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SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

May/June 2011
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10 Top Illusions

Candy for the Eye—and the Brain
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An Unfiltered Mind

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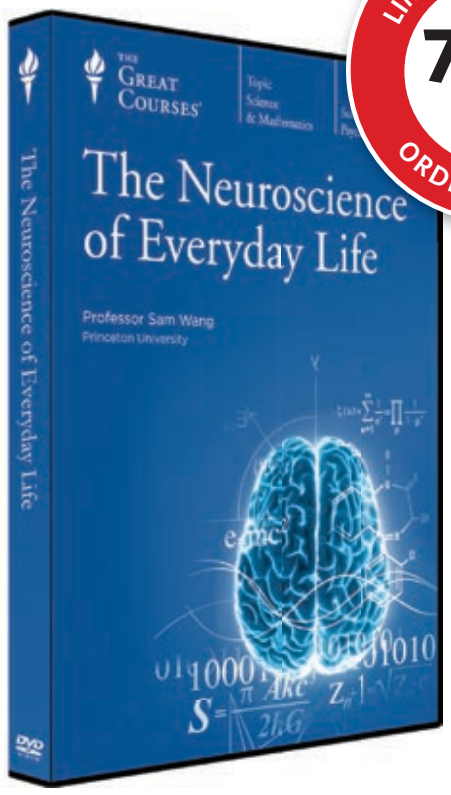

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COVER PHOTOILLUSTRATION BY JAMES PORTO

Feed Your Mind

When we launched *Scientific American Mind* as a new publication in 2004, it seemed like a great opportunity to give readers more stories about popular areas of mind and brain research—which, fortuitously, were also booming because of imaging and other advances. What I didn't realize at the time, but probably should have, is how often the findings in our pages would shake loose what I thought I knew about how our gray matter works. In every way, editing this magazine over the years has been, well, mind-expanding.

Take creativity, the subject of our cover story, "The Unleashed Mind," by Harvard University psychologist Shelley Carson. It is common for people to refer, with a knowing wink, to "creative types"—and we all know what that means. We think of someone a little … different from the rest of us workaday sorts. Someone who surprises us with spectacularly odd wardrobe choices but also with amazing insights into problems we are trying to solve.

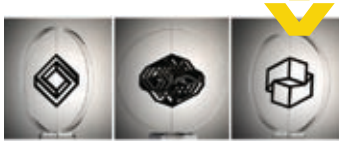
How do they do that? As it turns out, the elements that spur those creative insights—as well as a tendency to eccentricity—spring from something called cognitive disinhibition, which is characterized by an impaired ability of the brain to filter out extraneous details. When that unfiltered flow reaches the cortex of someone who is highly intelligent and who can process the information without being overwhelmed, novel ideas can burst forth. Of course, not everybody who is creative is unconventional, and vice versa. Turn to page 22 for more.

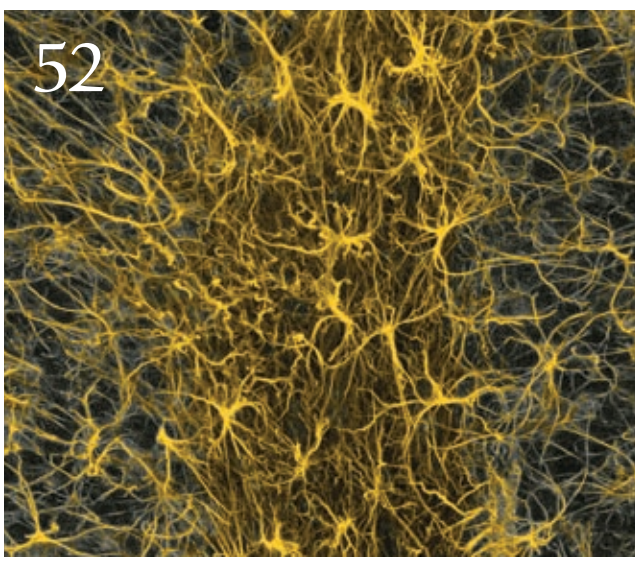
An essential way to nurture new notions often results from getting a different perspective on things. So after this issue, I will take a step back from *Scientific American Mind*'s day-to-day operations, the better to contribute to its long-term direction. Sandra Upson, who joins us as managing editor, will bring her own blend of insights, ideas and creative directions for the magazine. I can't wait to see what the team does next.

Mariette DiChristina
Editor in Chief
editors@SciAmMind.com

SCIENTIFIC AMERICAN MIND
Volume 22, Number 2, May/June 2011

FEATURES





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COSMOLOGY

Speaker: Lawrence Krauss, Ph.D.

- Quantum Man
- An Atom from Greece
- The Dark Side of the Universe: From Black Holes, to Dark Matter, and Dark Energy
- Hiding in the Mirror

PALEONTOLOGY

Speaker: Michael J. Benton, Ph.D.

- The Life and Times of the Dinosaurs
- Origins and Extinctions
- Origins of Modern Biodiversity
- The Dinosaurs of Eastern Europe and the Mediterranean

EVOLUTION

Speaker: Mohamed Noor, Ph.D.

