the same-race memory advantage. In a 2001 study neurosurgeon Alexandra J. Golby, now at Harvard Medical School, and her colleagues used functional magnetic resonance imaging to track people's brain activity while they viewed a series of white and black faces. The researchers found that individuals exhibited greater activity in a brain area involved in face recognition known as the fusiform face area [see "A Face in the Crowd," by Nina Bublitz, on page 58] when they viewed faces of their own racial group than when they gazed at faces of a different race. The more strongly a person showed the same-race memory advantage, the greater this brain difference was.

This identification with a group occurs astoundingly quickly. In a 2002 study University of Washington psychologist Anthony G. Greenwald and his colleagues asked 156 people to read the names of four members of two hypothetical teams, Purple and Gold, then spend 45 seconds memorizing the names of the players on just one team. Next, the participants performed two tasks in which they quickly sorted the names of team members. In one task, they grouped members of one team under the concept "win" and those of the other team under "lose," and in the other they linked each team with ei-

FAST FACTS

Subliminal Stereotyping

1» **All of us hold unconscious clichéd beliefs about social groups: black and white, female and male, elderly and young, gay and straight, fat and thin.**

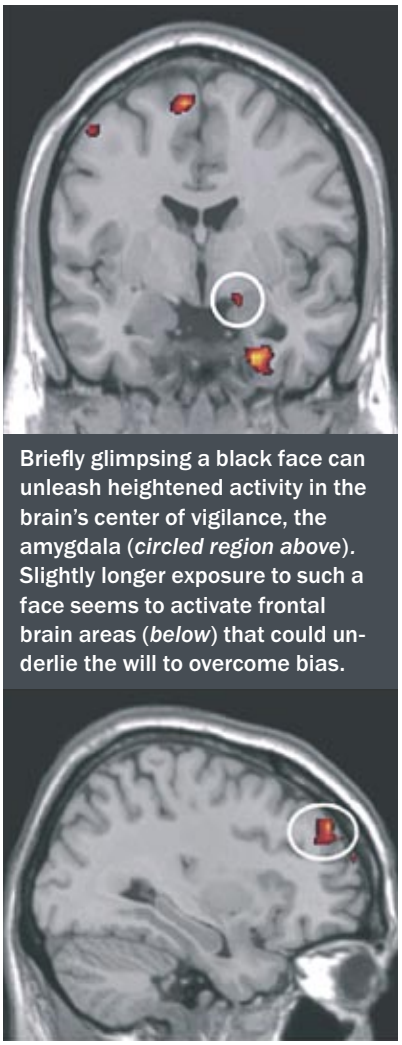
2» **Such implicit bias is far more prevalent than the more overt, or explicit, prejudice that we associate with, for instance, the Ku Klux Klan or the Nazis.**

3» **Certain social scenarios can automatically activate implicit stereotypes and attitudes, which then can affect our perceptions, judgments and behavior, including the choice of whom to befriend, whom to hire and, in the case of doctors, what treatment to deliver.**

4» **Recent research suggests we can reshape our implicit attitudes and beliefs—or at least curb their effects on our behavior.**

ther "self" or "other." The researchers found that the mere 45 seconds that a person spent thinking about a fictional team made them identify with that team (linking it with "self") and implicitly view its members as "winners."

Some implicit biases appear to be rooted in strong emotions. In a 2004 study Ohio State psychologist Wil A. Cunningham and his colleagues measured white people's brain activity as they viewed a series of white and black faces. The team found that black faces—as compared with white faces—that they flashed for only 30 milliseconds (too quickly for participants to notice them) triggered greater activity in the amygdala, a brain area associated with vigilance and sometimes fear. The effect was most pronounced among people who demonstrated strong implicit racial bias. Provocatively, the same study revealed that when faces were shown for half a second—enough time for participants to consciously process them—black faces instead elicited heightened activity in prefrontal brain areas associated with detecting internal conflicts and controlling responses, hinting that individuals were consciously trying to suppress their implicit associations [*see illustration on this page*].



Briefly glimpsing a black face can unleash heightened activity in the brain's center of vigilance, the amygdala (*circled region above*). Slightly longer exposure to such a face seems to activate frontal brain areas (*below*) that could underlie the will to overcome bias.

SOURCE: "SEPARABLE NEURAL COMPONENTS IN THE PROCESSING OF BLACK AND WHITE FACES," BY W. A. CUNNINGHAM ET AL., IN *PSYCHOLOGICAL SCIENCE*, VOL. 15; 2004

Why might black faces, in particular, provoke vigilance? Northwestern University psychologist Jennifer A. Richeson speculates that American cultural stereotypes linking young black men with crime, violence and danger are so robust that our brains may automatically give preferential attention to blacks as a category, just as they do for threatening animals such as snakes. In a recent unpublished study Richeson and her colleagues found that white college students' visual attention was drawn more quickly to photographs of black versus white men, even though the images were flashed so quickly that participants did not consciously notice them. This heightened vigilance did not appear, however, when the men in the pictures were looking away from the camera. (Averted eye gaze, a signal of submission in humans and other animals, extinguishes explicit perceptions of threat.)

Whatever the neural underpinnings of implicit bias, cultural factors—such as shopworn ethnic jokes, careless catchphrases and playground taunts dispensed by peers, parents or the media—often reinforce such prejudice. Subtle sociocultural signals may carry particularly insidious power. In a recent unpublished study psychologist Luigi Castelli of the University of Padova in Italy and his colleagues examined racial attitudes and behavior in 72 white Italian families. They found that young children's racial preferences were unaffected by their parents' explicit racial attitudes (perhaps because those attitudes were muted). Children whose mothers had more negative *implicit* attitudes toward blacks, however, tended to choose a white over a black playmate and ascribed more negative traits to a fictional black child than to a white child. Children whose mothers showed less implicit racial bias on an implicit bias test were less likely to exhibit such racial preferences.

Many of our implicit associations about social groups form before we are old enough to consider them rationally. In an unpublished experiment Mahzarin R. Banaji, a psychologist at Harvard University, and Yarrow Dunham, now a psychologist at the University of California, Merced, found that white preschoolers tended to categorize racially ambiguous angry faces as black rather than white; they did not do so for happy faces. And a 2006 study by Banaji and Harvard graduate student Andrew S. Baron shows that full-fledged implicit racial bias emerges by age six—and never retreats. "These filters through which people see the world are present very early," Baron concludes.

In one study, white preschoolers tended to categorize **racially ambiguous** angry faces as black rather than white; they did not do so for happy faces.

Dangerous Games

On February 4, 1999, four New York City police officers knocked on the apartment door of a 23-year-old West African immigrant named Amadou Diallo. They intended to question him because his physical description matched that of a suspected rapist. Moments later Diallo lay dead. The officers, believing that Diallo was reaching for a gun, had fired 41 shots at him, 19 of which struck their target. The item that Diallo had been pulling from his pocket was not a gun but his wallet. The officers were charged with second-degree murder but argued that at the time of the shooting they believed their lives were in danger. Their argument was successful, and they were acquitted.

In the Diallo case, the officers' split-second decision to open fire had massive, and tragic, consequences, and the court proceedings and public outcry that followed the shooting raised a number of troubling questions. To what degree are our decisions swayed by implicit social biases? How do those implicit biases interact with our more deliberate choices?

A growing body of work indicates that implicit attitudes do, in fact, contaminate our behavior. Reflexive actions and snap judgments may be especially vulnerable to implicit associations. A number of studies have shown, for instance, that both blacks and whites tend to mistake a harmless object such as a cell phone or hand tool for a gun if a black face accompanies the object. This "weapon bias" is especially strong when people have to judge the situation very quickly.

In a 2002 study of racial attitudes and nonverbal behavior, psychologist John F. Dovidio, now at Yale University, and his colleagues measured explicit and implicit racial attitudes among 40 white college students. The researchers then asked the white participants to chat with one black and one white person while the researchers videotaped the interaction. Dovidio and his colleagues found that in these interracial interactions, the white participants' explicit attitudes best predicted the kinds of behavior they could easily control, such as the friendliness of their spoken words. Participants' nonverbal signals, however, such as the amount of eye contact they made, depended on their implicit attitudes.

As a result, Dovidio says, whites and blacks came away from the conversation with very different impressions of how it had gone. Whites typically thought the interactions had gone well, but blacks, attuned to whites' nonverbal behavior, thought otherwise. Blacks also assumed that the whites were conscious of their nonverbal behavior and blamed white prejudice. "Our society is really characterized by this lack of perspective," Dovidio says. "Understanding both implicit and explicit attitudes helps you understand how whites and blacks could look at the same thing and not understand how the other person saw it differently."

Implicit biases can infect more deliberate decisions, too. In a 2007 study Rutgers University psychologists Laurie A. Rudman and Richard D. Ashmore found that white people who exhibited greater implicit bias toward black people also reported a stronger tendency to engage in a variety of discriminatory acts in their everyday lives. These included avoiding or excluding blacks socially, uttering racial slurs and jokes, and insulting, threatening or physically harming black people.

In a second study reported in the same paper, Rudman and Ashmore set up a laboratory scenario to further examine the link between implicit bias against Jews, Asians and blacks and discriminatory behavior toward each of those groups. They asked research participants to examine a budget proposal ostensibly under consideration at their university and to make recommendations for allocating funding to student organizations. Students who exhibited

People tend to mistake a harmless object such as a wallet for a gun if a black face accompanies it. This "weapon bias" might have played a role in the tragic shooting of West African immigrant Amadou Diallo in New York City.

CHRIS HONDROS *Getty Images*

White people who exhibit **greater implicit bias** toward black people report engaging in discriminatory behaviors, such as excluding blacks socially.

greater implicit bias toward a given minority group tended to suggest budgets that discriminated more against organizations devoted to that group's interests.

Implicit bias may sway hiring decisions. In a recent unpublished field experiment economist Dan-Olof Rooth of the University of Kalmar in Sweden sent corporate employers identical job applications on behalf of fictional male candidates—under either Arab-Muslim or Swedish names. Next he tracked down the 193 human resources professionals who had evaluated the applications and measured their implicit biases concerning Arab-Muslim men. Rooth discovered that the greater the employer's bias, the less likely he or she was to call an applicant with a name such as Mohammed or Reza for an interview. Employers' explicit attitudes toward Muslims did not correspond to their decision to interview (or fail to consider) someone with a Muslim name, possibly because many recruiters were reluctant to reveal those attitudes.

Unconscious racial bias may also infect critical medical decisions. In a 2007 study Banaji and her Harvard colleagues presented 287 internal medicine and emergency care physicians with a photograph and brief clinical vignette describing a middle-aged patient—in some cases black and in others white—who came to the hospital complaining of chest pain. Most physicians did not acknowledge racial bias, but on average they showed (on an implicit bias test) a moderate to large implicit antiblack bias. And the greater a physician's racial bias, the less likely he or she was to give a black patient clot-busting thrombolytic drugs.

Beating Back Prejudice

Researchers long believed that because implicit associations develop early in our lives, and because we are often unaware of their influence, they may be virtually impervious to change. But recent work suggests that we can reshape our implicit attitudes and beliefs—or at least curb their effects on our behavior.

Seeing targeted groups in more favorable social contexts can help thwart biased attitudes. In laboratory studies, seeing a black face with a church as a background, instead of a dilapidated street corner, considering familiar examples of admired blacks such as actor Denzel Washington and athlete Michael Jordan, and reading about Arab-Muslims' positive contributions

(The Author)

SIRI CARPENTER is a social psychologist and freelance science writer specializing in behavioral science topics. In the 1990s she studied implicit gender bias under Mahzarin R. Banaji, then at Yale University. She is also co-author of the book *Visualizing Psychology* (John Wiley & Sons, 2007). She lives in Madison, Wis.

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to society all weaken people's implicit racial and ethnic biases. In real college classrooms, students taking a course on prejudice reduction who had a black professor showed greater reductions in both implicit and explicit prejudice at the end of the semester than did those who had a white professor. And in a recent unpublished study Nilanjana Dasgupta, a psychologist at the University of Massachusetts Amherst, found that female engineering students who had a male professor held negative implicit attitudes toward math and implicitly viewed math as masculine. Students with a female engineering professor did not.

More than half a century ago the eminent social psychologist Gordon Allport called group labels "nouns that cut slices," pointing to the power of mere words to shape how we categorize and perceive others. New research underscores that words exert equal potency at an implicit level. In a 2003 study Harvard psychologist Jason Mitchell, along with Nosek and Banaji, instructed white female college students to sort a series of stereotypically black female and white male names according to either race or gender. The group found that categorizing the names according to their race prompted a prowhite bias, but categorizing the same set of names according to their gender prompted an implicit profemale (and hence problack) bias. "These attitudes can form quickly, and they can change quickly" if we restructure our environments to crowd out stereotypical associations and replace them with egalitarian ones, Dasgupta concludes.

In other words, changes in external stimuli, many of which lie outside our control, can trick our brains into making new associations. But an even more obvious tactic would be to confront such biases head-on with conscious effort. And some evidence suggests willpower can work. Among the doctors in the thrombolytic drug study who were aware of the study's purpose, those who showed more implicit racial bias were more likely to prescribe thrombolytic treatment to black patients than were those with less bias, suggesting that recognizing the presence of implicit bias helped them offset it.

In addition, people who report a strong personal motivation to be nonprejudiced tend to harbor less implicit bias. And some studies indicate that people who are good at using logic and willpower to control their more primitive urges, such as trained meditators, exhibit less implicit bias. Brain research suggests that the people who are best at inhibiting implicit stereotypes are those who are especially skilled at detecting mismatches between their intentions and their actions.

But wresting control over automatic processes is tiring and can backfire. If people leave interracial interactions feeling mentally and emotionally drained, they may simply avoid contact with people of a different race or foreign culture. "If you

Some good news: people who report a strong motivation to be nonprejudiced tend to harbor less implicit bias.

Revealing Remarks

After shouting a series of racist slurs during a performance, comedian Michael Richards of *Seinfeld* fame apologized to a late-night television audience: "I went into a rage.... I'm deeply, deeply sorry ... I'm not a racist."

JOE FOX Getty Images (*left*); RICK FRIEDMAN Corbis (*right*)

For making anti-Semitic remarks during a drunk-driving arrest, actor Mel Gibson (*left*) pleaded with the public: "Please know from my heart that I am not an anti-Semite. I am not a bigot. Hatred of any kind goes against my faith."

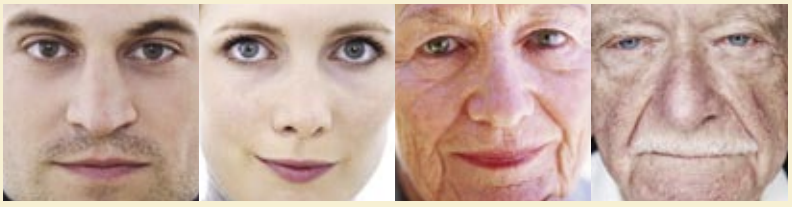
Apologizing for an antigay slur on television, comedian Jerry Lewis said, "Everyone who knows me understands that I hold no prejudices in this regard."

And backing away from intimations that black people are not as intelligent as whites, biologist and Nobel laureate James Watson (*right*) expressed bewilderment and contrition: "I cannot understand how I could have said what I am quoted as having said. There is no scientific basis for such a belief."

These public apologies betray a naïveté about the nature of prejudice. Because most people have no conception of the bias in all of us, they react with shock and alarm when racist, anti-Semitic or antigay remarks surface from those they admire, and the offenders are sometimes similarly perplexed. But to know how the mind works is to better understand the origins of such unappealing utterances: they stem, of course, from subconscious connections embedded in all our minds [*see accompanying main article*]. And the unsettling truth is that just about any of us could have made them. After all, we cannot fully choose our attitudes, because our conscious minds are not always in the driver's seat; thus, *wanting* to be nonprejudiced is not the same as *being* nonprejudiced. —*S.C.*

Detecting Implicit Bias

The most prominent method for measuring implicit bias is the Implicit Association Test (IAT), introduced in 1998 by Anthony G. Greenwald of the University of Washington and his colleagues. Since then, researchers have used the IAT in more than 500 studies of implicit bias. The test measures how quickly people sort stimuli into particular categories. For example, on an IAT examining implicit attitudes toward young versus old people, a test taker uses one key to respond to young faces and positive words such as "joy" and "peace" and another to respond to old faces and negative words such as "agony" and "terrible." Then the test taker does the reverse, pairing young faces with negative words and old faces with positive words. (Researchers vary the order of the pairings for different test takers.) The difference in response times for the two conditions suggests how strongly that person associates these social groups with positive versus negative concepts. To take the IAT, visit **https://implicit.harvard.edu/implicit**



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boil it down, the solution sounds kind of easy: just maximize control," says psychologist B. Keith Payne of the University of North Carolina at Chapel Hill. "But how do you do that? As it plays out in the real world, it's not so easy."

Other research suggests that developing simple but concrete plans to supplant stereotypes in particular situations can also short-circuit implicit biases. In an unpublished study Payne and his colleague Brandon D. Stewart, now a postdoctoral fellow at the University of Queensland in Australia, found that those who simply resolved to think of the word "safe" whenever they saw a black face showed dramatic reductions in implicit racial bias. "You don't necessarily have to beat people over the head with it," Payne observes. "You can just have this little plan in your pocket [think 'safe'] that you can pull out when you need it. Once you've gone to the work of making that specific plan, it becomes automatic."

Taking Control

Despite such data, some psychologists still question the concept of implicit bias. In a 2004 article in the journal *Psychological Inquiry,* psychologists Hal R. Arkes of Ohio State and Philip E. Tetlock of the University of California, Berkeley, suggest that implicit associations between, for example, black people and negative words may not necessarily reflect implicit hostility toward blacks. They could as easily reflect other negative feelings, such as shame about black people's historical treatment at the hands of whites. They also argue that any unfavorable associations about black people we do hold may simply echo shared knowledge of stereotypes in the culture. In that sense, Arkes and Tetlock maintain, implicit measures do not signify anything meaningful about people's internal state, nor do they deserve to be labeled "prejudiced"—a term they feel should be reserved for attitudes a person deliberately endorses.

Others dispute the significance of such a distinction. "There is no clear boundary between the self and society—and this may be particularly true at the automatic level," write Rudman and Ashmore in a 2007 article in the journal *Group Processes & Intergroup Relations*. "Growing up in a culture where some people are valued more than others is likely to permeate our private orientations, no matter how discomfiting the fact."