- What is "Evolution" Anyway and Why Should I Care?
- On the Origin of Species, Really
- Genetics, Genomics, and You: Don't Fear Your Genotype!
- Life in the US Academic Sciences

COMETS

Speaker: Mark Bailey, Ph.D.

- Meteors, Meteor Showers, and the Draconids
- Comets and Concepts in History
- The Life, Times, and Persistent Puzzles of Comets
- Risks Posed by Comets and Asteroids

GEOLOGY

Speaker: Michael Wysession, Ph.D.

- Changing Climates, the Black Sea Flood, and the Rise of Civilization
- Santorini and the History of Megatsunamis
- The Eruption of Vesuvius and the Impact of Volcanoes
- Fermi's Paradox and the Likelihood of Finding Another Earth

ANCIENT ASTRONOMY

Speaker: John Steele, Ph.D.

- Astronomy in Ancient Babylon
- Ancient Greek Astronomy
- The Antikythera Mechanism: An Ancient Mechanical Universe
- Eclipses in History

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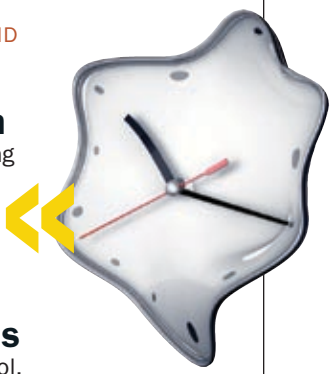
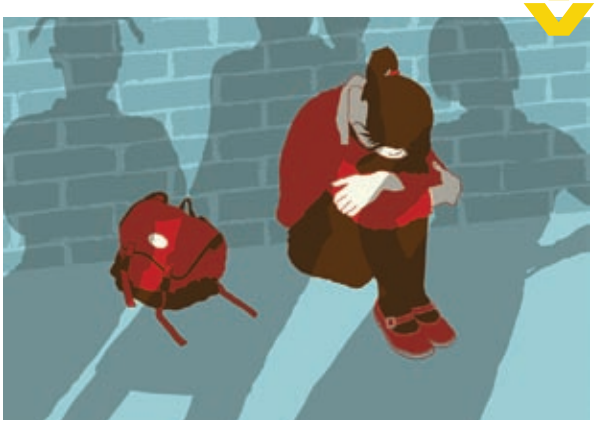
DEPARTMENTS





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IDEAS ABOUT ATTACHMENT

The biggest takeaway for me from "Get Attached," by Amir Levine and Rachel S. F. Heller, was how much my attachment style affects all my relationships, especially with friends and family. The need for independence does not limit itself to romance only.

Thanks for the great article.

Vern Martin
Alliance, Ohio

I'm increasingly inclined to view *Scientific American Mind* as a kind of snobbish self-help exercise. I confess that I love doing the Mensa puzzles and getting the instant gratification that most of the articles provide, but science? Do me a favor! This attachment piece is a case in point—so plausible and yet so irrefutable as to be meaningless. Any reasonably educated person could come up with his or her spectrum of epithets to describe basic human sensibilities; what substantive good comes from it?

"mathomas"
commenting at
www.ScientificAmerican.com/Mind

WHERE IS THE LOVE?

In "What, Me Care?" Jamil Zaki devotes a large portion of the article to speculation about various social factors that might have caused college students' empathy levels to decline over the past 30 years. I was surprised that Zaki didn't consider whether nonsocial factors might also have contributed to the decline. Researchers have found correlations between levels of lead in the blood and delinquent behavior, and they have speculated that pollutants in the environment may have contributed to a rise in autism rates. If it is reasonable to investigate whether pollutants are implicated in delinquent behavior and autism, then it seems reasonable to consider whether pollutants might also have contributed to the more general decline in empathy.

Molly Gardner
Madison, Wis.

So people have become less empathic in the past 30 years? During those 30 years English-speaking societies have been dominated by a move toward competitive individualism as the dominant—indeed, the only permitted—model of human nature and interaction. Competitive individualism is all about the fewest restraints possible on human action, including restraints from ties of mutual obligation. It's all about everyone maximizing his or her outcomes, and devil take the hindmost, especially because the "losers" in the rear are by definition responsible for their own failure.

Governments have led the way as they have stripped away social supports for the less fortunate. The only inexplicable aspect is that this trend could have escaped notice and that its outcomes at the individual level—indifference to our fellows—could be a surprise to anyone.

Catherine Scott
Camberwell, Australia

Perhaps low empathy levels could be improved if people were given the time and space to find one another interesting. I'm saying nothing new, but I think young people are overloaded with fast-paced activities and amusements. Other people, meanwhile, are represented by that slow person at the DMV, that classmate who gossips about you or that teacher who gave you the book report on *Wuthering Heights* you haven't yet fin-

ished. Obstacles, in other words. If it were somehow necessary for people to depend on the kindness of strangers, they might find reasons to care about them.

Unfortunately, that kind of widespread empathy seems to occur primarily after disasters. Society, when it's operational, tries to optimize it out.

"oodoodanoo"
commenting at
www.ScientificAmerican.com/Mind

I don't buy the hypothesis that less reading is a cause of lower empathy. I have always been an avid reader, but I have never felt as isolated from others as when, after spending the previous night reading a good book, I went to school or work to hear everyone else talking about something that was on the TV last night.