If we accept this tenet of the human condition, then we have a choice about how to respond. We can respond with sadness or, worse, with apathy. Or we can react with a determination to overcome bias. "The capacity for change is deep and great in us," Banaji says. "But do we want the change? That's the question for each of us as individuals—individual scientists, and teachers, and judges, and businesspeople, and the communities to which we belong." M

(Further Reading)

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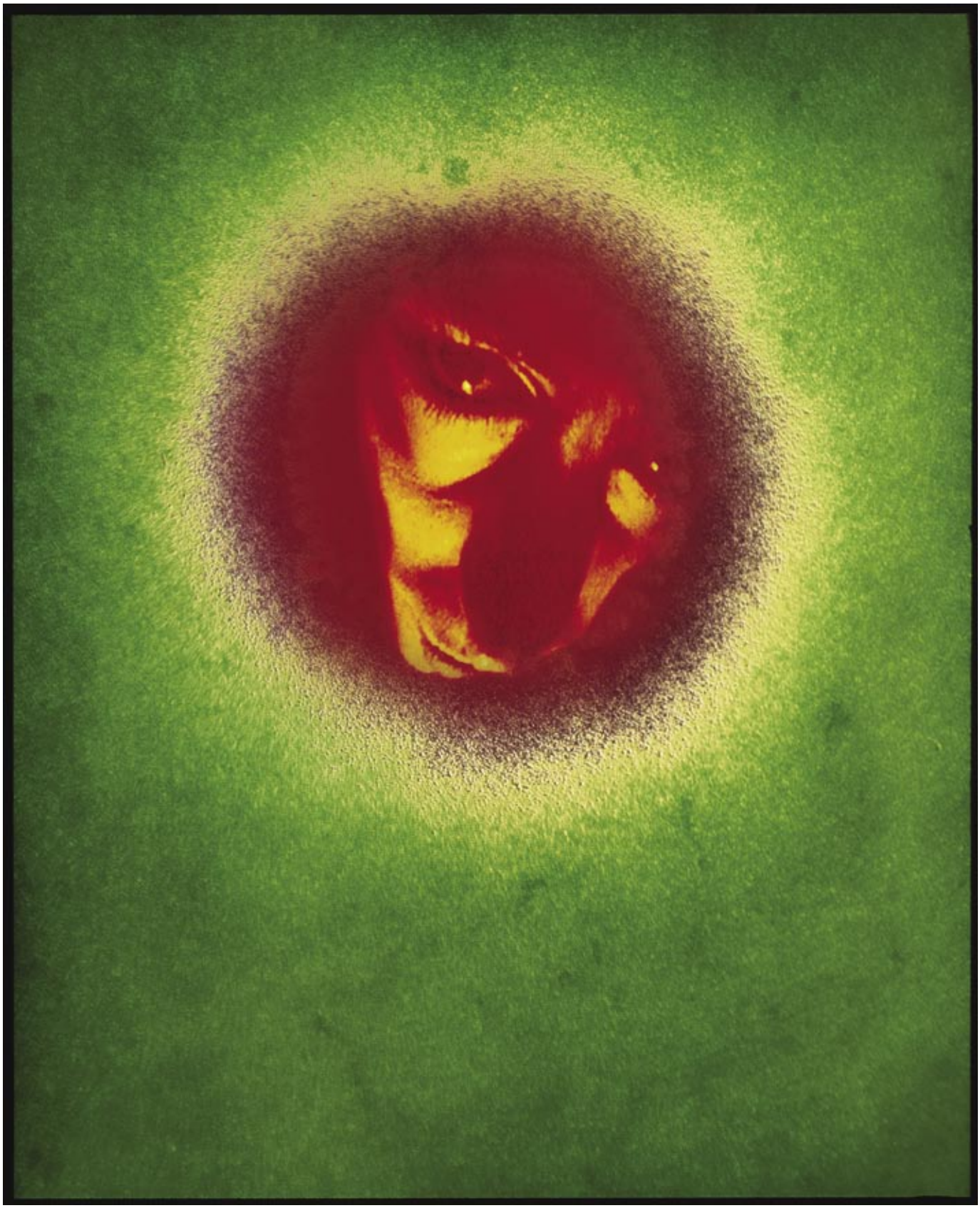
- **Sources of Implicit Attitudes.** Laurie A. Rudman in *Current Directions in Psychological Science,* Vol. 13, No. 2, pages 79–82; 2004.
- **Pervasiveness and Correlates of Implicit Attitudes and Stereotypes.** Brian A. Nosek et al. in *European Review of Social Psychology,* Vol. 18, pages 36–88; 2007.
- **Understanding and Using the Implicit Association Test,** Part 3**: Meta-analysis of Predictive Validity.** Anthony G. Greenwald, T. Andrew Poehlman, Eric L. Uhlmann and Mahzarin R. Banaji in *Journal of Personality and Social Psychology* (in press).
- **Mechanisms Underlying Malleability of Implicit Prejudice and Stereotypes: The Role of Automaticity versus Cognitive Control.** Nilanjana Dasgupta in *Handbook of Prejudice, Stereotyping and Discrimination.* Edited by Todd D. Nelson. Psychology Press (in press).



NIBSC/SPL/PHOTO RESEARCHERS, INC. (*influenza particles*); MEHAU KULYK *Photo Researchers, Inc.* (*face*)

Infected *with* Insanity

The evidence is mounting: mental illness might be caused by microbes

By Melinda Wenner

Schizophrenia is a devastating illness. One percent of the world's population suffers from its symptoms of hallucinations, psychosis and impaired cognitive ability. The disease destroys relationships and renders many of its sufferers unable to hold down a job. What could cause such frightening damage to the brain? According to a growing body of research, the culprit is surprising: the flu.

Up to one fifth of all schizophrenia cases are caused by **prenatal infections**, say Columbia University scientists.

If you are skeptical, you are not alone. Being condemned to a lifetime of harsh antipsychotic drugs seems a far cry from a runny nose and fever. And yet studies have repeatedly linked schizophrenia to prenatal infections with influenza virus and other microbes, showing that the children of mothers who suffer these infections during pregnancy are more likely to be diagnosed with schizophrenia later in life. In 2006 scientists at Columbia University asserted that up to one fifth of all schizophrenia cases are caused by prenatal infections.

Doctors have known for many years that microbes such as syphilis and streptococcus can, if left untreated, lead to serious psychiatric problems. Now a growing number of scientists are proposing that microbes are to blame for several mental illnesses once thought to have neurological or psychological defects at their roots. The strongest evidence pertains to schizophrenia, but autism, bipolar disorder and obsessive-compulsive disorder have also been linked to bacterial, viral or parasitic infections in utero, in childhood or in maturity. Some of these infections can directly affect the brain, whereas others might trigger immune reactions that interfere with brain development or perhaps even attack our own brain cells in an autoimmune mistake.

FAST FACTS

Bugs and the Brain

1» **Mental illnesses once thought to be the result of neurological or psychological defects may be caused by viral or microbial infections.**

2» **The strongest evidence links schizophrenia to prenatal influenza infection; pregnant women who become ill with the flu are more likely to give birth to children who will develop schizophrenia.**

3» **The body's immune reaction, rather than the infections themselves, may be to blame for the resulting brain damage and psychiatric symptoms.**

4» **Understanding the relation between infections and psychiatric disorders may someday allow us to prevent mental illness using drugs or vaccines.**

As scientists tease out the link between infections and psychiatric disorders, they anticipate opening the door to a new world of preventive measures. In the most immediate cases, a simple vaccine or regimen of antimicrobial drugs could rid the body of an infection before it damages the brain. And if our immune system is responsible, we might be able to develop drugs that stifle the effect of the immune response in the brain. The bottom line is, the more we know about the complex roots of mental illness, the better we can fight it.

What Causes Mental Illness?

In 1896 *Scientific American* published an editorial entitled "Is Insanity Due to a Microbe?" The question seemed logical, given that microbes were starting to be implicated in other diseases. In the editorial, two doctors described how they had injected cerebrospinal fluid of mentally ill patients into rabbits, which later got sick. The doctors concluded that "certain forms of insanity" could be caused by infectious agents, "similar to typhoid, diphtheria and others."

But when Freudian psychoanalysis became popular in the 1930s, the idea was more or less put to rest. Then, in the 1950s, the discovery of DNA as hereditary material sparked a rising interest in genetics as a cause of illness, including mental disorders. Several papers reported a clear hereditary component to diseases such as schizophrenia, but genes were obviously not the whole story—as a number of studies have found, the identical twin of someone with schizophrenia has only about a one-in-two chance of developing schizophrenia himself.

Certain environmental influences therefore probably interact with genes to trigger mental illness in a person with a genetic predisposition. Scientists began investigating everything from diet and lifestyle to parental nurturing and geographical location. In 1973 E. Fuller Torrey, now a research psychiatrist at the Stanley Medical Research Institute in Chevy Chase, Md., published an article in the British journal *Lancet* that revived an idea that had been set aside for decades—could microbial infection cause mental illness?

For the next 20 years, a few rogue scientists dominated the field, searching for connections between infections and psychiatric disorders—

and the closer they looked, the more they found.

The most compelling evidence is for schizophrenia. More than 200 studies have suggested that schizophrenia occurs between 5 and 8 percent more frequently than average in children born in the winter or spring. Scientists realized that viruses, which are most prevalent in the cold, dry winter months, could be one of the factors influencing this correlation.

In 2004 Alan S. Brown, a psychiatrist at Columbia University, analyzed blood samples collected from 1959 through 1966 from 189 pregnant women, 64 of whom had later given birth to children who became schizophrenic. The women had had their blood drawn multiple times during pregnancy, allowing Brown and his colleagues to compare if and when the women had been exposed to the flu. "We showed that if [flu] infection occurred in the early to middle part of pregnancy, the risk of schizophrenia was increased three times," Brown explains. "For first-trimester exposure, it was increased seven times."

Brown had also found in a 2001 study that children born to mothers who were exposed to the viral infection rubella, known as German measles, during the 1964 U.S. epidemic were 10 times more likely than other children to develop schizophrenia. Most people today are vaccinated against rubella during childhood, so the risk from this infection is now negligible. But Brown also showed a link between schizophrenia and *Toxoplasma gondii,* a single-celled parasite that infects about 40 percent of the human population through contaminated water and uncooked meat. One of his studies suggests that if *T. gondii* antibodies—the human immune system's soldier cells that are a sure sign of ongoing or previous infection—are elevated in a mother's blood, her child is 2.5 times more likely than other children to develop schizophrenia.

Although the case is strongest for schizophrenia, prenatal infections with rubella and several types of herpes have been linked less conclusively with psychiatric disorders, including autism, bipolar disorder and even Alzheimer's disease. To date, most of the correlations found between infections and psychiatric conditions are just that—correlations. There is no conclusive evidence that infections actually *cause* these diseases; it could be, for example, that carrying the genes for mental illness makes a person more likely to behave in a way that exposes him or her to a virus.

But animal studies lend powerful support to the idea that prenatal infections can affect an offspring's brain. In 2003 California Institute of Technology biologist Paul H. Patterson showed that mice born to mothers infected with flu during gestation are much more fearful than normal mice, reluctant to explore novel objects and interact with other mice. Neural development also appears to be disrupted in these animals: postmortem investigation reveals vast differences in the distribution of their neurons.

STEFANIE SUDEK *Getty Images*

When a woman gets sick during pregnancy, her baby is more likely to develop a psychiatric illness later in life.

As the evidence mounts, many experts are beginning to think that a causal link indeed exists between prenatal infections and psychiatric disorders. Now a new question arises: What exactly are these infections doing to the fetal brain?

The Immune Factor

Although a developing fetus is protected by the placenta—the organ that transfers nutrients and waste between mother and fetus and prevents their blood from mixing—some microbes can cross this hurdle. *T. gondii* has this ability during its initial, or acute, infection of a pregnant

Mice infected with *Toxoplasma gondii* lose their fear of cats, the parasite's preferred breeding ground. In humans, *T. gondii* infections may be linked to schizophrenia and bipolar disorder.

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woman. If an acute infection during early pregnancy is left untreated, it can cause severe birth defects or miscarriage. But the picture is less clear for acute infections in late pregnancy and dormant infections, in which the parasite hibernates quietly in the body and does not cross the placenta. Brown's antibody study suggests that these types of infections, once thought to be harmless, may lead to schizophrenia.

T. gondii is also one of the few microbes that can cross the blood-brain barrier, a protective membrane separating brain cells from the rest of the body. Once in the brain, *T. gondii* affects its hosts' behavior. Infected rats and mice lose their fear of cats, making the rodents more likely to approach and be eaten by a cat, which is in the parasite's best interest—it can reproduce only in a feline. In people, *T. gondii* appears to subtly alter personality, making its hosts more neurotic and insecure and making men more cautious and women more kind and openhearted.

The parasite probably instigates these behavioral changes by affecting the levels of certain brain chemicals. One study, for example, found that *T. gondii* increases the production of dopamine, an important neurotransmitter involved in a variety of brain processes, including motor activity, sleep, attention and reward. In a fetus, changes in dopamine levels can wreak havoc on normal brain development, and scientists have long known that schizophrenia is associated with an overabundance of dopamine in specific parts of the brain.

But a dormant *T. gondii* infection, which may also be correlated with an increased risk of schizophrenia in the fetus, does not cross the placenta and therefore cannot directly affect the fetal brain. The influenza link is equally difficult to understand, because flu does not usually infect the fetus. Something else, then, may be at play.

Some studies suggest that infections per se are not responsible for disrupting brain development; rather the body's immune response to infection affects the nervous system and does the damage. "When the immune system becomes activated, it can influence the functioning of the brain and, in turn, emotional and behavioral responses," explains Christopher L. Coe, a psychologist at the University of Wisconsin–Madison who studies the effects of psychological and environmental factors on the immune system.

For example, recall how you typically feel the day before you come down with the flu. "You just don't feel right—you're more achy, you lose your appetite, you have a sense of fatigue," Coe says. It is not the flu making you feel that way—it is your immune response to it. "You're feeling cytokines," he says, referring to the small molecules produced by many cell types, including immune cells, for signaling purposes.

Cytokines are produced in large numbers during infection, but their functions are not limited

When the **immune system** becomes active, it can influence the functioning of the brain.

to the immune system—they are also important for brain development. When scientists culture neurons in the lab and then add cytokines to them, the neurons do not grow properly. "We know that high levels of cytokines interfere with growth and connections of neurons," Coe says. "A maternal infection—could that affect the immature brain in a way that sets the stage for mental illness?"

It is possible, according to Coe; a pregnant mother's immune response may affect the way the placenta functions. The placenta's job is to pass hormones and nutrients to the fetus, but when the mother's body is fighting an infection the placenta likely behaves slightly differently. In some cases, it may prompt the fetus to produce its own cytokines; in other cases, the mother's cytokines will cross the placenta themselves. "There's sort of a reverberation, a harmonic—so as the mother is responding, it causes the baby to respond, even though there's no virus there," Coe explains.

Bolstering the idea that cytokines play a key role are a number of studies showing that the levels of certain cytokines, such as one called interleukin-8, were markedly increased in the blood of mothers who gave birth to schizophrenic children, based on blood samples taken from pregnant women decades ago and the psychiatric profiles of their adult children. Genetic research has uncovered two genes associated with schizophrenia that are also involved in cytokine function, and animal research has lent support as well. Patterson of Caltech recently performed an experiment in which he injected pregnant mice not with a flu virus but with a dose of synthetic double-stranded RNA. Although this molecule of viral genetic material does not behave like a virus on its own, it is recognized as foreign by the body, eliciting an immune response without other infection-related effects. He found that the mice born of mothers injected with RNA behaved exactly like the offspring of flu-infected mothers—suggesting that the immune response, not the virus, is what actually affects the brain.

Defense on the Offense

The immune system may inadvertently harm the brain in another way, too—and not only in a fetus. Although current scientific evidence most strongly links mental illness to prenatal infections, many researchers are also investigating the possibility that childhood or even adult infections could cause psychiatric conditions by triggering an autoimmune reaction. Similar to the way the body attacks insulin-producing pancreas cells in type 1 diabetes, certain infections may trick the immune system into attacking brain cells.

Vaccinating a pregnant woman may be risky if her immune response interferes with neuronal growth in her unborn baby's brain.

PULSE PICTURE LIBRARY/CMP IMAGES/PHOTOTAKE USA

One such infection may result from *Streptococcus*, the same organism that causes strep throat. In 1998 doctors who were performing long-term studies of children who had obsessive-compulsive disorder (OCD) noticed that a small percentage of the children had suddenly developed OCD and a tic disorder following an infection with group A beta-hemolytic *Streptococcus*. Typical OCD will "just kind of come on gradually," says Susan E. Swedo, a senior neuroscience investigator at the National Institute of Mental Health. "But with these kids, it was 24 to 36 hours between absolutely no symptoms and peak." In other words, these children literally woke up one day with OCD or serious tics.

Swedo and her colleagues named the new mental disorder PANDAS, for *p*ediatric *a*utoimmune *n*europsychiatric *d*isorders *a*ssociated with *s*treptococcal infections. They believe PANDAS

(The Author)

MELINDA WENNER is a freelance science writer based in New York City.

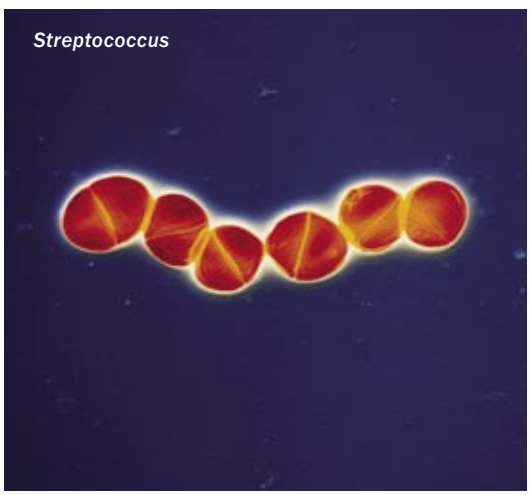
***Streptococcus*, the same bacterium responsible for strep throat, may trick the body into attacking its own brain cells. Some scientists think this immune mistake causes childhood OCD.**

tacking its own proteins. Some studies have found antibrain antibodies in PANDAS patients, and other studies have found temporal associations between a strep diagnosis and OCD onset.

Other research, however, has failed to replicate these findings, and PANDAS is still a highly controversial diagnosis. Many experts doubt that such a clear cause-and-effect relation exists between strep infection and OCD. "We feel very strongly that the data support that infections will make tics worse but not cause them," says neurologist and pediatrician Harvey Singer of Johns Hopkins University. In 2005 Singer and his colleagues analyzed blood samples from similar numbers of PANDAS patients and healthy people and did not find any major antibody differences between the two groups.

Although PANDAS remains a subject of debate, many scientists consider it an important piece of the puzzle. Whether through an autoimmune reaction or the disruption of fetal brain development, if the immune system, rather than the infections themselves, is to blame for infection-related mental illness, it would surely sim-

These children literally wake up one day with obsessive-compulsive disorder (OCD) or **serious tics**.



develops because the immune system begins attacking the brain after infection. The *Streptococcus* bacterium displays certain proteins on its surface that resemble proteins made by humans—a strategy that helps the bacterium evade detection by its host. Eventually, however, the body discovers the bacterium and attacks it. In that process of defense, the body also may begin attack-

plify the problem. It would also explain why so many different infections seem to be implicated in mental illness. Flu, rubella, strep, herpes, *T. gondii*—these infections do quite different things to our bodies, yes. But they do have us in common.

Stopping Illness before It Starts

Researchers hope that as they continue to unravel the complex causes of mental illness, they will also keep moving closer to the ultimate prize: a cure. "The most important thing, if you want to deal with mental disorders, is to prevent them from happening in the first place," Columbia's Brown says. If infections do play a causal role, then we have a number of new solutions at our fingertips. "I think that this may just be the tip of the iceberg," he says.