Between cell phones, IM and Facebook, young people nowadays seem, if anything, more connected to one another than they were 30 years ago. Perhaps it is what they see in those outside their social groups that is making them feel less connected. It certainly seems to me that public discourse by older people has become much more vitriolic and biased than it was when I was young.

"Never trust anyone over 30" was the catchphrase when I was 20. Sadly, it seems far more true now than it was then.

"TTLG"
commenting at
www.ScientificAmerican.com/Mind

WITHOUT BODY, NO MIND

Siri Carpenter's piece on embodied cognition, "Body of Thought," could have benefited from an increased sensitivity to philosophy.

Although research on embodied cognition may have begun relatively recently in the neuroscientific community, there is an important precedent in the research of philosophers Edmund Husserl and Maurice Merleau-Ponty in the early decades of the 20th century. Their arguments for the irreducibility of embodiment for any proper understanding of consciousness have been drawn on heavily in recent research in cognitive science. This is evident in the works of Alva Noë, Andy Clark, Antonio Damasio and Shaun Gallagher, among others.

In addition, although early on Carpenter critiques the dualist input-output model of earlier neuroscientific research, later she falls back into using precisely this model when she tries to explain embodiment's importance by using examples such as the causal effect of certain bodily stimuli (warm coffee and warm feelings). Although such examples are interesting and important in themselves, they miss or trivialize the real point that research into embodied cognition suggests; namely, that cognition in itself is inconceivable without embodiment. It is not simply that the body affects and is affected by conscious experience but that such experience is always and in principle embodied.

James N. McGuirk
Bodø, Norway

POSITIVE INTERFERENCE

Regarding "A Soothing Touch," by Ferris Jabr [Head Lines], another explanation for how touch can reduce pain is the "gate control theory," introduced by psychologist Ronald Melzack and neuroscientist Patrick David Wall in 1965, whereby sending many signals to the brain can somehow block out the pain signal or at least reduce its intensity. This theory helps to explain why acupuncture may work, and it is also the basis of chemicals such as BenGay, which are classified as counterirritants—they cause a sensation to compete with the pain sensation. Most people apply the counterirritant to the injured muscle, tendon or bone, but it would be just as effective if placed on a noninjured area.

"tommyoctober"
commenting at
www.ScientificAmerican.com/Mind

Is cognition possible without a body? Some philosophers argue it is not.

ATTENTION TO DETAIL

In addition to being a psychotherapist, I'm also an editor and proofreader. As such, I want to congratulate *Scientific American Mind* for having one of the best copyediting departments around.

Too many magazines, newspapers and printed books contain an abundance of misspellings, grammatical mistakes, dropped words and nonsequential thoughts. Your magazine consistently ranks among the top few that continue to pay attention to the English language. I'm guessing that's at least partially due to your excellent staff. I, for one, appreciate them!

Batya D. Wininger
via e-mail

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Head Lines

DANIEL STOLLE

>> GROUPTHINK

We're in This Together

In a crowd, everyone feels equally anxious

Anxiety, it seems, varies widely from one person to the next. What leaves you in a knot of angst may not even faze your friend. But two new studies show that during a crisis, anxiety seems to be contagious; you and your friends will probably ultimately arrive at the same anxiety level.

David Eilam of Tel Aviv University measured how groups of voles—a small, social rodent—responded to threats produced by barn owls, their main predator. Like humans, a few voles are very anxious, a few are not at all, and most are in the middle. When barn owls flew over the cages of individual voles, each of the animals' nervousness increased by about the same amount, as measured by standard behavioral tests. The frightened animals continued to display the wide range of anxiety levels they started with.

But when Eilam took groups of voles with different individual anxiety levels and exposed them to barn owls, they all ended up equally stressed out. "The variability that was there before diminished, and the entire group behaved almost the same," Eilam says.

He believes that behavioral norms might be beneficial for social animals during a crisis. This convergence to similar behaviors may help explain why humans turn to religion and other rituals after a major catastrophe. These ceremonies, Eilam says, may keep the most anxious humans from going over the edge.

—Carrie Arnold

>> CREATIVITY

Laughter Leads to Insight

Happy moods facilitate aha! moments

Stumped by a crossword puzzle? Try taking a break to watch a funny TV show. Recent research shows that people in a lighthearted mood more often have eureka moments of sudden inspiration.

Karuna Subramaniam, then at Northwestern University, and her colleagues found that boosting the mood of volunteers increased their likelihood of having an aha! moment that helped solve a word association puzzle. Those who watched a Robin Williams comedy special did measurably better at the task using insight than those who watched a quantum electronics talk or a scary movie. The games, in which players must find a word that connects three seemingly unrelated words, have been used for decades to demonstrate creative problem solving.

In the brain, sudden insight is accompanied by increased activity in the brain's anterior cingulate cortex (ACC) prior to solving each problem. The region is involved in regulating attention; in problem solving, it seems to work in conjunction with other brain areas either to stay focused on a particular strategy or to switch to a new one. Subramaniam found with functional MRI that people in a positive mood had more ACC activity going in to the task, which probably helped prepare the brain to find novel solutions. Participants who watched anxiety-producing movies such as *The Shining,* however, showed less activity in the ACC and less creativity in solving the puzzles. [For more on creativity in the brain, turn to "The Unleashed Mind," on page 22.]