Even the small body of work that now exists could have immediate policy implications. The Centers for Disease Control and Prevention currently recommend that all pregnant women get flu shots—a dangerous proposition if immune response, rather than infection itself, is respon-

RAY KACHATORIAN Getty Images (top); EYE OF SCIENCE/PHOTO RESEARCHERS, INC. (bottom)

Connecting the Dots

Recent studies have found links between a huge variety of infections and psychiatric ailments, from both prenatal and postnatal exposures. Here are some of the best-supported correlations:

Schizophrenia	Prenatal	Influenza, rubella, *Toxoplasma gondii,* herpes, Lyme disease, polio, measles
	Postnatal	*T. gondii,* Lyme disease, chlamydia, herpes
OCD/tic disorder	Prenatal	No links found
	Postnatal	*Streptococcus*
Bipolar disorder	Prenatal	Herpes, *T. gondii*
	Postnatal	Herpes, *T. gondii*
Autism	Prenatal	Rubella, herpes, Lyme disease
	Postnatal	Lyme disease, *Mycoplasma* (bacterium that causes "walking pneumonia"), *Clostridium* (bacterium that causes botulism)
Alzheimer's disease	Prenatal	Herpes
	Postnatal	No links found
Tourette's syndrome	Prenatal	No links found
	Postnatal	*Mycoplasma*

sible for harming the fetal brain. "I don't think they have considered this risk. In fact, I know they haven't considered this risk," Patterson says, referring to the CDC. "If you take it seriously and vaccinate everybody, then what's going to happen?" Researchers cannot yet predict how often a prenatal immune response might lead to fetal brain damage, but even if it happens less than 1 percent of the time, vaccinating an entire population of pregnant women could affect thousands of children.

Scientists also hope these new insights will help them develop preventive drug regimens, even perhaps using medications that exist today. A handful of studies have suggested that antipsychotic drugs have subtle effects on the immune system; Ina Weiner, a psychologist at Tel Aviv University, took this idea one step further. She wondered whether antipsychotics might be able to *prevent* schizophrenia—not just treat some of its symptoms. As Weiner explained at the 2007 conference of the International Brain Research Organization, she exposed mice in utero to an immune chemical that caused many of them to develop symptoms and brain abnormalities resembling schizophrenia's effects in humans. As in humans, the mice showed early signs of cognitive decline around the age of puberty, before developing full-blown schizophrenia. Administering antipsychotic medication as soon as these early symptoms appeared not only prevented future schizophrenic behavior but also protected the brain from the physical changes, such as a shrinking hippocampus, that accompany schizophrenia.

Future drugs and vaccines may target the infections directly or go after the immune system, controlling its interference with the developing brain or preventing an autoimmune attack on brain cells. "There are many, many things that can be done," Brown says—the more we learn about the impact of infections on the brain, the better we will be able to prevent the damage that leads to mental illness. Last century scientists cured a broad range of physical diseases caused by infections; many hope that the 21st century will bring cures for the infections ailing our minds. M

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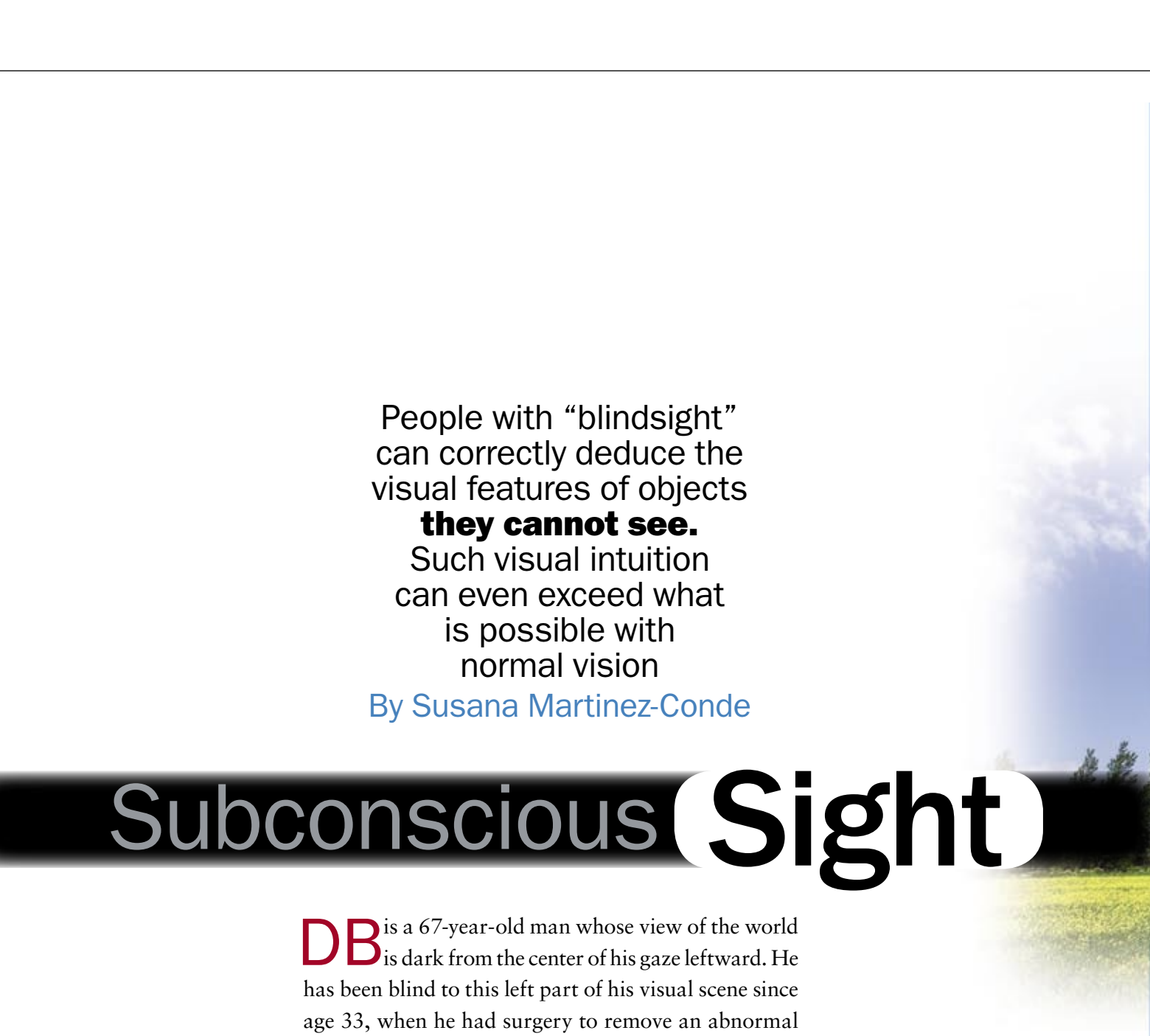
People with "blindsight" can correctly deduce the visual features of objects **they cannot see.** Such visual intuition can even exceed what is possible with normal vision

By Susana Martinez-Conde

Subconscious Sight



CHRISTINA PEDRAZZINI SPL/Photo Researchers, Inc. (*blindfolded man*); GETTY IMAGES (*meadow*)

DB is a 67-year-old man whose view of the world is dark from the center of his gaze leftward. He has been blind to this left part of his visual scene since age 33, when he had surgery to remove an abnormal tangle of blood vessels at the back of his brain. Unfortunately, while taking out the tangle, surgeons destroyed an important center of visual processing called the primary visual cortex, or area V1, which relays information from the eyes to higher-level brain areas dedicated to sight.

DB lost just the right half of V1. Because the right part of the brain processes visual information from the left visual field (and vice versa), his doctors were not surprised that DB became blind to the left portion of his view. But they were astounded that although DB

denied seeing anything to the left of center, he was nonetheless able to accurately "guess" many properties of targets, such as shape and specific location, presented in this perceptually dark field.

DB's ability to somehow intuit features of unseen objects and patterns is called blindsight. Researchers believe this strange phenomenon stems from the flow of information through neural pathways that bypass V1 but still convey a small amount of visual information to higher brain regions involved in sight. For unknown reasons, these secondary routes do not convey the feeling of sight.

Recent data suggest that the accuracy of a blindsight patient's guess about what something looks like, or where it is, can improve markedly with practice, hinting that such practice might improve blindsight patients' ability to detect objects in their everyday surroundings. And although an individual with blindsight cannot see in his or her blind field, a new study shows that DB, at least, has some object-detection abilities that surpass those of ordinary sighted people. This research also reveals that some awareness of unseen visual stimuli can accompany blindsight. DB's and others' cases of blindsight indicate that consciousness and visual perception can be separated in our brains.

Blind Beginnings

Neurological oddities typically emerge from studies of brain-damaged people, but experiments in animals offered the earliest hints of blindsight. Beginning in the 1930s and 1940s, neurobiologists who had surgically removed V1

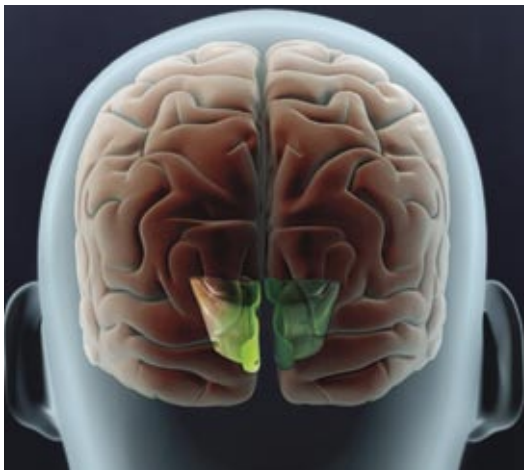
FAST FACTS

Sensing the Unseen

1» **The ability to subconsciously intuit the features of unseen objects and patterns in patients with injuries to the visual brain area known as V1 is called blindsight.**

2» **Researchers believe that the blindsight phenomenon stems from the flow of information through neural pathways that bypass the damaged visual region. For unknown reasons, these secondary conduits for visual information do not convey the feeling of sight.**

3» **Recent data suggest that blindsight patients' visual intuition can improve with practice and that the detection abilities of such patients can surpass those of ordinary sighted people.**



When the primary visual cortex, or area V1 (*light- and dark-green patches*), at the back of the brain is destroyed, so, too, is the conscious sensation of sight.

in monkeys noticed that the animals appeared to retain some visual skills, such as the ability to detect contrast and to tell one object from another by the objects' shapes.

But few scientists believed that people could see without V1: the known human patients whose primary visual cortex had been destroyed were totally blind. Some exceptions to this rule included soldiers who had sustained injuries during World Wars I and II that abolished the function of V1. A few neurologists who treated these men claimed that some of them retained residual visual function. But at the time the scientific community did not take such observations seriously. Instead researchers concluded that humans and monkeys were different in this respect, despite the striking anatomical similarities in their visual pathways.

In 1973 neuroscientist Ernst Pöppel, then at the Massachusetts Institute of Technology, and his colleagues reported measuring eye movements in patients who had lost area V1. The patients said that they could not see visual targets, but their eye movements were biased toward them nonetheless, hinting that their visual system was obliquely informed of the targets.

But it was the work of University of Oxford psychologist Larry Weiskrantz and his colleagues, who first examined DB in the early 1970s, that shattered the skepticism about blindsight in people. Like Pöppel's patients, DB showed eye movements biased toward visual targets. In addition, however, Weiskrantz and his co-workers unmasked other visual skills with a technique borrowed from animal experiments: they forced

BARROW NEUROLOGICAL INSTITUTE

Patients with "blindsight" can correctly guess the color or shape of an unseen object but cannot detect **complex trajectories**.

BETSIE VAN DER MEER *Getty Images*

DB to choose between defined options instead of just asking him what he saw. That is, Weiskrantz's team presented DB with a choice of, say, two possible colors or locations and asked him to guess which one applied to a visual target he claimed he could not see. DB's "guesswork" was correct much more often than would have been expected by chance—matching the findings in primates.

DB himself was astonished. Because he could not see the objects, he had thought that his guesses were completely random. In the wake of these experiments, Weiskrantz coined the term "blindsight," which appeared in a 1974 article in the journal *Lancet*.

Scientists then identified and examined other patients who displayed this curious ability. Although none of them so far has demonstrated detection skills as acute as those of DB, many of these patients can deduce the color or shape of an object in their blind field and predict whether it is moving or still; they can also guess the orientation of unseen lines or gratings, the timing of an object's appearance, and the expressions on unperceived faces at better-than-chance levels. On the other hand, these patients cannot intuit fine details in their blind fields. Nor can they detect complex movements.

Extraordinary Vision

Whatever a patient's ability to detect the unseen, practice can enhance it. In a 2006 study Weiskrantz, along with neuroscientists Ceri T. Trevethan and Arash Sahraie of the University of Aberdeen in Scotland and their colleagues, asked 12 patients with blindsight to repeatedly guess which of two stimuli—a flickering grating or a gray dot—had appeared in the middle of their blind field. After three months of daily practice, the patients increased the number of correct responses by up to 25 percent and could detect gratings of lower contrast than those they could detect before. They also generally reported being more consciously aware of the correct answer.

(The Author)

SUSANA MARTINEZ-CONDE is director of the Barrow Neurological Institute's Laboratory of Visual Neuroscience in Phoenix, where she studies the neural code and dynamics of visual perception.

The results suggest that these patients can learn to "see" in ways that could enhance their quality of life.

DB might not need much more practice, however, after having participated in numerous vision experiments over four decades. Indeed, in 2007, Weiskrantz, Trevethan and Sahraie showed that DB's blind-field sensitivity is actually better than what normal vision can achieve. The researchers showed DB a two-second-long stimulus called a Gabor patch [*see illustration below*] on a gray screen in one of two time spans. Because the patch was small and had very low contrast, even a person with normal vision would find it hard to perceive. Weiskrantz's team asked DB to indicate, with a button press, in which time interval he thought the pattern had appeared.

In two different experiments involving more than 150 distinct presentations of the stimulus, DB performed significantly better in his blind field than in his sighted field. He consistently identified the time span containing the stimulus 87 percent of the time in his blind field as opposed to only half of the time—a rate no better than chance—in his sighted field. By varying the stimulus contrast, the researchers also learned that DB could detect stimuli of significantly lower contrast in his blind field as compared with his sighted field. Ironically, DB found the tests on the sighted field hard work, whereas the blind-field tests seemed effortless: "No problem, I'm just guessing," he remarked.

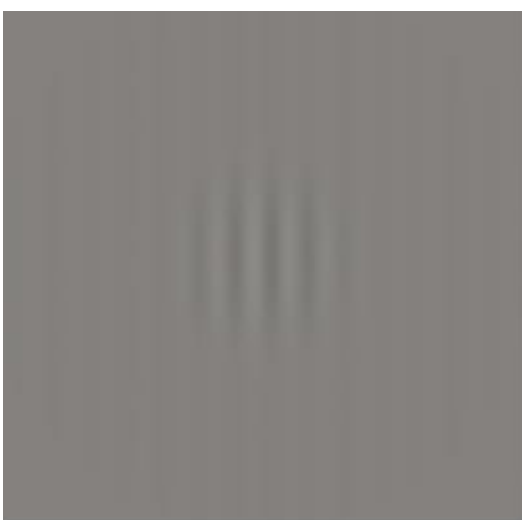
The researchers ruled out the possibility that DB might simply have abnormally poor vision in his sighted field. When they compared DB's performance in his sighted field with that of six age-matched participants who had normal vision, they found DB's sighted-field vision to be equal to that of the unimpaired subjects. Thus, DB's blind-field sensitivity is not superior merely to that of his own sighted field but also to that of normal vision.

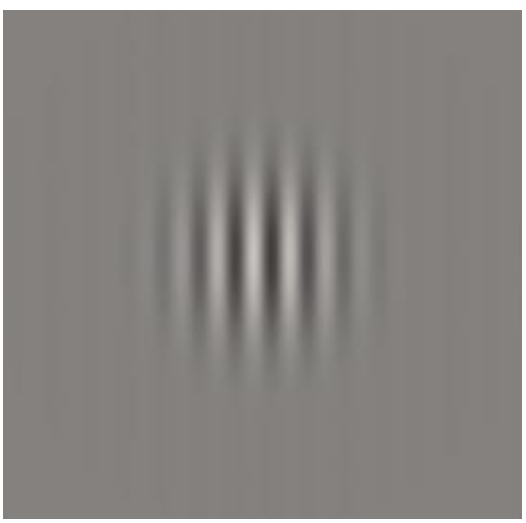
Blindly Aware

Meanwhile DB reported no awareness of the Gabor patch when it was presented to his sighted field (confirming that he was essentially guessing about when it showed up). Nevertheless, DB had some subjective awareness of 80 percent of stimuli presented to the blind field. This awareness was nothing like vision, DB explained; he described it instead as "feeling as if a finger is pointing through the screen."

Interestingly, DB's awareness of the unseen pattern vanished during trials in which researchers randomly alternated its presentation to the blind or sighted field. DB reported being aware of the presence of the Gabor patch only during the trials in which the researchers first showed it repeatedly to the blind field and then switched to the sighted field for a second block of 30 trials. That is, DB's awareness of a stimulus seems to

The patient DB was often oddly aware of the unseen patterns placed in his blind field.





Gabor patches of two different contrast levels are shown at the right. Such patches are commonly used in tests of visual perception.

JORGE OTERO-MILLAN *Martinez-Conde Laboratory, Barrow Neurological Institute*

Parsing the Unseen

People with blindsight cannot see anything in their blind field, and yet they may be vaguely aware of objects there and even proffer correct guesses about the objects' visual features. Such a peculiar skill is exclusive to patients with bona fide brain damage. The phenomenon shares similarities with common experiences such as navigating in dim light and gut feelings of danger, but these subconscious capacities differ from blindsight in important ways.

A soldier may display a type of "sixth sense" that warns him or her of danger; that skill is not the same thing as blindsight, however.

The ability to navigate in the dark—say, through the woods on a moonless night—without being able to see exactly what is underfoot also relies on an awareness of objects in a blind spot. But contrary to the situation in blindsight, researchers can account for the dim-light phenomenon with known properties of visual neurons. In the eye, a type of light-detecting neuron, or photoreceptor, called a rod can respond to very little light. There are no rods in the center of your vision, where you have the best perception of detail in daylight, so in darkness you are literally blind to the portion of your field of view on which you focus most during the day. People are not aware of this central blind spot when they are in the dark, because the brain fills it in with information from the surroundings. The use of peripheral vision (rather than central vision) to navigate in the darkness may partly explain why people think they are using their hunches to prevent themselves from bumping into branches.

The ability of some people to sense approaching danger probably involves yet another type of subconscious process. Although this skill might result from a dim awareness of unseen objects akin to blindsight, it more likely stems from expertise. Experts can use so-called implicit knowledge to make automatic analyses and, in such cases, are often unaware of how they came to their decision. For instance, an infantry soldier in a war zone may have a gut feeling that something is amiss. He might not be able to pinpoint the problem, however, because the thought process that led to the decision "*we must leave immediately*" was subconscious. Although it may seem as if that soldier has a "sixth sense," his skill is not related to blindsight but to his expert ability to automatically analyze complex information. For further reading on this topic, I recommend the book *Blink,* by Malcolm Gladwell.

—*S.M.-C.*

depend on his ability to predict its appearance in the blind field—and thus on the expectation that he will *not* be able to actually see it.

The feeling of being aware of something is, of course, different from actually seeing it. Because DB was aware but unseeing, his damaged brain area, V1, may be essential only to the sensation of visual perception and not to subjective awareness. Thus, if you sustain damage to V1, you may be aware of much that you cannot see.