—Elizabeth King Humphrey

CORBIS (*left*); SELYA KAWAMOTO Getty Images (*right*)

>> POLITICAL VIEWS

What Are You Looking At?

Conservatives may be less sensitive to certain social cues

Liberals might be more likely than conservatives to check out what you are looking at, according to a study published online November 4 in *Attention, Perception, and Psychophysics*. Experiments show that people take longer to notice when an object appears if they have first seen a face looking in the other direction. Now a team of psychologists and political scientists at the University of Nebraska–Lincoln report that whereas liberals do just that, conservatives do not. The researchers asked 72 undergraduates to look at a drawing of a face that looked to the left or right of a computer screen and then press a key when a black dot appeared. Despite being told the face would not predict the dot's location, liberals took 10 to 20 milliseconds longer—about 5 percent—to notice the dot when the face looked away from it instead of toward it, indicating that they had followed the face's gaze. Conservatives did not—they took the same amount of time regardless of where the face looked.

Study co-author Kevin Smith says one possible explanation is that "liberals are more sensitive to social cues," such as where someone looks, whereas conservatives value individual independence. Whatever the explanation, the results bolster the idea that political dispositions depend in part on differences in how people use social information.

—Nathan Collins

>> ECONOMICS

Tweeting the Bull or the Bear

To predict the stock market, there's no need to look into a crystal ball. Instead just sign on to Twitter. Researchers at Indiana University collected almost 10 million tweets to measure collective mood in the U.S. on different days. Johan Bollen and his colleagues tracked words indicating six emotions (calm, alert, sure, vital, kind and happy) and measured changes to the Dow Jones Industrial Average. A calm American public, they found, predicted a stock-market rise three or four days afterward—and negative language predicted a drop.

—Carrie Arnold

GETTY IMAGES

>> EVOLUTIONARY BIOLOGY

Crying Women Turn Men Off

Weeping releases a chemical that reduces sexual arousal

Women may have a more subtle way of telling men "no" than anyone imagined. Chemical cues in their tears signal that they are not interested in romantic activities, according to a study published online January 6 in *Science*.

Crying reveals a person's mood, but its evolutionary origins have long been a mystery. Because emotional tears have a different chemical makeup than those evoked by irritants in the eye, cognitive neuroscientist Noam Sobel of the Weizmann Institute of Science in Rehovot, Israel, wondered whether emotional tears relay chemical messages to others.

Sobel and his research team collected tears from self-professed "easy criers" as they watched sad movies.

Later, the researchers held jars containing the odorless tears and pads that had been dipped in the tears under men's noses.

These men rated female faces as less sexually attractive than did men who sniffed saline. Moreover, their sexual excitement dropped, as indicated by their own reports and by levels of testosterone in their saliva.

The researchers then scanned the men's brains as they watched a titillating movie scene using functional MRI. Brain regions associated with sexual arousal showed less activity in men who sniffed tears compared with those who sniffed saline.

The findings represent the first evidence that human tears send chemical messages, Sobel reports. Because a decrease in testosterone levels is linked to reduced hostility, he speculates that weeping dampens not only the libido but also violent behavior. "If the signal really lowers aggression toward you, then the evolutionary value of crying is clear," he says. *—Janelle Weaver*

>> EMOTIONS

Fascinated by Fear

Researchers get a rare glimpse at life without fright

One of the few exceptions to the old saying "everybody is afraid of something" is a 44-year-old woman known to psychologists as patient SM. She suffers from a rare case of brain damage to an almond-shaped region of her brain called the amygdala that, according to a paper published online December 16 in *Current Biology*, makes her incapable of experiencing fear.

For three months researchers did everything they could to scare SM. "We tried to use stimuli common in Western society," says Justin Feinstein, a University of Iowa graduate student who worked on the study. They showed her horror movies, walked her through haunted houses and exposed her to all kinds of other situations that the average person would consider frightening. They dug through her past, questioning her about times when she had been held up at knifepoint and gunpoint and nearly killed in a domestic dispute. Not once in any of these situations did they find evidence that SM felt afraid, by her report or via observation.

They found instead that situations that would terrify most people evoked in SM an intense feeling of fascination. At one point they took SM to a pet store to see how she would behave around snakes, an animal she had earlier told them she hated. When she saw the snakes, she was immediately drawn to them. She even picked one up and began playing with its tongue. When asked to explain her behavior, she said that she was overwhelmed with curiosity.

These findings suggest that our emotional response to danger involves elements of both fear and fascination. When we find ourselves in potentially threatening situations, Feinstein explains, "the amygdala helps us navigate the fine boundary between approach and avoidance." If the amygdala is functioning properly, these emotions work together to get us out of trouble—and enable us to enjoy the occasional gruesome movie. When it is damaged, however, our response can actually work against our survival, attracting us to the very things we should be avoiding. As the researchers concluded, "the evolutionary value of fear is lost." *—Joe Kloc*

GETTY IMAGES (*top*); LOUIE PSIHOYOS *Getty Images* (*bottom*)

>> PSYCHOLOGY OF FOOD

A Thinking Person's Diet

Imagining the act of eating can trick you into eating less

Dieters take note: thinking in detail about eating can reduce actual food consumption, according to a study in the December 10, 2010, issue of *Science*. Imagining an experience is known to evoke the same physiological responses as the real experience, so researchers at Carnegie Mellon University tested whether imagining chowing down could simulate the experience enough to satisfy people's cravings. Study participants thought about eating a food—M&M's or cubes of cheese—one morsel at a time and then afterward were offered the same food to eat. Those who imagined eating 30 M&M's ate half as many candies as those who pictured putting 30 quarters into a laundry machine. The effect was specific to the type of food imagined, with those thinking about eating cheese consuming about half the amount of cheese eaten by those who had thought about eating M&M's.