Still, not all studies of blindsight indicate that patients are aware of unseen visual stimuli. Tests of a blindsight patient known as GY showed that his talent for detecting a symbol was not accompanied by the ability to consciously predict (and bet on) his performance [see "Put Your Money Where Your Mind Is," by Kaspar Mossman; Scientific American Mind, April/May 2007].

DB is probably a particularly gifted patient. From all his experience, he may have developed an intuitive sense for when something is going to appear—and may have learned to trust his intuition. Thus, DB may represent the pinnacle of a phenomenon in which brain damage or inborn defects that lead to amnesia, dyslexia, blindness or myriad other difficulties can nonetheless leave behind surprising residual powers. Such revelations give new meaning to the legendary rejoinder of the blind comic-book superhero Daredevil: "Yeah, tell them you got beat by a blind man, too." M

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New Weapons against Cocaine Addiction

Drug therapies show promise in the battle against addictive stimulants

By Peter Sergo

Many people still chalk up the destructive behavior of a drug addict to a lack of willpower or weakness of character. To a neuroscientist, however, drug addiction is a psychiatric illness that develops when the repeated use of narcotics disrupts brain chemistry. Such a chemical disturbance cries out for a chemical solution—that is, a drug treatment.

Doctors have few pharmaceutical remedies for drug addiction, which is often resistant to talk therapy. Relapse rates run as high as 40 to 60 percent for many types of substance abuse. Heroin addicts often benefit from methadone, a synthetic opioid that thwarts cravings by substituting for some of heroin's effects; naltrexone, an opioid receptor blocker, helps alcoholics kick their habit by reducing the desire for alcohol. But most victims of drug dependence are left with no antidote to the neurological havoc their habit has wrought in their brain. "We have very few medications for the treatment of addiction," says Nora D. Volkow, director of the National Institute on Drug Abuse (NIDA), "and it's urgent" that more such drugs are developed.

Among the most urgent needs is a pharmacological weapon to combat the abuse of cocaine, a powerfully addictive stimulant that is synthesized from a pure form found in the leaf of the *Erythroxylon coca* bush. About 1.7 million Americans abused cocaine in 2006, according to the Department of Health and Human Services. Such compulsive drug taking not only ruins addicts' lives—breaking up families, for instance, or causing severe cardiovascular disease—but also exacts large costs to society, spreading crime

FAST FACTS

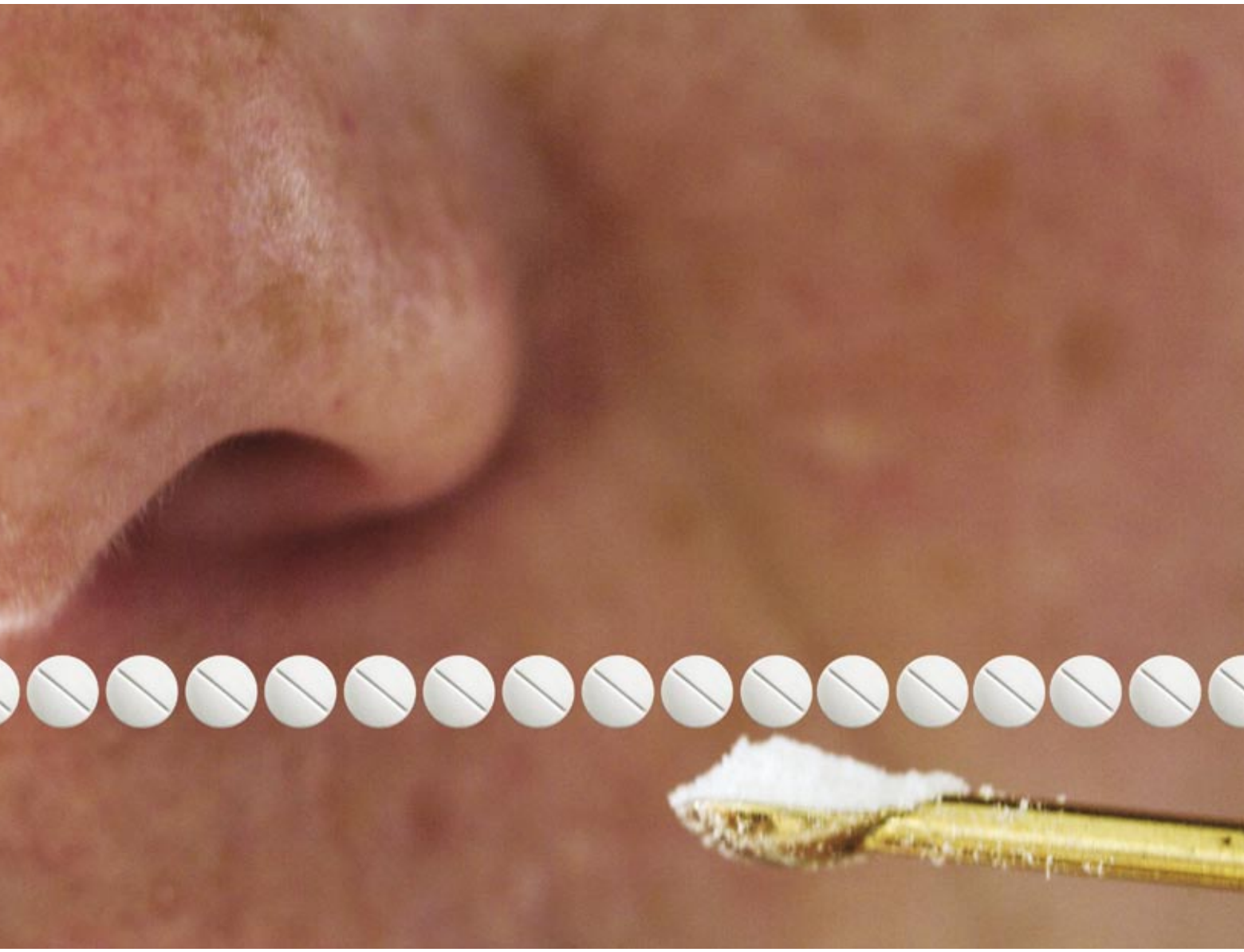
Counteracting Cocaine

1» **Doctors have few pharmacological remedies for addiction and no standard drug therapy for cocaine dependence. A decrease in cocaine use by 10 percent could save the U.S. $745 million in medical, law-enforcement and other cocaine-related expenses.**

2» **Experimental therapies, including one marketed for epileptic seizures and another for the sleep disorder narcolepsy, appear to help addicts quench or diminish the thirst for cocaine.**

3» **Scientists are also trying to enlist the immune system to thwart cocaine abuse.**

SETH RESNICK *Getty Images (cocaine on spoon)*; GETTY IMAGES *(pills)*



and HIV, among other ills. If a medication could decrease cocaine use by even 10 percent, it could save the U.S. $745 million in cocaine-related expenses, such as those from the incarceration of sellers and users and medical treatment for babies born to addicted mothers, according to a 2000 study in *Pharmacoeconomics*.

Officials at the NIDA are gunning for such savings. The institute fronted about $15 million for drug treatments for cocaine addiction in fiscal year 2007. Those funds accounted for one third of the total money the institute doled out for pharmacological trials in that year. So far several drug candidates have emerged from this effort, including medications currently marketed for epileptic seizures and the sleep disorder narcolepsy that act in the brain to help quench or diminish an addict's thirst for cocaine. Meanwhile scientists are also trying to enlist the immune system to prevent cocaine from entering the brain in the first place.

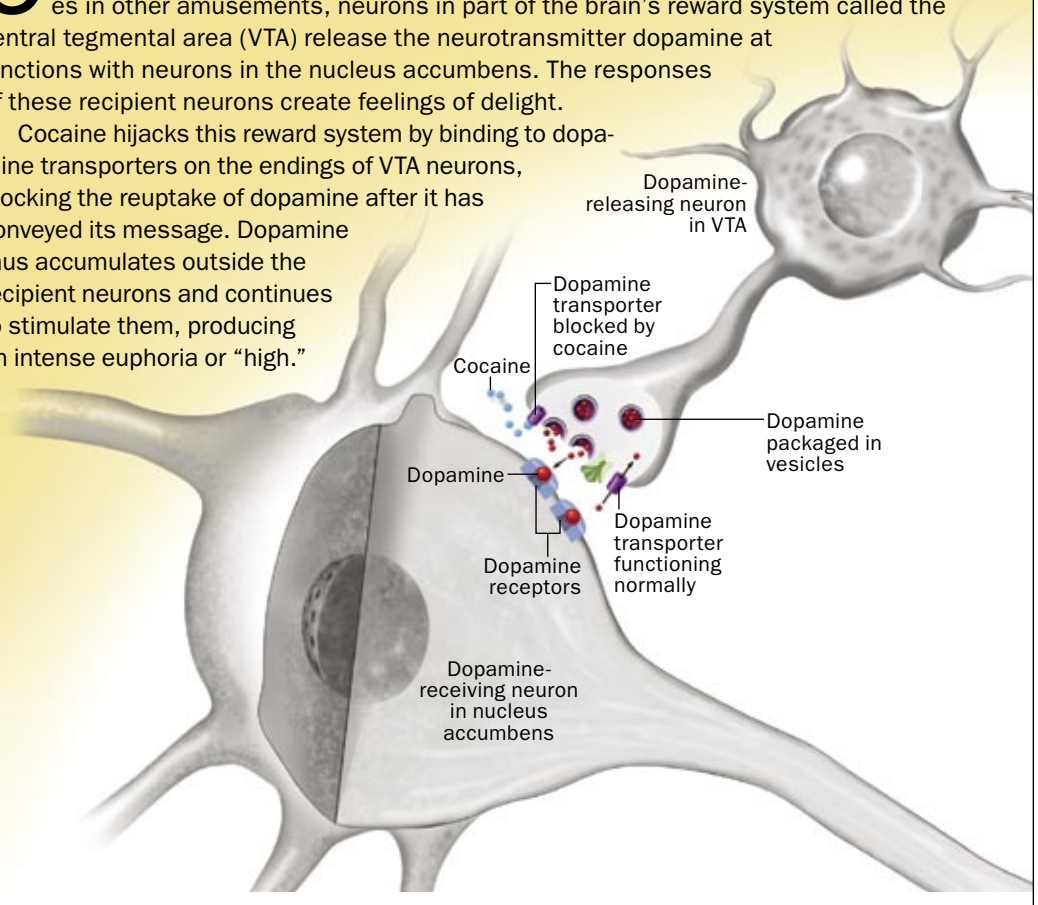
Too Much of a Good Thing

Cocaine exerts its insidious effects by hijacking the parts of the brain dedicated to the perception of pleasure. Whenever we eat or have sex, for example, neurons in these so-called reward centers release the chemical messenger, or neurotransmitter, dopamine. When dopamine conveys its message to the recipient neurons, their

Cocaine in the Brain

Cocaine hooks users by chemically corrupting the regions of the brain that govern our feelings of pleasure and reward. When a person eats delicious food, has sex or engages in other amusements, neurons in part of the brain's reward system called the ventral tegmental area (VTA) release the neurotransmitter dopamine at junctions with neurons in the nucleus accumbens. The responses of these recipient neurons create feelings of delight.

Cocaine hijacks this reward system by binding to dopamine transporters on the endings of VTA neurons, blocking the reuptake of dopamine after it has conveyed its message. Dopamine thus accumulates outside the recipient neurons and continues to stimulate them, producing an intense euphoria or "high."



responses engender feelings of delight, satisfaction or arousal. Dopamine's effects, however, quickly fade as the chemical is sucked back into the cells that released it by transporter molecules in a process known as reuptake [*see box above*].

Cocaine blocks the transporters and prevents dopamine reuptake, causing the neurotransmitter to build up in the brain. As dopamine concentrations reach double or even 10 times those the brain experiences from ordinary amusements, the neurotransmitter continually stimulates the receiving neurons, producing euphoria or a "high." A user also may feel unnaturally energetic and alert—features of stimulants, which include methamphetamine ("speed") as well as cocaine.

Not everyone who tries cocaine becomes addicted to it, but many people have trouble restraining their need for and use of the drug. Cocaine can perturb the brain's reward centers such that drug-seeking behavior becomes a conditioned, almost reflexive, response. Cocaine is often the sole source of pleasure for an addict, as he or she loses the motivation to engage in other once enjoyable activities. Meanwhile any reminder of drug use, such as glimpsing a fellow user or drug-related paraphernalia, triggers a small surge of dopamine that brings on intense cravings for the drug.

In the past researchers have tried to end this brutal cycle with drugs that directly target dopamine or its receptor, but the therapies proved addictive themselves and produced other unwanted side effects. Now scientists are turning their attention to compounds that adjust the activity of other neurotransmitters—such as glutamate and gamma-aminobutyric acid (GABA)—to either satisfy an addict's cravings or dampen reward responses in the brain, dulling the incentive to use. At least one experimental medication may also cushion the harsh withdrawal symptoms, including nausea and depression, that result from the sudden drop in dopamine that occurs when users become abstinent.

(The Author)

PETER SERGO is a freelance science writer living in New York City.

TERESE WINSLOW

An approved narcolepsy treatment called modafinil, for example, acts as a mild stimulant that, among other effects, increases levels of the excitatory neurotransmitter glutamate in the brain. Modafinil may thus work as a cocaine replacement, safely satiating an addict's cravings while diminishing withdrawal symptoms. In 2005 psychiatrist Charles A. Dackis of the University of Pennsylvania and his colleagues reported that 30 cocaine-dependent subjects who received modafinil steered clear of cocaine for an average of 3.4 of the eight weeks of treatment as compared with 1.9 weeks of abstinence for 32 users who received a placebo. But in an unpublished trial of 210 cocaine addicts conducted in 2007, psychiatrist Ahmed Elkashef and neuropharmacologist Frank Vocci, both at the NIDA, and their co-workers found that only 17 percent more of the addicts who took modafinil as compared with those who took a placebo were cocaine-free for at least two of the eight weeks of treatment.

Holding Back the "High"

Other possible cocaine-curbing remedies act in the opposite fashion: instead of exciting neurons, they augment the activities of the inhibitory neurotransmitter GABA. One such compound is topiramate, an antiseizure medication that also blocks the release of glutamate. In 2004 Penn psychiatrist Kyle M. Kampman and his colleagues reported that in combination with psychotherapy, topiramate led to three weeks of abstinence in 59 percent of addicts who took it for 13 weeks, whereas just 26 percent of users in the placebo group remained cocaine-free for that long. Studies suggest that addicts who are abstinent for three to four weeks will remain so for at least six months to a year.

Another GABA booster is vigabatrin (gamma-vinyl-GABA, or GVG), a drug used in some countries to treat epilepsy. GVG works by blocking an enzyme, GABA transaminase, that chemically breaks down GABA, causing the neurotransmitter to build up inside neurons. These neurons normally release their stores of GABA in response to a surge of dopamine, such as the one that accompanies a cocaine binge. By boosting GABA stores, GVG greatly enhances the inhibitory firepower of these neurons, suppressing the cocaine high and giving addicts less reason to use. GVG thus calms an overactive reward system rather than shutting it down entirely, which may reduce its potential side effects.

So far GVG is faring well in small-scale trials. According to Jonathan Brodie, a psychiatrist at the New York University School of Medicine, 14 of 50 addicts (or 28 percent) who were given GVG in an unpublished study that he and his colleagues conducted in Mexico were clean for the last three of nine weeks of treatment as compared with four of 53 addicts (or 7.5 percent) given a placebo. Catalyst Pharmaceutical Partners in Coral Gables, Fla., is now testing the compound in 180 cocaine addicts in the U.S. and expects results later this year.

A more far-reaching potential remedy taps the body's immune system to target cocaine circulating in the blood. Because the cocaine molecules are too small to provoke a strong immune response, developers link the drug to larger molecules, such as a bacterial toxin, that powerfully invigorate immune cells. Some of these cells churn out antibodies against the attached cocaine molecules that, after immunity is established in six to 10 weeks, are poised to prevent cocaine from entering the brain whenever a person uses it, undercutting the potential high. In studies of cocaine-obsessed rats and in small-scale clinical trials, the vaccine spawned the production of anticocaine antibodies and decreased cocaine use. Unlike a neurotransmitter-based remedy, however, a vaccine is unlikely to quell cravings or ease withdrawal.

No one knows whether such a vaccine, or any of the other possible antidotes to cocaine dependence, will prove to be safe and effective in trials involving large numbers of addicts. Unfortunately, big pharma may resist sinking money into such trials. The NIDA's Volkow warns that companies see little payoff in treating destitute drug addicts, especially because many insurance companies do not cover addiction treatments. Undeterred, neuroscientists are continuing to look for new ways of combating addiction while also fighting the false perception that compulsive drug use is a symptom of character flaws. "We can be at the mercy of drugs that inflict damage to brain tissue representing control functions," Volkow says. But that idea, she admits, will be slow to seep into the public consciousness. M

Experimental cocaine treatments work to either satisfy an addict's cravings or dampen reward responses in the brain.

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A Face in the Crowd

Is our remarkable ability to recognize human faces hardwired in the brain or a result of lots of practice?

By *Nina Bublitz*

LE STUDIO/AGE FOTOSTOCK

Dashing for a train in a busy station at rush hour, I picked out a face in the crowd—the familiar configuration of features, the laugh lines and the mole above the right eye. I immediately knew the distinctive visage belonged to my former classmate, Robert.

Most of us are highly skilled at recognizing faces, even though they all have similar features arranged in roughly the same configuration: two eyes separated by a standard-issue nose, along with a mouth, chin and cheeks. We are similarly adept at reading facial expressions to intuit a person's mood and at extracting information about an individual's sex, age and direction of gaze. We do this reading within a fraction of a second, an ability that is critically important for normal social interactions.

Human perception of faces exceeds that of other objects and patterns. Can you imagine recognizing a particular Granny Smith apple in someone's shopping cart that you had just seen in the produce pile? Apples do not appear terribly distinctive to us the way faces do; the same thing is true for trees, cars, butterflies and, well, you name it.

FAST FACTS

Seeing Faces

1» Most of us can identify a familiar face in a mere fraction of a second, even though all faces are made up of similar features in roughly the same configuration. We are also adept at reading facial expressions to intuit a person's mood and at extracting information about an individual's sex, age and direction of gaze.

2» Neuroscientists have long debated the biological basis for human face perception. Because this skill is so critical to communication, many researchers believe that specialized neural hardware has evolved to detect faces—and indeed, face-specific neurons have been found in both human and monkey brains.

3» Many psychologists propose that a unique type of visual processing occurs in the "face place" in the brain. Others believe that face-detecting neurons process faces in the same way other brain neurons distinguish objects and that face cells are more discriminating because of people's greater experience with faces.

Neuroscientists have long debated the biological basis for human face perception. Because this skill is so critical to communication, many researchers believe that specialized neural hardware has evolved to detect faces. Indeed, back in the 1970s researchers found neurons in a small section of the monkey brain that responded much more strongly to faces than to any other item. Since then, vision scientists have discovered a region in the human visual system that seems similarly sensitive to the human countenance. What is more, people can selectively lose the ability to recognize faces as a result of brain damage or a congenital abnormality [see "Forgetting Faces," by Thomas Grueter; Scientific American Mind, August/September 2007].

Many psychologists propose that a unique type of visual processing occurs in the region of the brain involved in recognizing faces. Such processing might enable greater perceptual precision and might account for such findings as our spectacular *inability* to recognize upside-down faces relative to upside-down examples of other objects. Others believe that face-detecting neurons process faces in the same way other brain neurons distinguish objects, except that they are more finely tuned to subtlety because of greater experience with faces. A more contrary group of vision scientists contests the existence of innate face detectors entirely, arguing that practice with faces trains generic object detectors to respond to the human countenance.

Beyond satisfying our curiosity, a better understanding of human face perception might help doctors diagnose and treat disorders such as autism, in which face perception is seriously impaired. It could also aid the quest to develop robotic devices able to tell one person from another by their facial characteristics.

The Upside-Down Effect

The idea that face perception might involve unique neural processes first emerged in the late 1960s, when psychologist Robert K. Yin, then at

A house is easy to identify from a picture, even upside down, but inverted human faces are much harder to discern.

the Massachusetts Institute of Technology, compared the ability of 70 students to recognize photographs or drawings of faces with their ability to recognize airplanes, houses and cartoon figures without distinct faces. The students identified the faces more often than the other objects as long as the photographs were right side up. They found all the images more difficult to recognize upside down, but inverted faces were especially hard to discern as compared with the upturned images of the other objects.

Based on this so-called face-inversion effect, Yin proposed that recognizing faces requires some type of visual processing in the brain distinct from that used for perceiving other objects and patterns. In particular, he speculated that face perception may be more holistic—or, all at once—than that of objects, which the brain is thought to perceive from their component shapes.

In the conventional account of visual perception, light detectors at the back of the eye, in the retina, respond most vigorously to spots of light. Signals from groups of these cells eventually coalesce in the primary visual cortex (V1) at the back of the brain, where neurons react best to lines or edges. Signals from those neurons combine to assemble ever more complex shapes as they travel up the hierarchy of visual areas, from V2 through V4 and, finally, to the inferior temporal cortex, where cells are tuned to the perception of complex objects, such as faces, birds and cars.

Such shape-based processing may work reasonably well for most inverted objects. But inverting a face, Yin surmised, might preferentially disrupt a holistic processing that operates only for faces.

Meanwhile other researchers were entertaining alternative explanations for the uniqueness of face perception. Some suggested that instead of processing faces holistically, the brain dissects the human countenance in two steps, by first recognizing its features and then computing their configuration. The face-inversion effect might thus arise from a failure to process the configuration of inverted faces, leaving features as the only guide to the uniqueness of a face.

Psychologist Helmut Leder of the University of Vienna has demonstrated that the spatial characteristics of a face—say, the distance between the eyes and that between the nose and mouth—are important for face recognition and are also very sensitive to orientation. In a 1998 study, for example, Leder and psychologist Vicki Bruce of the University of Edinburgh doctored pictures of faces to alter just their features or the spatial relations among their features. Both types of change made the faces equally more distinctive to viewers and easier for them to recognize than the original face was. But when the faces were upside down, those with unusual feature *relations* proved far less distinctive or familiar than the faces with touched-up features. Leder and Bruce concluded that face perception involves processing both the individual features and their configuration but that inverting a face preferentially disrupts the latter.

Further evidence suggests that the configuration idea may explain the inversion effect better than the holistic-perception hypothesis does. In 2000 Leder and Bruce reported asking subjects

Some scientists believe that a unique type of visual processing underlies our spectacular ability to recognize human faces.

CORBIS (*house*); MICHAEL OCHS ARCHIVES/CORBIS (*Elvis*)

to identify faces either by unique combinations of features, such as eye and hair color, or by distinctive relations between features. As expected, inverting the faces made the ones defined by unusual feature relations much harder to identify than those with distinguishing features. But surprisingly, the faces with odd configurations were also harder to identify upside down than were faces with *both* distinctive attributes, bolstering the configuration theory over the holistic explanation for the inversion effect.

In 2006 Leder, along with University of Vienna psychologist Claus-Christian Carbon and their colleagues, published work showing that patients with face blindness have the most difficulty with a face-matching task when the faces differ only by their features' spatial relations. Thus, problems sorting out the configuration of facial features may also explain some pathological deficits in face recognition.

Face Space

Meanwhile researchers had fingered the place in the human brain where such sorting may take place. In 1997 psychologist Nancy Kanwisher, now at M.I.T., and her colleagues used functional magnetic resonance imaging (fMRI) to scan the brains of 15 people while they viewed intact and scrambled faces, full-front views of faces and houses, or three-quarter views of faces and images of human hands. In each case, a blueberry-size region they dubbed the fusiform face area (FFA),

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located in the fusiform gyrus [*see top illustration at right*], reacted more strongly to the intact face stimuli.

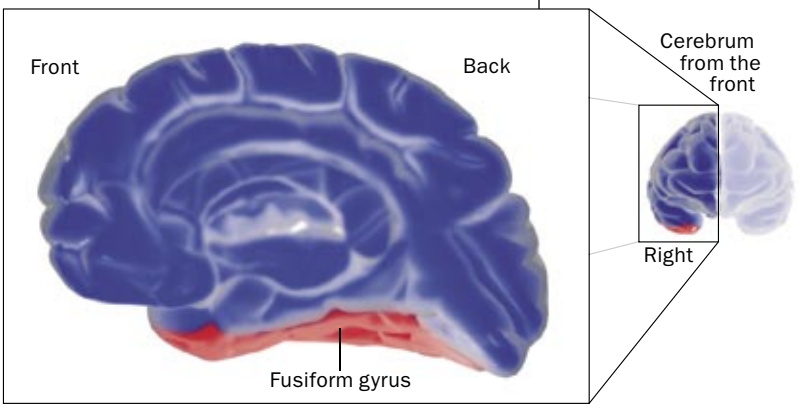
Not all scientists are convinced that the FFA homes in on feature arrangements. Yet another theory, first proposed in 1991 by psychologist Tim Valentine, now at Goldsmiths College in London, is that face perception revolves around the representation of a prototype face, against which the brain compares all other visages. In the brain, this reference face may be an average of the activity patterns created in response to seeing many different faces, suggests cognitive scientist Martin A. Giese of the University of Tübingen in Germany. Some scientists visualize a multidimensional face space, which contains the average of all faces at its center and individual faces radiating out from the origin as a function of their distinctiveness [*see bottom illustration at right*]. This picture jibes with the observation that exaggerating features, as is done in caricatures, makes faces easier to recognize.

Giese, along with neurophysiologists David A. Leopold, now at the National Institute of Mental Health, and Igor V. Bondar of the Institute of Higher Nervous Activity and Neurophysiology in Moscow, tested the face-space hypothesis in the visual system of rhesus monkeys, whose ability to recognize faces is very similar to our own. They created an "average" human face by merging the characteristics of a large number of human faces and then constructed caricatures based on that norm. They showed these faces to monkeys while measuring the activity of neurons in the inferior temporal cortex, where their face-detecting cells reside.

In 2006 they reported that the average face elicited relatively low levels of activity from the face neurons and that the neuronal responses became increasingly vigorous as the caricatures became more and more distinctive. "Cells that signal deviations from the facial norm react strongly to small variations in the shape of the face," Giese says. "This [mechanism] makes it possible for us to recognize minimal differences with a limited number of neurons." It also may explain why changes in facial expression have to be learned only once and not relearned for each new face.

Not everyone is convinced, however, that such findings prove the brain uses a norm-based system for processing faces. For example, computational neuroscientist Maximilian Riesenhuber of Georgetown University says the results may instead reflect the general tendency of neurons to "adapt to a facial norm that is shown frequently and then subsequently respond to it less strongly," a tendency that is not specific to face recognition.

A Cerebral Spot for Faces



The brain's presumed face detector resides in the fusiform gyrus in the temporal lobe.

Shaping Up

Indeed, Riesenhuber rejects the idea that seeing faces requires any such special computation by the brain. Instead, he says, face perception operates by the same rules that object perception does. He and his colleagues created a computer model of standard shape-based visual processing and showed that it could account for the human forte in perceiving faces, along with the extreme preference for upright versions, with one additional ingredient: expertise.

Based on classical visual theory, Riesenhuber's simulation represents objects as conglomerations of component shapes. Neurons detecting, say, spots or edges feed information to cells that respond to more complex patterns until eventually cells respond to whole objects. Cells in defined regions of the brain react to different classes of objects, and within each area various objects excite different cells—the proposed biological basis of a person's ability to tell objects apart.

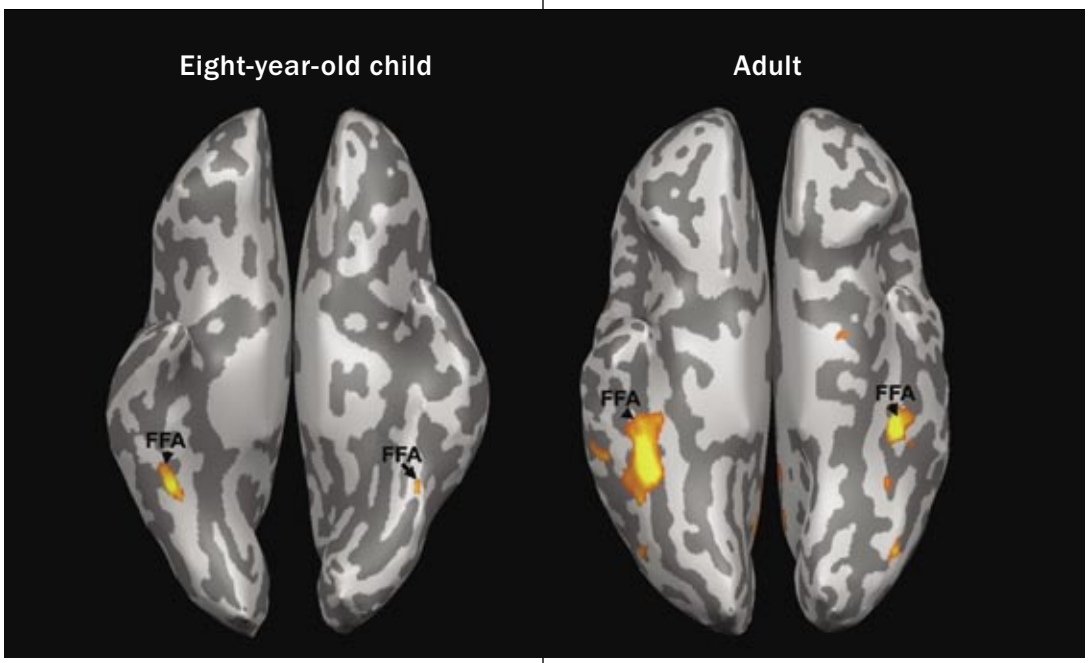
In one theory of face perception, the brain stores a reference face (*center*) and compares all other faces to it.

The more neurons devoted to a class of objects, the more distinctions they can make among objects within that class. Thus, when a person develops expertise at recognizing, say, butterflies or cars, Riesenhuber reasons, the brain recruits more neurons to enable finer

(The Author)

NINA BUBLITZ is a biologist and science journalist living in Hamburg, Germany.

GEHIRN & GEIST/SIGANIM (*top*); DAVID A. LEOPOLD *National Institute of Mental Health* (*bottom*)



The brain's face-recognition region (the fusiform face area, or FFA) is larger in adults than in children, and its expansion with age is correlated with improved memory for faces.

FROM "DIFFERENTIAL DEVELOPMENT OF HIGH-LEVEL VISUAL CORTEX CORRELATES WITH CATEGORY-SPECIFIC RECOGNITION MEMORY," BY G. GOLARAI ET AL., IN *NATURE NEUROSCIENCE*, VOL. 10, NO. 4; APRIL 10, 2007 (EPUB: MARCH 11, 2007)

discriminations among them. "Faces comprise one object class that everyone is expert in," Riesenhuber explains. So in his model he finessed face perception by devoting a large number of neurons to it: in different scenarios, groups of 70 to 190 neurons in the virtual visual area V4 supply information to 180 individual face units, each tuned to a different face.

"We have different groups of neurons that respond to different faces," one scientist says. "This enables us to distinguish similar faces."

To determine how well these imitation neurons could tell faces apart, Riesenhuber and his colleagues fed them digital portraits that differed from an original in a stepwise fashion, from one to 10 "morph steps." As they reported in 2006, they found that face units receiving a greater number of inputs were more finely tuned to a specific face than were those with fewer inputs; they responded much less vigorously even to faces that were very similar to their "favorite" face. And the more discriminating the face unit, the less it responded to an inverted version of that face, providing an explanation for the inversion effect. "Our model is the first to account for the behavioral data in a quantitative fashion," Riesenhuber claims.

To ascertain whether the brain actually sees faces this way, Riesenhuber's team scanned the brains of 13 people while they looked at the morphed portraits. If face cells are simply highly selective shape detectors as the model suggests, then just a small difference in a face should excite a distinct set of neurons in the FFA. Indeed, faces differing by just one morph step activated separate, but overlapping, sets of cells. As the portrait pairs became increasingly dissimilar, so, too, did the responsive cell groups, until at 10 morph steps apart the faces excited totally separate cell clusters. "We have different groups of neurons that respond to different faces," Riesenhuber concludes. "This enables us not only to distinguish similar faces but to remember new ones more easily."

People are not born with the ability to make such fine distinctions, Riesenhuber says. Children do not achieve adultlike proficiency at recognizing faces until about age 14, studies suggest. Thus, although innate neural hardware may exist for recognizing faces, experience looking at the human countenance also very likely plays a role in the maturation of the brain's face areas. Riesenhuber and others believe this process involves the recruitment of additional finely tuned cells.

Stanford University psychologist Kalanit Grill-Spector and her colleagues have now garnered anatomical evidence for that theory. These researchers used fMRI to compare the size of the FFA, among other brain areas involved in object perception, of adults and children. They reported in 2007 that the FFA was considerably larger in adults and that this expansion was correlated with a better memory for faces [*see box above*].

Expert Eyes

People can acquire visual expertise for other objects, of course, and some evidence indicates that such knowledge can produce some of the

Fantastic constructions called greebles may excite neurons in the face area of the brain in trained observers just as human faces do in most people.

ISABEL GAUTHIER *Vanderbilt University*

same perceptual peculiarities that people exhibit with faces, lending support to the view that face and object perception are not so different after all. Back in 1986, for example, M.I.T. psychologists Rhea Diamond and Susan Carey reported that they found an inversion effect for dog faces among dog experts—in this case, experienced jurors of canine beauty contests. In their experiments, the jurors could no longer recognize the breed of a dog when the dog's photograph was upside down.

Anatomically, some studies show that the basis for such specialized acuity develops in brain areas near, but separate from, the FFA, leaving intact the concept of dedicated neural real estate for faces even if the visual system detects them similarly. In 2004 psychologist Gillian Rhodes of the University of Western Australia and her colleagues pointed to a brain region in butterfly experts that was specialized for parsing butterflies. The researchers found that the neurons that responded best to views of these winged insects were near, but largely separate from, the cells that responded vigorously when the *Lepidoptera* connoisseurs viewed human faces. "You have learning for butterfly experts in a brain region that is very close to the neurons that like faces," Riesenhuber comments.

In a 2007 study Riesenhuber and his colleagues documented the biological effect of such visual learning in people with expertise in looking at cars. They determined that a clustered group of neurons in the so-called lateral occipital cortex became more selective for different types of cars after the scientists trained study subjects to recognize cars. Such findings indicate that the brain does use largely separate populations of neurons when learning to distinguish among members of different object classes and that the FFA is the cerebral spot for faces.

That idea remains controversial, however. Other work rebuts the postulate that neurons in the FFA are faithful to faces, instead suggesting that they can switch allegiance to other objects or patterns for which a person has developed expertise. In the late 1990s psychologist Isabel Gauthier, then at Yale University, and her colleagues detected elevated activity in the FFA of test subjects who had been trained to recognize bizarre constructions they called greebles, which vaguely resemble bird heads [*see illustration at left*].

Looking at greebles elicited far less activity in the FFA of people who had no previous exposure to them. What is more, as with faces, the FFA was less active in the greeble experts when they were viewing inverted, as opposed to upright, greebles. Gauthier, now at Vanderbilt University, concludes that the FFA becomes stimulated when a person has to identify a particular item within a group of similar items regardless of the type of object.

But even the view that faces must share their place in the brain does not diminish the wonder of our extraordinary ability to decode them nor their importance in our lives. As 18th-century physicist Georg Christoph Lichtenberg once said: "The most entertaining surface on the face of the earth is that of the human face." M

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PETER TURNER *Getty Images* (*silhouette of head*); ALTRENDO IMAGES/GETTY IMAGES (*fireworks*)

Achieving sexual climax requires a complex conspiracy of sensory and psychological signals—and the eventual silencing of critical brain areas

The Orgasmic Mind

By Martin Portner

She did not often have such strong emotions. But she suddenly felt powerless against her passion and the desire to throw herself into the arms of the cousin whom she saw at a family funeral. "It can only be because of that patch," said Marianne, a participant in a multinational trial of a testosterone patch designed to treat hypoactive sexual desire disorder, in which a woman is devoid of libido. Testosterone, a hormone ordinarily produced by the ovaries, is linked to female sexual function, and the women in this 2005 study had undergone operations to remove their ovaries.

After 12 weeks of the trial, Marianne had felt her sexual desire return. Touching herself unleashed erotic sensations and vivid sexual fantasies. Eventually she could make love to her husband again and experienced an orgasm for the first time in almost three years. But that improvement was not because of testosterone, it turned out. Marianne was among the half of the women who had received a placebo patch—with no testosterone in it at all.

Marianne's experience underlines the complexity of sexual arousal. Far from being a simple issue of hormones, sexual desire and orgasm are subject to various influences on the brain and nervous system, which controls the sex glands and genitals. And many of those influences are environmental. Recent research, for example, shows that visual stimuli spur sexual stirrings in women, as they do in men. Marianne's desire may have been invigorated by conversations or thoughts about sex she had as a result of taking part in the trial. Such stimuli may help relieve inhibitions or simply whet a person's appetite for sex.

Achieving orgasm, brain-imaging studies show, involves more than heightened arousal. It requires a release of inhibitions and control in which the brain's center of vigilance shuts down in males; in females, various areas of the brain involved in controlling thoughts and emotions become silent. The brain's pleasure centers tend to light up brightly in the brain scans of both sexes, especially in those of males. The reward system creates an incentive to seek more sexual encounters, with clear benefits for the survival of the species. When the drive for sex dissipates, as it did with Marianne, people can reignite the spark with tactics that target the mind.

Biologist Alfred Kinsey shocked the public more than half a century ago with his revelations about human sexual behavior.

FAST FACTS

Principles of Pleasure

1» Sexual desire and orgasm are subject to various influences on the brain and nervous system, which controls the sex glands and genitals.

2» The ingredients of desire may differ for men and women, but researchers have revealed some surprising similarities. For example, visual stimuli spur sexual stirrings in women, as they do in men.

3» Achieving orgasm, brain imaging studies show, involves more than heightened arousal. It requires a release of inhibitions engineered by shutdown of the brain's center of vigilance in both sexes and a widespread neural power failure in females.