Although these findings seem counterintuitive given that the sight of a candy machine can set off an intense craving for chocolate, the key difference is in how people think about food, says Carey Morewedge, the psychologist who led the study. "When people are normally thinking about eating food, they're not imagining the actual consumption," he says. Indeed, when subjects thought about placing 30 M&M's into a bowl, they ate 1.6 times more than those who only thought about eating them. But when people engaged in the mental imagery that would accompany actual eating, it wore down their desire to eat. Morewedge plans next to explore whether this kind of mental simulation can help smokers reduce their craving for cigarettes.

—Michele Solis

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>> COMMUNICATION

Far from Conflict

Physical distance may improve a negotiating climate

GETTY IMAGES

Buying a house or car? Perhaps you should try making the deal via e-mail. A January study in the *Journal of Experimental Social Psychology* suggests negotiations are smoother when the parties are separated by distance. When undergraduates who negotiated the purchase of a motorcycle over Instant Messenger believed they were physically far apart (more than 15 miles), negotiations were easier and showed more compromise than when participants believed they were closer (a few feet). The experimenters explain that when people are farther apart, they consider the factors in a more abstract way, focusing on the main issues rather than getting hung up on less important points. So next time you have to work out a complex deal, the researchers say, it may be worthwhile to begin from a distance, such as when you are traveling. *—Harvey Black*

NEUROCHEMISTRY

The Prejudice Hormone

A chemical well known for encouraging bonding may also underlie bias

Oxytocin is known as the "love hormone" because it encourages trust, cooperation and social bonding. But these effects may exist only for members of your own clan, according to a study published in January in the *Proceedings of the National Academy of Sciences USA*. Psychologists at the University of Amsterdam found that Dutch men who inhaled oxytocin were more likely to associate positive words, such as joy and laughter, and complex positive emotions, such as hope and admiration, with Dutch people than with Germans or Arabs.

Next, subjects had to choose whether to stop a trolley from running into five people by hitting a switch that would divert it to another track, where it would kill only one person—a commonly studied moral dilemma. Under the influence of oxytocin, Dutch men were less likely to sacrifice a Dutch male than a German or Arab. Because the drug enhances bias against people belonging to other groups, it may contribute to bigotry just as much as harmony. *—Janelle Weaver*

MIND-BODY CONNECTION

Pain Lessens Guilt

Physical discomfort can alleviate mental suffering

We tend to regard pain as an unfortunate by-product of physical harm. Sensations of crushing, burning and piercing are the language of alert, used by our bodies to communicate tissue damage, whether imminent or real. But what about the pain we inflict on ourselves? What about the moment of anguish when we tear at our hair or thrust our fists into the wall? New research suggests that we seek out physical pain to provide an emotional catharsis for feelings of guilt or shame. More important, it suggests that such actions may work.

"Pain may actually be functional in many ways," explains Brock Bastian, a psychologist at the University of Queensland in Australia. Psychologists working with self-mutilating patients have long suspected this to be true, and leaders in the field describe an intense overlap between emotional and physical pain. But Bastian has demonstrated the first results in a nonpatient population. He asked participants to focus on an episode in their past that made them feel guilty while submerging one hand in a bucket of either freezing or tepid water. Those who had their hands in icy water kept them there for longer and felt less guilt over time. In Bastian's opinion, guilt motivated them to prolong their exposure to physical pain as a prescription for the psychological pain.

Consider our rituals of apology and religious atonement, and his theory begins to make sense. If you're looking for a way to wash away your own sins, it may help to turn your shower knob as far as it can go to the right or left. Yes, it will hurt, but that's the point. *—Morgen Peck*

PETER CADE *Getty Images (top)*; GETTY IMAGES *(bottom)*

RELATIONSHIPS

The Language of Love

Word usage predicts romantic attraction

What distinguishes a fling that ends in tears from long-term love? Past research suggests that the most successful couples share common interests, values and personality traits. Now new research published in *Psychological Science* proposes that the simplest words lovebirds use to speak to each other also make a difference—both in determining how attracted they are and how likely they are to stay together.

James Pennebaker and his colleagues at the University of Texas at Austin recorded 40 men and 40 women as they participated in a speed-dating exercise in which they talked to 12 strangers of the opposite sex for four minutes apiece. Later, the subjects rated each date based on how much they seemed to have in common and whether they wanted to see the person again. Pennebaker analyzed the participants' conversations based on their use of pronouns and articles, such as "him," "the," "and," "as" and "be." These function words are used in most contexts and are processed rapidly and unconsciously. [For more on how Pennebaker uses function words to reveal personality and other traits, see "You Are What You Say," by Jan Dönges; Scientific American Mind, July/August 2009.]

The pairs who used similar types of function words with similar frequencies, he found, were more likely to want to see each other again, regardless of how much they felt they had in common. In a follow-up study, Pennebaker compared the language used by 86 couples in committed relationships via writing samples from instant messages. He found that the more their function words matched, the more likely they were to be together three months later, irrespective of how happy they said they were in their relationships at the time. The big question is whether individuals feel more aligned to others who already talk the way they do or whether they adapt their language to match that of individuals they really like. Pennebaker admits that both are possible, but he believes the latter is the driving force: language, he says, predicts relationship success because it reflects how well couples listen to each other. What is Pennebaker's advice for living happily ever after with a loved one, then? "Pay closer attention to the other person," he says.

—Melinda Wenner Moyer

MEMORY

Brain Boosters

Two simple tips to learn better and take tests more effectively

Need to learn a lot of material fast and perform well when it counts? Two new studies suggest easy ways to speed up learning and ease anxiety before a test.

A simple recall drill may be the best way to solidify new information in your memory, according to a study published online January 20 in *Science*. Many teachers encourage students to use elaborate conceptual methods to learn complicated material, but psychologists at Purdue University found that practice at retrieving facts works better. College students who read short science texts and then spent 20 minutes recalling as much as possible by writing down what they had read performed about 50 percent better on tests the next week than did students who drew complex maps depicting relations between concepts. The authors say that the act of reconstructing knowledge enhances learning and strengthens memories. Put simply, practice makes perfect.

But sometimes all that studying is for naught when a test or a big performance rolls around and you choke. It turns out that focusing on your worries by writing about them before a test can boost your scores, according to a different paper published in January in *Science*. Psychologists at the University of Chicago found that college students who first wrote about their thoughts and feelings about an upcoming math exam for 10 minutes solved more arithmetic problems than did students who sat quietly. And the writing task improved

the scores of highly anxious ninth graders so much that they performed as well as students with low anxiety on a biology final exam. The authors say that the technique may be most useful for habitual worriers in high-pressure situations.

—Janelle Weaver

TED HOROWITZ *Corbis (top)*; EDWARD BOCK *Corbis (bottom)*

>> SOCIAL COGNITION

Might Makes Right

Babies understand that bigger beasts usually top the pecking order

To be socially savvy, you have to learn the hierarchy. This skill is so crucial that even babies possess it, according to a study published January 28 in *Science*. Infants only 10 months old know that bigger beings usually get their way.

Developmental psychologist Lotte Thomsen of the University of Copenhagen and her collaborators showed infants cartoon movies in which two different-size blocks, each having an eye and a mouth, bounced toward each other starting from opposite sides of a platform. When they met in the middle, the blocks collided, then backed up several times, as if competing for the right to move forward. Then one block bowed down and scooted out of the way of the other one, which continued along its path.

Ten-month-old infants looked longer at scenes in which the bigger object surrendered, indicating that they were surprised at this outcome (the amount of time infants spend studying a scene is a well-tested experimental metric for piqued interest). The finding suggests that babies understand conflicting goals and social dominance, even though they cannot talk or actively fight. Whether because of some innate sense that size matters or because of experiences such as an older sibling taking their toys, babies know that bigger people often get what they want.

—Janelle Weaver

>> PERSONALITY

Speaking with Affect

People take on different character traits depending on which language they are using

If you speak multiple languages, you might have multiple personalities. Reporting October 15 in *Personality and Social Psychology Bulletin*, psychologists at Hong Kong Polytechnic University found that native Chinese students who were fluent in English appeared more assertive, extraverted and open to new experiences—personality traits often associated with Westerners—when conversing with an interviewer in English as opposed to Cantonese.

The interviewer's ethnicity mattered, too. In either language, observers rated students as more extraverted, assertive, helpful and open to new experiences when speaking to a Caucasian interviewer as compared with when they talked to a Chinese interviewer.

The authors argue that personalities are not fixed. Instead the language a person is speaking—and with whom—can lead individuals to take on the personality traits of the culture associated with that language or person.

—Nathan Collins

MICHEL TCHEREVKOFF *Getty Images (top)*; GETTY IMAGES *(bottom)*

Found! The Last Morgan Silver Dollars

Amazing Discovery from Montana Silver Collector

Montana. A old-time silver collector recently liquidated a hoard of Morgan Silver Dollars he'd acquired that were part of an estate sale. They'd been hidden away for decades—originally purchased from the U.S. Treasury.