Sex in Circles

Biologists identified sex hormones such as estrogen and testosterone in the 1920s and 1930s, and the first studies of human sexuality appeared in the 1940s. In 1948 biologist Alfred Kinsey of Indiana University introduced his first report on human sexual practices, *Sexual Behavior in the Human Male*, which was followed, in 1953, by *Sexual Behavior in the Human Female*. These highly controversial books opened up a new dialogue about human sexuality. They not only broached topics—such as masturbation, homosexuality and orgasm—that many people considered taboo but also revealed the surprising frequency with which people were coupling and engaging in sexual relations of countless varieties.

Kinsey thus debuted sex as a science, paving the way for others to dig below statistics into the realm of biology. In 1966 gynecologist William Masters and psychologist Virginia Johnson—who originally hailed from Washington University before founding their own research institute in St. Louis—described for the first time the sexual response cycle (how the body responds to sexual stimulation), based on observations of 382 women and 312 men undergoing some 10,000 such cycles. The cycle begins with excitation, as blood rushes to the penis in men, and as the clitoris, vulva and vagina enlarge and grow moist in women. Gradually, people reach a plateau, in which they are fully aroused but not yet at orgasm. After reaching orgasm, they enter the resolution phase, in which the tissues return to the preexcitation stage.

In the 1970s psychiatrist Helen Singer Kaplan of the Human Sexuality Program at Weill Medical College of Cornell University added a critical element to this cycle—desire—based on her experience as a sex therapist. In her three-stage model, desire precedes sexual excitation, which is then followed by orgasm. Because desire is mainly psychological, Kaplan emphasized the importance of the mind in the sexual experience and the destructive forces of anxiety, defensiveness and failure of communication.

In the late 1980s gynecologist Rosemary Basson of the University of British Columbia proposed a more circular sexual cycle, which, despite the term, had been described as a largely linear progression in previous work. Basson suggested

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Simple sensations and more complex mental processes probably contribute to orgasm in both sexes.

that desire might both lead to genital stimulation and be invigorated by it. Countering the idea that orgasm is the pinnacle of the experience, she placed it as a mere spot on the circle, asserting that a person could feel sexually satisfied at any of the stages leading up to an orgasm, which thus does not have to be the ultimate goal of sexual activity.

Dissecting Desire

Given the importance of desire in this cycle, researchers have long wanted to identify its key ingredients. Conventional wisdom casts the male triggers in simplistic sensory terms, with tactile and visual stimuli being particularly enticing. Men are drawn to visual erotica, explaining the lure of magazines such as *Playboy*. Meanwhile female desire is supposedly fueled by a richer cognitive and emotional texture. "Women experience desire as a result of the context in which they are inserted—whether they feel comfortable with themselves and the partner, feel safe and perceive a true bond with the partner," opines urologist Jennifer Berman of the Female Sexual Medicine Center at the University of California, Los Angeles.

Yet sexual imagery devoid of emotional connections can arouse women just as it can men, a 2007 study shows. Psychologist Meredith Chivers of the Center for Addiction and Mental Health in Toronto and her colleagues gauged the degree of sexual arousal in about 100 women and men, both homosexual and heterosexual, while they watched erotic film clips. The clips depicted same-sex intercourse, solitary masturbation or nude exercise—performed by men and women—as well as male-female intercourse and mating between bonobos (close ape relatives of the chimpanzee).

The researchers found that although nude exercise genitally aroused all the onlookers the least and intercourse excited them the most, the type of actor was more important for the men than for the women. Heterosexual women's level of arousal increased along with the intensity of the sexual activity largely irrespective of who or what was engaged in it. In fact, these women were genitally excited by male and female actors equally and also responded physically to bonobo copulation. (Gay women, however, were more particular; they did not react sexually to men masturbating or exercising naked.)

The men, by contrast, were physically titillated mainly by their preferred category of sexual partner—that is, females for straight men and males for gay men—and were not excited by bonobo copulation. The results, the researchers say, suggest that women are not only aroused by a variety of types of sexual imagery but are more flexible than men in their sexual interests and preferences.

JAMIE GRILL Getty Images

Like men, women can be aroused by visual stimuli.

When it comes to orgasm, simple sensations as well as higher-level mental processes probably also play a role in both sexes. Although Kinsey characterized orgasm in purely physical terms, psychologist Barry R. Komisaruk of Rutgers University has defined the experience as more multifaceted. In their book *The Science of Orgasm* (Johns Hopkins University Press, 2006), Komisaruk, endocrinologist Carlos Beyer-Flores of the Tlaxcala Laboratory in Mexico and Rutgers sexologist Beverly Whipple describe orgasm as maximal excitation generated by a gradual summing of responses from the body's sensory receptors, combined with complex cognitive and emotional forces. Similarly, psychologist Kent Berridge of

(The Author)

MARTIN PORTNER is a neurologist living in Brazil. He is author of *Inteligência Sexual* (*Sexual Intelligence,* Editora Gente, 1999). He lectures and leads workshops on the brain and creativity.

During ejaculation, neural activity declines in the amygdala (*red region*), the brain's seat of vigilance—an apparent sign that men are momentarily throwing caution to the wind. In females, various regions of the brain, including the amygdala, virtually shut down at orgasm.

HANK MORGAN SPL/Photo Researchers, Inc.

the University of Michigan at Ann Arbor has described sexual pleasure as a kind of "gloss" that the brain's emotional hub, the limbic system, applies over the primary sensations.

The relative weights of sensory and emotional influences on orgasm may differ between the sexes, perhaps because of its diverging evolutionary origins. Orgasm in men is directly tied to reproduction through ejaculation, whereas female orgasm has a less obvious evolutionary role. Orgasm in a woman might physically aid in the retention of sperm, or it may play a subtler social function, such as facilitating bonding with her mate. If female orgasm evolved primarily for social reasons, it might elicit more complex thoughts and feelings in women than it does in men.

Forgetting Fear

But does it? Researchers are trying to crack this riddle by probing changes in brain activity during orgasm in both men and women. Neuroscientist Gert Holstege of the University of Groningen in the Netherlands and his colleagues attempted to solve the male side of the equation by asking the female partners of 11 men to stimulate their partner's penis until he ejaculated while they scanned his brain using positron-emission tomography (PET). During ejaculation, the researchers saw extraordinary activation of the ventral tegmental area (VTA), a major hub of the brain's reward circuitry; the intensity of this response is comparable to that induced by heroin. "Because ejaculation introduces sperm into the female reproductive tract, it would be critical for reproduction of the species to favor ejaculation as a most rewarding behavior," the researchers wrote in 2003 in *The Journal of Neuroscience*.

The scientists also saw heightened activity in brain regions involved in memory-related imagery and in vision itself, perhaps because the volunteers used visual imagery to hasten orgasm. The anterior part of the cerebellum also switched into high gear. The cerebellum has long been labeled the coordinator of motor behaviors but has more recently revealed its role in emotional processing. Thus, the cerebellum could be the seat of the emotional components of orgasm in men, perhaps helping to coordinate those emotions with planned behaviors. The amygdala, the brain's center of vigilance and sometimes fear, showed a decline in activity at ejaculation, a probable sign of decreasing vigilance during sexual performance.

To find out whether orgasm looks similar in the female brain, Holstege's team asked the male partners of 12 women to stimulate their partner's clitoris—the site whose excitation most easily leads to orgasm—until she climaxed, again inside a PET scanner. Not surprisingly, the team reported in 2006, clitoral stimulation by itself led to activation in areas of the brain involved in receiving and perceiving sensory signals from that part of the body and in describing a body sensation—for instance, labeling it "sexual."

When a woman reached orgasm, something unexpected happened: much of her brain went silent.

But when a woman reached orgasm, something unexpected happened: much of her brain went silent. Some of the most muted neurons sat in the left lateral orbitofrontal cortex, which may govern self-control over basic desires such as sex. Decreased activity there, the researchers suggest, might correspond to a release of tension and inhibition. The scientists also saw a dip in excitation in the dorsomedial prefrontal cortex, which has an apparent role in moral reasoning and social judgment—a change that may be tied to a suspension of judgment and reflection.

Brain activity fell in the amygdala, too, suggesting a depression of vigilance similar to that seen in men, who generally showed far less deactivation in their brain during orgasm than their

female counterparts did. "Fear and anxiety need to be avoided at all costs if a woman wishes to have an orgasm; we knew that, but now we can see it happening in the depths of the brain," Holstege says. He went so far as to declare at the 2005 meeting of the European Society for Human Reproduction and Development: "At the moment of orgasm, women do not have any emotional feelings."

But that lack of emotion may not apply to all orgasms in women. Komisaruk, Whipple and their colleagues studied the patterns of brain activation that occur during orgasm in five women with spinal cord injuries that left them without sensation in their lower extremities. These women were able to achieve a "deep," or nonclitoral, orgasm through mechanical stimulation (using a laboratory device) of the vagina and cervix. But contrary to Holstege's results, Komisaruk's team found that orgasm was accompanied by a general activation of the limbic system, the brain's seat of emotion.

Among the activated limbic regions were the amygdala and the hypothalamus, which produces oxytocin, the putative love and bonding hormone whose levels jump fourfold at orgasm. The researchers also found heightened activity in the nucleus accumbens, a critical part of the brain's reward circuitry that may mediate orgasmic pleasure in women. In addition, they saw unusual activity in the anterior cingulate cortex and the insula, two brain areas that Rutgers anthropologist Helen Fisher has found come to life during the later stages of love relationships. Such activity may connect a female's sexual pleasure with the emotional bond she feels with her partner.

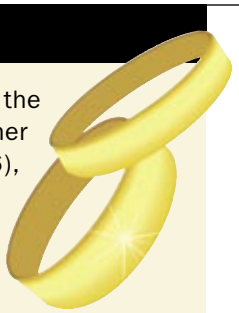
Pleasure Pill?

Disentangling the connections between orgasm, reproduction and love may someday yield better medications and psychotherapies for sexual problems. As Marianne's case illustrates, the answer is usually not as simple as a hormone boost. Instead her improvement was probably the result of the activation or inactivation of relevant parts of her brain by social triggers she encountered while participating in an experiment whose purpose centered on female sexual arousal. Indeed, many sex therapies revolve around opening the mind to new ways of thinking about sex or about your sexual partner [*see box on this page*].

Companies are also working on medications that act on the nervous system to stimulate desire. One such experimental compound is a peptide called bremelanotide, which is under development by Palatin Technologies in Cranbury, N.J. It blocks certain receptors in the brain that are involved in regulating basic drives such as eating and sex. In human studies bremelanotide has prompted spontaneous erections in men and boosted sexual arousal and desire in women, but the U.S. Food and Drug Administration has held up its progress out of concern over side effects such as rising blood pressure.

Continued scientific dissection of the experience of orgasm may lead to new pharmaceutical and psychological avenues for enhancing the experience. Yet overanalyzing this moment of intense pleasure might also put a damper on the fun. That is what the science tells us anyway. M

Domestic Bliss



Is the pursuit of sexual gratification vital to the health of an established relationship? In her book *Mating in Captivity* (HarperCollins, 2006), New York–based psychotherapist Esther Perel emphasizes the importance of eroticism and orgasm in a marriage. She chronicles the typical dissolution of a couple's sex life when the love bond becomes politically correct and excessively domesticated. To avoid sexual staleness, Perel advocates unusual strategies such as cultivating separateness—developing different interests and groups of friends from those of your partner, for example—instead of closeness, as a way of making your partner more mysterious and exciting. She also suggests looking for creative ways to let fantasy and even a little craziness thrive within the confines of a long-term relationship.

Other psychologists, however, advise against placing too much emphasis on orgasm in a mature relationship. In her book *Peace Between the Sheets* (Frog Books, 2003), couples therapist Marnia Robinson suggests that the journey to orgasm renders us prisoners to dopamine, a neurotransmitter secreted in the brain's reward centers. After all, dopamine underlies other addictive behaviors, from gambling to drug abuse. In Robinson's view, partners should mutually unite in pleasure, without the sexual relationship necessarily having to be crowned by orgasm. —*M.P.*

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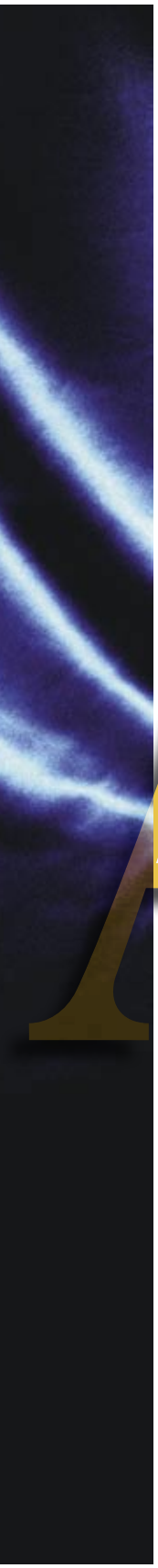

DAVID McGLYNN Getty Images

Some people are convinced that they are hideously deformed because of an obscure or nonexistent physical "flaw"

Imagined Ugliness

By Susanne Rytina

At 19, Aron Cowen suddenly became distraught over his hair, considering its curliness a "bad condition." He chemically straightened it every week for a year, giving up only after it became severely damaged and developed an orange tint. While on a trip to Israel when he was 25, Cowen glanced at his reflection in a store mirror and saw his nose as huge and grossly malformed, like a beak. After that, he spent up to two hours each day reshaping his nose in front of a mirror and obsessing over its ugliness.

Unable to shake his fixation, Cowen opted for plastic surgery, but the effect was short-lived. A week after the operation the young man from Sherman Oaks, Calif., was back at the mirror, intensely scrutinizing his nose and noticing new flaws. And this time he felt responsible. "Now I felt butchered and disfigured," he recalls. "I felt I had destroyed my nose."

After a second surgery—this one requiring the removal of cartilage from his ear—Cowen began to question whether his nose was really the problem. The operation left him no happier about his face; in fact, he became so depressed that for a month, he did not want to leave his apartment and only did so on his girlfriend's insistence. Two months later Cowen recognized his symptoms in a book about body dysmorphic disorder (BDD), in which a person becomes pathologically preoccupied with an imagined or barely noticeable defect in his or her appearance.

The disorder is suprisingly common. A large 2006 survey conducted in Germany indicates that 1 to 2 percent of the population suffers from BDD; a 2001 study of Boston-area women suggests a lower prevalence rate of 0.7 percent. Individuals with BDD are most commonly dejected over facial features, such as excess hair, acne, scars, or the shape of their nose or lips. They may also dislike a characteristic or part of their body such as their breasts, hips, height or genitals. As a result of the imagined defect, a person with BDD feels that he or she looks repulsive, even though

BDD patients as a group are about as attractive as the general population and include some people who are considered to be quite beautiful.

Such a deranged conviction can be debilitating. People with BDD may spend hours every day examining their reflection in a mirror, picking their skin, grooming, or engaging in other compulsions that take time away from work, family and other important pursuits. One man lost his job because his compulsive mirror gazing made him repeatedly late for work. Sufferers may become depressed, anxious, ashamed and afraid of social interaction. In one study, nearly one third of BDD patients had been housebound for at least one week. Thirty percent have eating disorders; many abuse alcohol or drugs, and up to a quarter attempt suicide.

Psychologists and psychiatrists are searching for the cause of this affliction in hopes of bringing relief to patients. Psychological factors such as low self-esteem, coupled with society's restrictive definition of physical beauty, are likely to play a role in the disorder. Recently, however, researchers have discovered that BDD patients also exhibit distorted visual perception, suggesting that future treatments may focus on retraining the visual system.

Off the Radar

Body dysmorphic disorder was first known as dysmorphophobia (fear of ugliness), a term coined in 1891 by Italian psychiatrist Enrico Morselli. Morselli had treated nearly 80 patients whose preoccupations with imagined deformities ruled their lives. Years after completing his therapy, Sigmund Freud's famous patient "the Wolf Man" became obsessed with his supposedly malformed nose. Nobody considered a diagnosis of dysmorphophobia, however; instead a colleague of Freud's diagnosed a penis complex.

In 1980 dysmorphophobia appeared in the third edition of psychiatry's official diagnostic book, the *Diagnostic and Statistical Manual* (*DSM*). The term "body dysmorphic disorder" replaced dysmorphophobia in the volume's 1987 edition, after psychiatrists realized that the condition was less a phobia than an irrational conviction. BDD is also known as Thersites complex, after the warrior who was described in the *Iliad* as the "ugliest man in the Greek army."

Despite its official status as a psychiatric disorder, BDD is relatively unknown, even among those who would treat it. "It's off the radar for most psychiatrists," says psychiatrist and BDD researcher Jamie D. Feusner of the University of California, Los Angeles. BDD patients are often diagnosed with depression, anxiety or an eating disorder, or even all three at once, without the doctor realizing that BDD may be the cause of all the trouble, Feusner says.

For their part, patients often say very little about the problem because they do not recognize it as a mental illness, instead believing that they are simply ugly—and what would a psychiatrist do about that? Many are also ashamed to talk about their odd obsession.

MILK PHOTOGRAPHIE *Corbis*

FAST FACTS

Distorted Perceptions

1» An estimated 1 to 2 percent of the population has body dysmorphic disorder (BDD), a preoccupation with an imagined or barely noticeable defect in personal appearance. As a result of this perceived flaw, people with BDD are convinced that they are extremely ugly.

2» The disorder can lead to depression, severe social anxiety, eating disorders, substance abuse and suicide. BDD patients also may engage in compulsive activities such as mirror gazing and reassurance seeking that take valuable time away from their work, family and other important commitments.

3» Psychological factors such as low self-esteem, coupled with society's restrictive definition of physical beauty, contribute to BDD. Many researchers now believe, however, that BDD also stems partly from a problem with the visual system.

As a result, BDD sufferers typically wait three to 13 years for a diagnosis. In that time, many of them seek help from plastic surgeons. Some reports suggest that BDD patients make up nearly 15 percent of plastic surgeons' clientele. As in Cowen's case, surgery seldom solves the problem because it fails to address its causes.

What those causes are, however, is still a matter of some speculation. In the past, most researchers attributed BDD to personality traits such as low self-esteem and perfectionism, which may lead some individuals to be overly critical of how they look. Often such severe self-consciousness emerges at puberty, when dramatic changes to the body can produce feelings of inadequacy about appearance and when many people with BDD recall the first signs of the disorder.

Biological factors, including genes and brain chemistry, are likely to predispose a person toward such insecurities. For example, researchers have linked BDD to a disturbance in the balance of the neurotransmitter serotonin in the brain similar to that found in depression, which afflicts about 70 percent of BDD patients. In 2001 and 2002 psychiatrist Katharine A. Phillips of Brown Alpert Medical School and her colleagues reported in two separate studies that most BDD patients improve after treatment with drugs such as Prozac that inhibit serotonin uptake by nerve cells in the brain. These so-called selective serotonin reuptake inhibitors are also used as antidepressants, often at a lower dose than is required to treat BDD.

Environmental variables probably contribute to BDD, too. These variables may include being raised in a family that places excessive emphasis on physical beauty or having been teased or repeatedly criticized about a physical feature such as weight or facial blemishes. In one 2007 study, for example, clinical psychologist Ulrike Buhlmann and her colleagues at Harvard Medical School and Massachusetts General Hospital found that 16 individuals with BDD reported having been teased about their appearance more often than 17 mentally healthy controls did.

Seeing Too Much

In recent years, however, some researchers have begun to question whether a vulnerable personality, combined with an unfavorable environment, can fully explain BDD. Instead they have been advancing a radically different hypothesis: that BDD arises, at least in part, from a perceptual abnormality. A 2002 study by psychiatrist Jose A. Yaryura-Tobias of the Bio-Behavioral Institute in Great Neck, N.Y., and his colleagues lends some support to this theory. The researchers asked three groups of 10 individuals—one of BDD patients, another of patients with obsessive-compulsive disorder (OCD), and a third of mentally healthy people—to make changes to a computerized image of their face, if needed, to match what they believed their face looked like. (The computer-rendered image was accurate to an ordinary person's eye, but the study participants were not told that.) About half of the patients with BDD and OCD altered these depictions, whereas nobody in the control group did, suggesting that at least some BDD patients perceive their own face differently than others do.

Some evidence suggests that BDD patients may be more visually attuned than most of us are. In a study to appear in the journal *Abnormal Psychology,* Ulrich Stangier, a psychotherapist at the University of Jena in Germany, and his colleagues briefly flashed an image of a female face, along with one of five digitally distorted renditions of that face, in front of 21 female BDD patients, 20 patients with disfiguring skin conditions, and 19 individuals without any disorder and asked them to judge the extent of the distortion. The manipulated images had more widely spaced eyes, bigger noses, lighter hair, or additional pimples and scars. The participants chose among five levels of distortion that ranged from "hardly" to "extremely." The researchers found that the BDD patients were better at judging the degree of image manipulation than the others

COURTESY OF ARON COWEN

Aron Cowen underwent two plastic surgeries on his nose, which he viewed as grossly misshapen. From left to right: Cowen before the surgeries, after the first surgery, and after the second surgery.

(The Author)

SUSANNE RYTINA is a journalist from Esslingen am Neckar in Germany who specializes in psychology-related topics.

were, suggesting that people with BDD may have unusually acute perceptual abilities.

What is more, such acute perception might sometimes produce perversions. In 2000 Harvard psychologist Thilo Deckersbach and his colleagues reported asking BDD patients to copy a complex figure and then to duplicate it from memory. The BDD patients performed poorly as compared with mentally healthy subjects, because they drew lots of details without capturing the figure's overall shape. Although the BDD patients could have been exhibiting poor strategic thinking in the figure task, their main problem might be an overemphasis on visual details, helping explain why they worry so much about minuscule deviations in their features.

The main problem in BDD may be an overemphasis on visual details that is rooted in the brain.

In one study patients with BDD appeared to visually process normal (*left*) and blurred (*center*) pictures of faces the way most people perceive highly detailed pictures (*right*), as if they were looking for details that did not exist.

Feusner, along with cognitive neuroscientist Susan Bookheimer and their U.C.L.A. colleagues, has since found support for the latter idea. His group used functional magnetic resonance imaging to scan the brains of 12 patients with BDD and 12 healthy subjects while the participants viewed three versions of various photographs of faces: a normal image, a blurred image and a flat but highly detailed image [*see illustration above*].

The healthy people processed both the normal and blurred faces with parts of their brain's right hemisphere that ordinarily decode larger-scale visual features; their left hemisphere lit up only when they viewed the detailed pictures. In contrast, the BDD patients used their left hemisphere to interpret all the photographs. "They are processing all photos like highly detailed photos," Feusner explains. "It's almost as if their brains are trying to extract details from an image even when there are none." The results, reported in December 2007, suggest that BDD may stem partly from an abnormality in visual-information processing.

The ability to appreciate beauty may, after all, have evolutionary value. Physical attractiveness could, in some cases, be related to health status; that is, "ugly" can be a proxy for less fit. Thus, being more adept at sorting the beautiful from the less handsome might have given a person a better chance of selecting a fit mate and passing good genes to his or her offspring. BDD may represent an extreme version of this talent.

Of course, nobody can say for sure that the visual problem is a cause rather than a consequence of the disorder. "We still don't know whether people who develop BDD are born with [the visual-processing abnormality] or whether BDD came first and caused the problems with visual processing," Feusner admits.

Image Correction

If aberrant visual processing is a cause of BDD, future therapies might focus on training patients to see things more globally using the right half of their brain. Repeated exposure to a blurred image or to a picture viewed from a distance or for only a fraction of a second, for example, might force the brain to adopt a more holistic way of seeing, Feusner speculates.

Medications also may be able to change the side of the brain a person is using for visual processing, Feusner says. Benzodiazepines such as Valium (diazepam) or Xanax (alprazolam) can shift brain activity to the right during a visual-processing task, some preliminary studies suggest. Eventually, alternative drugs may accomplish this shift with fewer side effects.

Still, doctors agree that the problem cannot be entirely visual. Whereas more than 88 percent of BDD patients say they also scrutinize the appearance of others, focusing on the feature that they dislike most about themselves, a May 2007 study by Buhlmann and her colleagues shows they do not see the same perversions in other faces that they do in their own. BDD patients rated photographs of other people categorized as "attractive" (by the researchers) as being significantly better looking than did two other groups without BDD, suggesting that the patients' perception of detail in others does not evoke the same negative emotional response that it does when applied to their own physique, Feusner says.

Indeed, many therapists treat BDD by tackling its emotional aspects, including patients' perfectionism and fear of being rejected because of how they look. In cognitive-behavior therapy, psychotherapists attack patients' distorted perceptions head-on and assign actions to help them give up their destructive habits. For instance, in some cases, they may instruct patients to ask other people—friends, family or even strangers—for feedback on their appearance. The others' invariably positive, or at least neutral, comments can open the door to a patient developing a more realistic and better self-image. The act of confronting others might also help a patient overcome the social anxiety that often accompanies BDD.

Cognitive-behavior techniques can prompt significant recovery from the disorder, according to a 1999 study by psychologist Sabine Wilhelm and her colleagues at Harvard Medical School. But other psychologists believe in a more psychodynamic approach, in which they and the patient also work on uncovering past experiences that may have led to a BDD patient's poor self-image.

In some cases, patients were neglected as children, says Uwe Gieler, a BDD therapist at the University of Giessen in Germany. According to one theory of attachment, if a mother or father rejects a child during the first 15 months of life, that child may question affection from others as well as his or her own self-worth. As a result, the person can be saddled with both relationship problems and low self-esteem.

Understanding the origins of the problem, Gieler opines, empowers a patient to recognize and "correct" a distorted self-image and put concerns about appearance in perspective. That is, patients may come to understand that imperfections in their face do not equal being an unattractive person or prevent them from having good relationships.

A New Perspective

When Cowen suspected that he had BDD, he went to see Feusner at the Los Angeles Body Dysmorphic Disorder and Body Image Clinic. Feusner diagnosed him with a moderately severe form of the disorder and put him on Prozac, which is now a standard treatment for BDD. He also put Cowen in touch with clinic director and therapist Arie Winograd, who told Cowen to stop touching or looking at his nose, a strategy aimed at curtailing Cowen's obsessive behaviors.

In particular, the therapist instructed Cowen

BIDDY O'NEILL *zefa/Corbis*

to avoid all mirrors, which perpetuate the illness because they put a person's appearance in the forefront of consciousness. Or, as Cowen put it: "You need to forget how you look to reclaim how you are inside." At close range, mirrors also enable patients to focus too much on facial details, Feusner says, and so may exacerbate the perceptual problem that accompanies the illness.

Cowen was an obedient patient. He stopped the mirror cold turkey, he says, and then gradually relearned to use it—in the normal way—with help from Winograd. For example, Winograd would turn the lights out so Cowen's face looked less distinct and would coach Cowen to see his visage as a whole rather than focusing on the contours of his nose.

A year after beginning treatment Cowen was able to let go of his obsession with his appearance. "My looks and features and body parts don't define me now," Cowen says. "Sometimes I even think I look good." M

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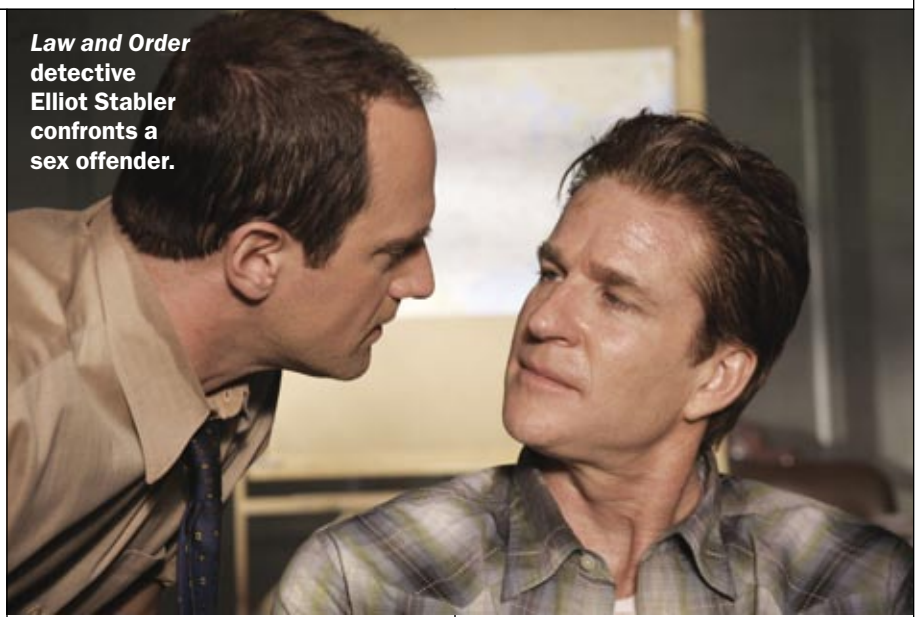
Misunderstood Crimes

Once a sex offender, always a sex offender?

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD



Law and Order detective Elliot Stabler confronts a sex offender.

SEX CRIMES evince such strong feelings of revulsion and repugnance that it is perhaps not surprising that people misunderstand their nature. The public, whose opinions are reinforced by portrayals in the media and in popular culture, believes that sex offenders will almost always repeat their predatory acts in the future and that all treatments for perpetrators are ineffective. The truth is not so cut and dried—and gives us cause for hope in certain cases.

Before we discuss these beliefs, a few basics are in order. The two most common types of sex offenses are rape and child molestation, but others exist [*see box on opposite page*]. In most cases, the victim, usually female, knows the perpetrator, generally male. By some estimates, one third or more of all sex offenders are under the age of 18, with some even as young as five years. Most begin to offend sexually in adolescence. Now what does the research tell us about common beliefs?

Repeat Offenders

First, the notion that recidivism (repeat offending) is inevitable needs a second look. Recently sex crimes researcher Jill Levenson of Lynn University in Florida and her colleagues found that the average member of the general public believes that 75 percent of sex offenders will reoffend. This perception is consistent with media portrayals in such television programs as *Law and Order: Special Victims Unit,* in which sex offenders are almost always portrayed as chronic repeaters.

The evidence suggests otherwise. Sex crimes researchers R. Karl Hanson and Kelly E. Morton-Bourgon of Public Safety Canada conducted a large-scale meta-analysis (quantitative review) of recidivism rates among adult sex offenders. They found a rate of 14 percent over a period averaging five to six years. Recidivism rates increased over time, reaching 24 percent by 15 years. The figures are clearly out of alignment with the public's more dire expectations.

Also contrary to media depictions, most offenders do not "specialize" in one type of sex crime. Most are "generalists" who engage in a variety of sex and nonsexual crimes as well. Hanson and Morton-Bourgon found that sex offenders had a total recidivism rate (for both sex crimes and nonsexual violent crimes) of approximately 36 percent over a period of five to six years. Nevertheless, perpetrators of different types of sex crimes exhibit varying rates of repeat offending. The 15-year recidivism rate is 13 percent for incest perpetrators, 24 percent for rapists, and 35 percent for child molesters of boy victims.

When providing clarifications about the lower than generally acknowledged rates of recidivism, we must be careful not to oversimplify. Recidivism research is as difficult as it is important. For instance, although average rates tell us what percentage reoffends one or more times, we also need to be aware that a subset reoffends at a frighteningly high rate. In addition, there are reasons to think that published findings underestimate the true rates. Most research necessarily omits those offenders who were not

The notion that **recidivism is inevitable** needs a second look, as does the idea that all treatments are ineffective.

COURTESY OF HAL ARKOWITZ (*top*); COURTESY OF SCOTT O. LILIENFELD (*bottom*); UNIVERSAL TV/THE KOBAL COLLECTION (Law and Order)

detected and arrested or whose victims did not report the crime. Further, many sex offenders plea-bargain down to a nonsexual offense.

Still, there are other reasons to believe that recidivism rates may not be that different from what researchers have found. Frequent offenders are more likely than other offenders to be caught. Many safeguards probably help to keep the recidivism rate in check. Sex offenders released on probation are closely monitored, and those who are considered to be at high risk for recidivism are required to register with authorities. These registries are distributed to law-enforcement personnel. Finally, states are legally required to publicly identify higher-risk sex offenders. The Department of Justice coordinates a Web site (www.fbi.gov/hq/cid/cac/registry.htm) that enables anyone to search for the identity and location of known offenders.

Taking the research and its limitations into account, it is still likely that the public's belief that very high recidivism rates are well documented is incorrect, although this verdict may change in the future.

Treatment Realities

If recidivism is not as common as people generally believe, how do their impressions of treatment's failure or success hold up? Levenson and her colleagues also found that a whopping 50 percent of the public believes that treatment for sex offenders is ineffective and will not prevent them from relapsing. Yet some studies have shown that treatment can significantly reduce recidivism for both sex and nonsexual crimes. Hanson and his colleagues conducted a meta-analysis on treatment and found that 17 percent of untreated subjects reoffended, whereas 10 percent of treated subjects did so. When recidivism rates for sex and nonsexual violent crimes were combined, 51 percent of untreated and 32 percent of treated subjects reoffended.

The advantage for treatment over nontreatment does not appear to be that large; because meta-analyses group studies together, they may mask the fact that some of them found fairly large effects of treatment and others found smaller or no effects. Results of this meta-analysis also suggest that we might be making progress. More recent studies show significantly larger treatment benefits than do the older studies.

Most approaches employ a number of treatments. The majority include two components: cognitive-behavior therapy, which aims to change sexually deviant thoughts, behaviors and arousal patterns, and relapse prevention, which aims to teach sex offenders how to anticipate and cope with problems (such as feelings of anger or loneliness) that can lead to reoffending.

Although the development of treatments for sex offenders is still in its infancy, studies show that therapy can make a difference. Sex offenders are not all fated to repeat their horrible crimes, and we—through the actions of the general public, policy leaders and legislators—can encourage hope by supporting further research on such therapies. M

Categories of Offenses

Many categories of sex offenses exist; precise legal descriptions of types of sex offenses can vary from state to state. Not all uncommon sexual behaviors are illegal. For example, no laws bar transvestism, which usually involves a heterosexual man who dresses in women's clothing. *—H.A. and S.O.L.*

Sex Offense	General Description
Rape	Sexual intercourse with a minor or unwilling adult
Child molestation	Sexual behaviors between an adult and juvenile who are not blood relatives
Incest	Sexual behaviors between an adult and juvenile who are blood relatives
Exhibitionism	Exposing one's genitals to an unwilling stranger
Voyeurism	Watching unsuspecting others who either are in a state of undress or are having sexual relations
Frotteurism	Sexually oriented touching of an unsuspecting person

HAL ARKOWITZ and SCOTT O. LILIENFELD serve on the board of advisers for *Scientific American Mind.* Arkowitz is a psychology professor at the University of Arizona. Lilienfeld is a psychology professor at Emory University. The authors thank R. Karl Hanson of Public Safety Canada and Laura Kirsch and Amanda Fanniff of the University of Arizona for their invaluable help with this column. Any statements made in the column, however, are solely the responsibility of the co-authors.

Send suggestions for column topics to editors@SciAmMind.com

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Why Things Cost $19.95

What are the psychological "rules" of bartering?

BY WRAY HERBERT

ONE OF ALFRED HITCHCOCK'S most enduring bits of cinematic comedy is the auction scene in the espionage thriller *North by Northwest*. Cary Grant plays Roger Thornhill, a businessman who has been mistaken for a CIA agent by the ruthless Phillip Vandamm. At a critical juncture, Thornhill is cornered by his enemies inside a Chicago auction house, and the only way he can escape is by drawing attention to himself. When the bidding on an antique reaches $2,250, Thornhill yells out, "Fifteen hundred!" When the auctioneer gently chides him, he loudly changes his bid: "Twelve hundred!" When the bidding on a Louis XIV chaise longue reaches $1,200, Thornhill blurts outs, "Thirteen dollars!" The genteel crowd is outraged, but Thornhill gets precisely what he wants: the auctioneer summons the police, who "escort" him past Vandamm's henchmen to safety.

Clever thinking and good comedy. It is funny for a lot of reasons, and one is that Thornhill violates every psychological "rule" for how we negotiate price and value with one another. So much of life involves "auctions," whether it is buying a used car or making health care choices or even choosing a mate. But, unlike Roger Thornhill, most of us are motivated by the desire for a fair deal, and we employ some sophisticated cognitive tools to weigh offers, fashion responses, and so forth—all the to-and-fro in getting to an agreement.

But how does life's dickering play out in the brain? And is it a trustworthy tool for getting what we want? Psychologists have been studying cognitive bartering for some time, and several basics are well established. For example, an opening "bid" of any sort is usually perceived as a mental anchor, a starting point for the psycho-

> How does **life's dickering** play out in the brain? And is it a trustworthy tool for getting what we want?

MATT MENDELSOHN (*Herbert*); HOLGER WINKLER A.B./zefa/Corbis (*price tags*)

Sellers who listed their homes for $494,500 as opposed to $500,000 consistently got **closer to their asking price**.

logical jockeying to follow. If we perceive an opening bid as fundamentally inaccurate or unfair, we reject it by countering with something in another ballpark altogether. But what about less dramatic counter offers? What makes us settle on a response?

University of Florida marketing professors Chris Janiszewski and Dan Uy suspected that something fundamental might be going on, that some characteristic of the opening bid itself might influence the way the brain thinks about value and shapes bidding behavior. In particular, they wanted to see if the degree of precision of the opening bid might be important to how the brain acts at an auction. Or, to put it in more familiar terms: Are we really fooled when storekeepers price something at $19.95 instead of a round 20 bucks?

Cary Grant in *North by Northwest:* violating all the rules for negotiating price and value.

Janiszewski and Uy ran a series of tests to explore this idea. The experiments used hypothetical scenarios, in which participants were required to make a variety of "educated guesses." For example, they had subjects think about a scenario in which they were buying a high-definition plasma TV and asked them to guesstimate the wholesale cost. The participants were told the retail price, plus the fact that the retailer had a reputation for pricing TVs competitively.

There were three scenarios involving different retail prices: one group of buyers was given a price of $5,000, another was given a price of $4,988, and the third was told $5,012. When all the buyers were asked to estimate the wholesale price, those with the $5,000 price tag in their head guessed much lower than those contemplating the more precise retail prices. That is, they moved farther away from the mental anchor. What is more, those who started with the round number as their mental anchor were much more likely to guess a wholesale price that was also in round numbers. The scientists ran this experiment again and again with different scenarios and always got the same result.