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Survival Against All Odds

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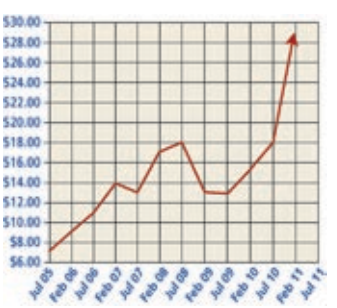

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>> OPTIMISM

The Downside of Hope

Wishful thinking worsens our decisions about the future

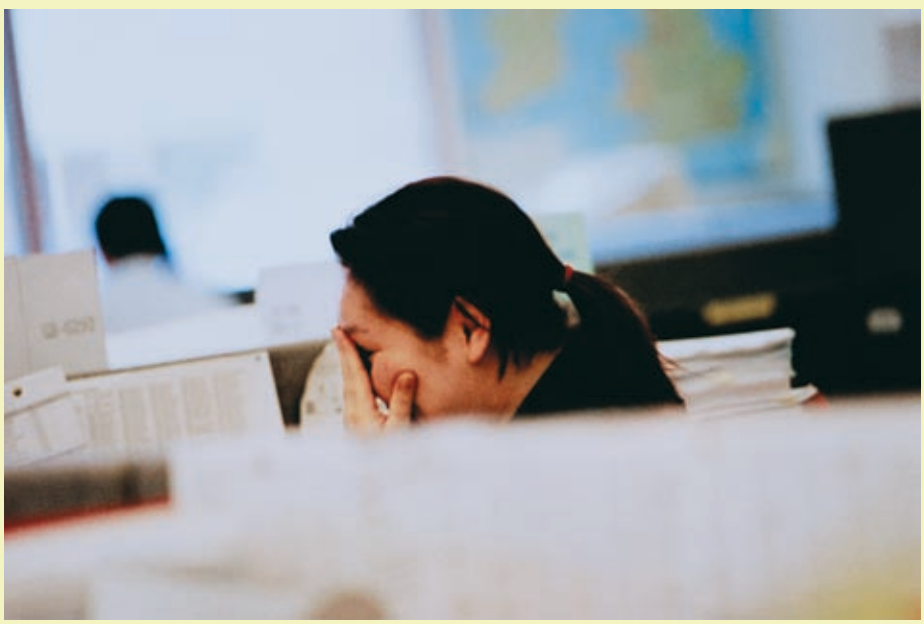
Everything has a downside—even optimism. In a new study published in *Psychological Science,* researchers asked hundreds of football fans to predict the outcome of each game of the 2008 NFL season a week before it was played. They found that fans always predicted an above-average probability of success for their favorite teams, no matter how poorly the teams had performed in previous games. Some of the most important decisions we make—such as whom we will marry—rely on our ability to predict the future, one of the researchers explained. Accounting for the negative effects of optimism might not make these predictions any brighter, but with any luck it will make them better.

—Joe Kloc

>> MENTAL HEALTH

Depressed or Burned Out?

Although they have similar symptoms, the two conditions affect the body in different ways



Most of us have seen it happen: a friend or colleague with enviable energy and dedication to a stressful job suddenly burns out. In place of tireless toil comes unrelenting exhaustion, difficulty falling asleep, low mood and a sense of inefficacy. These symptoms may look a lot like depression, but new research suggests that burnout is subtly different in the body and brain.

Although burnout is not recognized as a distinct psychiatric disorder, it seems to cause a unique profile of changes to neurological functioning, according to work by psychologist Agneta Sandström of Umeå University in Sweden. Sandström compared women with burnout, known formally as exhaustion syndrome, to women with major depression, and she found subtle but significant differences between the two groups. For instance, both groups of women had sleep difficulties, but women with depression reported waking too early, whereas women with chronic burnout had difficulties falling asleep.

Sandström also asked healthy women and those with exhaustion syndrome and major depression to complete a working-memory test. Both depressed and burned-out women found it hard to focus and remember simple details, compared with control women. But women with exhaustion syndrome had even lower brain activity, measured by functional MRI, during these memory tests than depressed women did.

Over time, Sandström says, small daily stressors can accumulate to create chronic burnout. By coping better with these seemingly insignificant pressures, people may be able to reduce their risk of developing exhaustion syndrome. "It's okay to get stressed, but you also have to find time during the day to rest," Sandström says. Just as your muscles can get tired, so can your brain. "We need to think about how much the brain can cope with during a normal workday," she says.

—Carrie Arnold

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

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Fickle Friends

"Frenemies" can be bad for your health, but understanding these taxing relationships can make them less painful

BY KIRSTEN WEIR

On average, about half of our social ties consist of ambivalent friendships. In such relationships, qualities such as warmth and understanding are accompanied by rejection, jealousy and feelings of insecurity.

UWE UMSTÄTTER *age Fotostock*

HAVE YOU EVER had a friend who makes plans to hang out but cancels when a better offer comes along? Or a buddy who helped you through a bad breakup, then flirted with your ex? To scientists, these problematic pals are known as ambivalent friends. To a more slang-savvy crowd, they are called "frenemies."

Either term has come to describe a range of complicated relationships—those that boost you up and bring you down, for any of a variety of reasons. They include the well-meaning friend who is overly competitive, the pal who is a pillar of support when times are tough but cannot quite take pleasure in your successes, and the college buddy who drops everything to lend you a hand when you need one but gossips about you later.

In these troublesome relationships, qualities such as warmth and understanding go hand-in-hand with criticism, jealousy or rejection. "It's a friend who drives you nuts," says Karen Fingerman, a psychologist at Purdue University. "You love them, you don't want to lose them, but they're really a pain."

Researchers have only recently begun examining these mixed-emotion associations. So far they are finding that such ties have negative effects on mental and physical well-being, boosting blood pressure and risk of depression while lowering resistance to stress. But if you want to keep your frenemies—and most people do—you can minimize these effects by buffering your interactions with the mixed-weather friends and considering impartial reasons for their hurtful behavior.