Why would this happen? As Janiszewski and Uy explain in the February issue of *Psychological Science,* people appear to create mental measuring sticks that run in increments away from any opening bid, and the size of the increments depends on the opening bid. That is, if we see a $20 toaster, we might wonder whether it is worth $19 or $18 or $21; we are thinking in round numbers. But if the starting point is $19.95, the mental measuring stick would look different. We might still think it is wrongly priced, but in our minds we are thinking about nickels and dimes instead of dollars, so a fair comeback might be $19.75 or $19.50.

The psychologists decided to check these lab findings in the real world. They looked at five years of real estate sales in Alachua County, Florida, comparing list prices and actual sale prices of homes. They found that sellers who listed their homes more precisely—say $494,500 as opposed to $500,000—consistently got closer to their asking price. Put another way, buyers were less likely to negotiate the price down as far when they encountered a precise asking price. Furthermore, houses listed in round numbers lost more value if they sat on the market for a couple of months. So, bottom line: one way to deal with a buyer's market may be to pick an exact list price to begin with.

This isn't all about money, however. Medical information, Janiszewski and Uy note, can also be offered in either precise or general terms: a physician might say that your chance of responding to a medication is "good" or that your chance of responding is 80 percent. The percentage is more precise, but many studies have shown that patients prefer vague generalities like "good," so doctors tend to use them. But remember that life is an auction. In his mind, the patient is dickering with the doctor, so why not negotiate "good" up to "excellent"? When treatment choices are on the line, the auction house can indeed be a perilous place. M

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

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

(Further Reading)

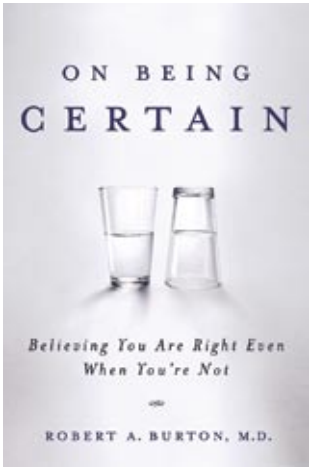
◆ **Precision of Anchor Influences the Amount of Adjustment.** Chris Janiszewski and Dan Uy in *Psychological Science,* Vol. 19, No. 2, pages 121–127; February 2008.

MGM/THE KOBAL COLLECTION

› YOU NEVER KNOW

On Being Certain: Believing You Are Right Even When You're Not

by Robert A. Burton. St. Martin's Press, 2008 ($24.95)



The day after the 1986 *Challenger* shuttle accident, psychologist Ulric Neisser asked 106 students to write down exactly where they were and what they were doing when they first heard about the explosion. When he interviewed the students two and a half years later, 25 percent of them gave strikingly different accounts. But when confronted with their original journal entries, many students defended their beliefs. One of them answered, "That's my handwriting, but that's not what happened."

In *On Being Certain,* neuroscientist and novelist Robert A. Burton tries to get to the bottom of the curious sensation he calls the "feeling of knowing"—being certain of a fact despite having no (or even contrary) evidence. Throughout his book, Burton makes the compelling argument that certainty "is neither a conscious choice nor even a thought process." Instead, he says, that unmistakable sense of certainty "arises out of involuntary brain mechanisms that, like love or anger, function independently of reason."

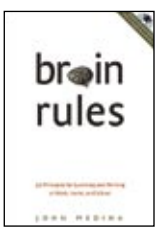
Burton thinks that just as we perceive our external world through our physical senses, our internal world presents itself in the form of feelings, such as familiar or strange and correct or incorrect. And he shows that these inner perceptions are necessary for us to function properly in everyday life, because our thoughts are subject to constant self-questioning. For example, even though reason may tell us that running up a tree to escape a lion is an excellent strategy, experience shows that great strategies can fail and that there may be better options. Because alternative choices are present in any situation, logical thought alone would be doomed to a perpetual "yes, but" questioning routine. Burton reasons that it is the feeling of knowing that solves this dilemma of how to reach a conclusion. Without this "circuit breaker," indecision and inaction would rule the day.

One of the startling implications of Burton's thesis is that we ultimately cannot trust ourselves when we believe we know something to be true. "We can't afford to continue with the outdated claims of a perfectly rational unconscious or knowing when we can trust gut feelings," he writes. *On Being Certain* challenges our understanding of the very nature of thought and provokes readers to ask what Burton calls "the most basic of questions": How do we know what we know? —*Nicole Branan*

Mind Reviews

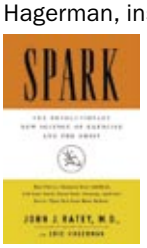
Your Brain: A User's Manual

Ever wonder what neuroscience can do for you? Find out in these new books about how to make the most of your mind:

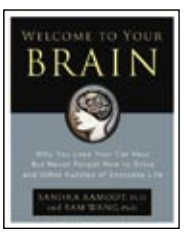


›› New studies often raise intriguing questions about the brain. So what exactly do scientists know for certain? Enter biologist John Medina of the University of Washington: in ***Brain Rules: 12 Principles for Surviving and Thriving at Work, Home, and School*** (Pear Press), he lays out 12 rock-solid facts, such as "Vision trumps all other senses," and explains how the science behind these statements can show us how to be happier and more efficient.

›› Another fact: exercise, once thought to benefit only our muscles, has a huge positive effect on the brain. Psychiatrist John J. Ratey, with science writer Eric Hagerman, instructs readers in how to build a workout routine that maximizes neuron growth, boosts mood, relieves stress and sharpens cognition in ***Spark: The Revolutionary New Science of Exercise and the Brain*** (Little, Brown).



›› According to psychologist Gary Marcus, our brain is nothing but a "kluge"—an inelegant, cobbled-together mess. Yet knowing and embracing our brain's peculiar shortcomings, he writes in ***Kluge: The Haphazard Construction of the Human Mind*** (Houghton Mifflin), will allow us to make better decisions and meet our goals.



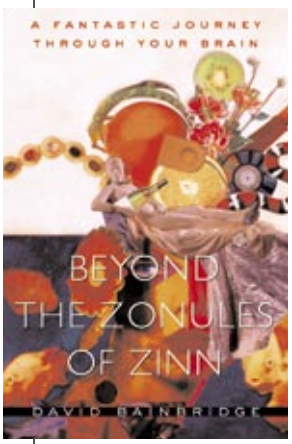
›› Truly following the form of a user's guide, Sandra Aamodt and Sam Wang answer common questions, dispel myths and offer practical tips in ***Welcome to Your Brain*** (Bloomsbury). Through illustrations, helpful sidebars and clever anecdotes, the two neuroscientists provide a fun and useful guide to the brain's quirky machinery.

● *Compiled by Karen Schrock*

> NEURAL GEOGRAPHY

Beyond the Zonules of Zinn: A Fantastic Journey through Your Brain

by David Bainbridge. Harvard University Press, 2008 ($25.95)



When David Bainbridge, a University of Cambridge anatomist, witnessed through ultrasound his daughter's gestation, he was unexpectedly moved. Mesmerized by the detailed images of her budding nervous system, he saw in her eyes a tiny ring of fibers encircling each lens, known as the zonules of Zinn.

This experience spurred him to write *Beyond the Zonules of Zinn,* a tale of the brain by a physiologist. Because form often gives insight into function, he uses evolutionary biology to walk us through human gestation, explaining how natural selection favors genes that enhance functions critical to survival, which often later give rise to specialized anatomical features. In the brain we find spectacular geographic specificity, where tiny patchworks of neurons give us language, planning and vision.

Even in a nine-week-old human fetus, a primitive nervous system emerges. Bainbridge explains how a neural bud bulges into a forebrain, midbrain and hindbrain, culminating in the cerebral cortex—the creviced, convoluted tissue layer that makes up the brain's surface. On the evolutionary trail, he describes how primitive drives (such as hunger, sex and sleep) evolved into higher functions, including memory, learning and emotions.

> "We cannot understand any phenomenon in the brain until we have first discovered where it occurs."

Gender differences, brain size, intelligence and even bizarre teenage behavior all have underpinnings in neural anatomy. Bainbridge marvels at how the fragile sheet of the cerebral cortex organizes our sensations, leading naturally to consciousness. In contrast to philosophical speculations on consciousness, Bainbridge focuses on neural hardware. Distilling seven leading theories of consciousness, he argues that consciousness is material, not mystical—something "our brain does."

His tour concludes with the ultimate loss of consciousness, death—reflecting physiologically on near-death experiences. He postulates that survivors' reports of soaring down tunnels of light and reliving memories reflect the brain's response to being starved of oxygen and flooded with stress-induced neurotransmitters. Otherwise orderly neural operations most likely go haywire, triggering the visual cortex to generate apparent white light and memory storage mechanisms to go awry. This speculation underscores Bainbridge's theme—that what often appears to be supernatural really is natural after all. *—Richard Lipkin*

> BRAINS DOWN UNDER

All in the Mind

Listen to the show and read Natasha Mitchell's blog at www.abc.net.au/rn/allinthemind

Who spends her Saturdays debating the nature of happiness, eavesdropping on brain surgery and investigating the evolutionary reasons for grief? Natasha Mitchell, that's who—host of the award-winning Australian Broadcasting Corporation radio show *All in the Mind,* now in its sixth year. Every week for half an hour, Mitchell finds a new doorway through which to explore the world of the brain, whether via the diary of a brain tumor patient or art made by the mentally ill. Her forays, though always creative, never come at the expense of the science: Mitchell is not only fascinated by the mind but also adept at understanding and communicating its nuances.

Based in Melbourne, *All in the Mind* occasionally focuses on local events and issues such as the Australian science fair, but more often than not the show provides listeners with a rich, global perspective about brain, behavior and scientific research in general. One recent segment, for example, delved into the ways in which animal experimentation ethics differ in Australia, America and the U.K. Mitchell invites listeners from around the world to share their stories and experiences on the air. And although she may be broadcasting from the other side of the world, her warm demeanor and soothing voice recall the girl next door.

The show's Web site provides free access to previous episodes, transcripts and Mitchell's recently launched blog, so fans can catch up with the host and her thoughts on the latest neuroscience and psychology news all week long. "Think of it as a digital play space for the mind," Mitchell says. *—Melinda Wenner*

> QUICK FIX

60-Second Psych

Listen at www.SciAm.com/podcast

Need a conversation starter for your next cocktail party? Grab some quirky, insightful material from *60-Second Psych,* a weekly mind-themed podcast produced by Scientific American online, a sister division of *Scientific American Mind.* Host Christie Nicholson, SciAm.com's community editor and a former psychiatric research assistant, covers heady topics with lightning speed: Why does fear boost Iraqi teens' self-esteem? Do bisexual women have a distinct sexual orientation? And what does neuroimaging tell us about ESP?

Nicholson culls the journals and newsstands for a balanced mix of hard neuroscience and popular psychology stories. Although you might expect the weekly minute of reporting to feel rushed, she takes her time to break down the science in each study.

Her references to pop culture and historical research bring a helpful—and fun—perspective to each installment. In a recent podcast, Nicholson linked Harvard psychologist Steven Pinker's research on romantic infatuation to the film *Fatal Attraction* and to Beyoncé's hit song "Crazy in Love." In 60 seconds, a little something for everybody. *—Corey Binns*

askthe**Brains**

Could déjà vu be explained by grid cells?

—Robyn Ganeles, San Francisco

Neuroscientist **Edvard I. Moser** of the Norwegian University of Science and Technology responds:

THIS IS A GREAT QUESTION, because grid cells, which are involved in processing spatial information about our surroundings, are located in a brain region that is part of a larger memory system thought to be responsible for the feeling of familiarity. After considering their function in detail, however, I think it seems more likely that a different system of neurons, place cells, plays a stronger role in providing us with the sense that a new locale is familiar—a feeling called "déjà visité."

In any environment, the brain must keep track of the distinct locations within the surrounding area (say, at the kitchen table versus in front of the refrigerator). It also must note how these different locales relate to one another (the table is three feet to the right of the fridge, for instance). Place cells are involved in the former type of processing; each place cell corresponds to a specific location in an environment and fires when you pass through that spot.

In contrast, grid cells work in a network to produce a kind of internal coordinate system, noting information about distance and direction. These neurons do not correspond to a specific location but become active across several regularly spaced points in any setting. The geometric arrangement of these cells, relative to one another and to the external setting, ultimately helps us form a mental map of a certain environment.

Grid cells are located in the entorhinal cortex, a brain region that processes information before sending it to the hippocampus, the area where place cells are located. Because we know that place cells have a unique firing pattern for nearly every experience, it is likely that the hippocampus, and not primarily the entorhinal cortex, decides whether a location is novel or being revisited. When a strange place is experienced as familiar, it may be because the activated ensemble of place cells at that location happens to be similar to a pattern of activity that was elicited by a previous locale.

Do the typical sleep schedules of elderly people have a physiological benefit, or do they simply reflect generational trends?

—Shannon Atkinson, Raleigh, N.C.

Michael V. Vitiello, professor of psychiatry and behavioral sciences at the University of Washington, replies:

IT IS UNLIKELY that the "typical sleep schedules of elderly people" either reflect generational trends or convey any physiological benefit. There is no evidence to support the idea that the typical sleep schedules of older adults in developed countries—marked by earlier sleep and rise times, less total sleep and more nighttime wakefulness—are cohort effects (that is, result from having grown up or lived during a specific time period). The few studies that have looked at how sleep patterns change as people age show slow and progressive changes in sleep patterns across the human life span. If there were specific cohort or generational differences, this pattern of regular, progressive change would be much less predictable.

Given that the sleep patterns of older adults appear long after these individuals are capable of reproduction, they probably do not confer any physiological benefit. It is much more likely that they reflect biological and social changes that occur as people age. Biological changes include alterations in the body's underlying circadian rhythm, which helps to regulate the timing and depth of sleep, and age-related reductions in the homeostatic sleep drive, the metabolic process that causes the inclination to sleep after a period of wakefulness.

Studies show progressive changes in sleep patterns across the human life span. If there were specific generational differences, this pattern would be much less predictable.

Other factors likely to influence the quality and timing of sleep in older adults include the increased prevalence of illnesses, such as osteoarthritis, that can directly disrupt sleep, and the presence of primary sleep disorders, such as obstructive sleep apnea or restless legs syndrome. Various behaviors and environmental factors can also disrupt sleep. Many of these variables, such as irregular sleep schedules, staying in bed too long, and bedding or a bedroom that is not conducive to sleep, can be adjusted for improved slumber.

A comprehensive review of the impact of aging on sleep, including suggestions for maximizing sleep quality, can be found at the National Sleep Foundation: www.sleepfoundation.org. M

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

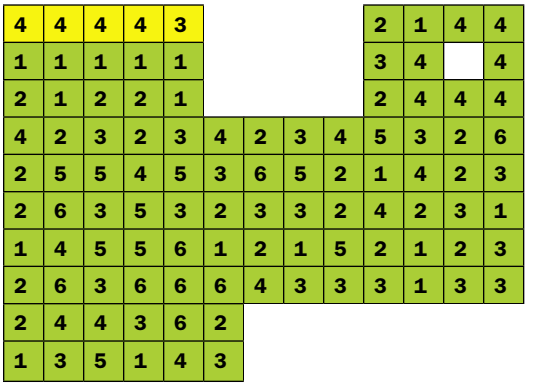
COURTESY OF EDVARD I. MOSER AND MICHAEL V. VITIELLO

Head Games

Match wits with the Mensa puzzlers

1 MATH GOLF

Start at any of the yellow tees and move the indicated number of spaces either horizontally, vertically or diagonally. You may go in only one direction for each move. You may not go out of bounds, and you must land by exact count in the hole. Par for this hole is three.



2 TARGET PRACTICE

A large circular target has a radius of 12 feet. The next ring inward has a radius of six times the square root of 3. The next ring inward has a radius of six times the square root of 2. The inner ring has a radius of six feet.

If you shoot at this target randomly, which region are you most likely to hit?

3 RIDDLE

We are hunting the elusive "red apes" that have been sighted in these parts. We haven't had any luck yet. Suddenly, in the forest, there's one! And another! And a third! And look, a mated pair! Soon lots of our coveted objects pop out. Then they vanish again. And there aren't any visible. Finally, as we leave we see a shy pair hiding in the woods.

What are the "red apes," and how many were sighted?

4 MISSING PIECES

Fill in the blanks according to the clues.

a)	**_ T E E _**	**Male bovine**
b)	**T E _ _ E _**	**It is often legal**
c)	**T _ E _ _ E _**	**Given something special**
d)	**T _ E E _**	**Type of jacket**
e)	**_ _ T E E _**	**Regard**
f)	**_ _ _ T E _ E _**	**Focused**
g)	**T _ E _ _ _ _ E _**	**Created a hypothesis**
h)	**_ _ _ T E _ E**	**Spartan**
i)	**_ _ T E _ _ E _**	**Meant**

5 BASES LOADED

Start at third base. Next go to second base, then left field. End at center field. What is the call?

6 A-E-I-O-U

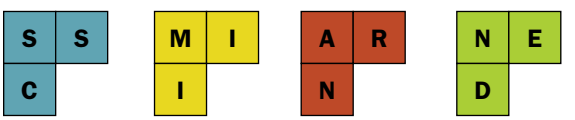
Fill in each blank below. All the missing words have the same pattern of consonants, but each word contains a different vowel.

I dug a _____ and _____ my cooking _____ in it.
Then I gave my _____ a _____ on the head.

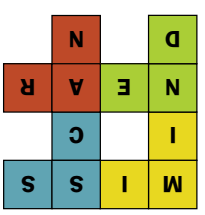
7 FOUR CORNERS

Rearrange these 3-letter pieces to make four 4-letter words.

You may not rotate or flip the pieces.



Answers



7.

4. a) STEER, b) TENDER, c) TREATED, d) TWEED, e) ESTEEM, f) CENTERED, g) THEORIZED, h) AUSTERE, i) INTENDED

5. Third (letter of) "base" = S. Second (letter of) "base" = A. Left (letter of) "field" = F. And the center (letter of) "field" = E. The call is "SAFE!"

6. PIT, PUT, POT, PET, PAT.

1. Start at the second tee from the left. Go diagonally down and right four spaces (end on 3). Go vertically down three spaces (end on 6). Go diagonally up and right six spaces (end in the hole).

2. Each region has the same area, so they are all equally likely.

3. There were 16 "red apes," which are the letters "o."

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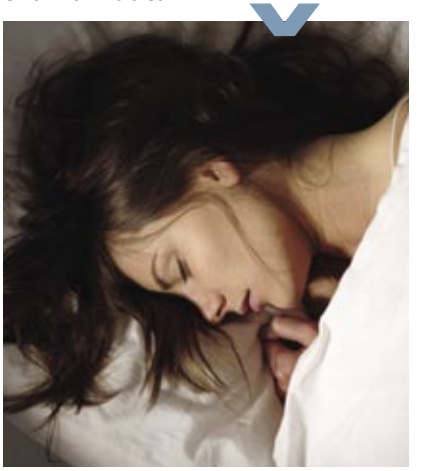

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The Brain's Spam Filter

Figuring out how we deal with extraneous information could be key to explaining intelligence and memory.

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Ask the Brains How does confidence affect learning and knowledge?
Illusions Play tricks on your brain—and gain insights about mental functions.
Head Games Brainteasers and puzzles.

BRUNO MALLART *Getty Images (left)*; MONIKA BENDER *Getty Images (right)*