Quality over Quantity

Humans are an extremely social species, and a friendless existence has many drawbacks, including depression, hypertension and cognitive decline. But if you want to be happy (and by extension, healthy), having lots of friends is much less important than having good ones. In a 2006 study psychologists Meliksah Demir and Lesley Weitekamp, then both at Wayne State University, gave 423 college students questionnaires about their personality, their happiness level, and the quality and number of their friendships. The researchers defined quality friendships as those scoring high on help, intimacy, self-validation, reliable alliance, emotional security and stimulating companionship. Fifty-eight percent of the variance in happiness could be attributed to the quality of a person's friendships, compared with 55 percent for personality. The number of friends, on the other hand, had no significant effect on how happy a subject was.

From this angle, frenemies are problematic. No friendship is perfect, of course. But frenemies are consistently imperfect, scoring low on factors such as reliable alliance and self-validation, for example. And once you develop ambivalent feelings for a person, "future interactions with that person may be judged through

Blood pressure was more elevated in the presence of ambivalent friends than it was with people the subjects disliked.

that lens," says psychologist Julianne Holt-Lunstad of Brigham Young University. In other words, you are less able to overlook a thoughtless comment made by a frenemy than one made by someone you think of as supportive.

Our lives are riddled with frenemies. From surveys asking people to assess their relationships, Holt-Lunstad and University of Utah psychologist Bert Uchino have found that, on average, about half a person's social network is made up of ambivalent ties. Many are in the family. Fingerman has found that people are likely to view spouses, parents, children and siblings with more ambivalence than friends and acquaintances. One reason: it is much harder to swap out a family member than a friend, no matter how troublesome he or she is. In addition, even irritating family members often provide support and warmth you cannot afford to give up.

Unhealthy Ties

Ambivalent relationships may do more than dishearten. In a study published in 2003 Holt-Lunstad and Uchino asked 102 male and female volunteers to wear blood pressure monitors for three days. Every time a subject had a social interaction lasting more than five minutes, he or she would describe it in a diary and rate the quality of that relationship. Not surprisingly, blood pressure readings were typically higher when individuals encountered ambivalent friends than when they saw supportive friends. But intriguingly, blood pressure was also more elevated in the presence of ambivalent friends than it was with people the subjects disliked but could not avoid (such as classmates or co-workers). You expect very little from someone you loathe, Holt-Lunstad surmises, whereas ambivalent friends, unpredictable as they are, often raise your hopes only to dash them. And that disappointment, or fear of it, can negatively affect your health.

Other research suggests that ambivalent friends can lower resistance to stress. In 2001 Holt-Lunstad and Uchino reported asking 133 individuals aged 30 to 70 to rate important members of their social networks according to how helpful or upsetting they were. Then the volunteers completed two stressful exercises: a mental arithmetic task and a speech defending themselves against a false accusation. The more ambivalent friends a person had, the higher his or her heart rate and blood pressure were, in general, during these activities. The result suggests that supportive relationships buffer the body against stress but that ambivalent friends have the opposite effect. Consistent with that conclusion, the individuals with a greater number of ambivalent friends were more likely to suffer from depression.

If such friends make us unhappy, why do we keep them? In a 2009 study Holt-Lunstad and graduate student Briahna Bigelow Bushman found that people hang onto difficult friendships deliberately—because the relationship has a long history, because the good in the relationship outweighs the bad or because, for whatever reason, they just do not want to give up on the person.

Indeed, you may not need to give up on your frenemies if you know how to manage these relationships to minimize the pain they produce [*see box on this page*]. Whether your friend is worth this effort depends on what he or she means to you. But either way, you can work on keeping your end of the friendship bargain. As Holt-Lunstad says, "Start with controlling your own behavior and being the kind of friend you'd want others to be." M

KIRSTEN WEIR is an independent science writer based in Portland, Me.

Coping with Frenemies

You can limit the heartache of troublesome—but valuable—friendships and family ties using a couple of simple strategies. Psychologist Julianne Holt-Lunstad of Brigham Young University recommends avoiding previously problematic subjects or situations. If your frenemy tends to cancel at the last minute, for example, create backup plans. If talking about politics or religion has led to snide remarks, steer clear of that subject.

In addition, give your frenemy's motives a positive, or at least neutral, spin. If a friend often calls you at work, you might be tempted to think, "She has no respect for my job or my time." But perhaps she is the type who needs to share her news right away. "The latter way of thinking is not as personal," explains psychologist Karen Fingerman of Purdue University. "That's the kind of social cognition that contributes to better relationships." —*K.W.*

(Further Reading)

- **On the Importance of Relationship Quality: The Impact of Ambivalence in Friendships on Cardiovascular Functioning.** Julianne Holt-Lunstad et al. in *Annals of Behavioral Medicine,* Vol. 33, No. 3, pages 278–290; September 2007.
- **Understanding Social Relationship Maintenance among Friends: Why We Don't End Those Frustrating Friendships.** Briahna Bigelow Bushman et al. in *Journal of Social and Clinical Psychology,* Vol. 28, No. 6, pages 749–778; June 2009.

PAPER BOAT CREATIVE/GETTY IMAGES

Fatal Attraction

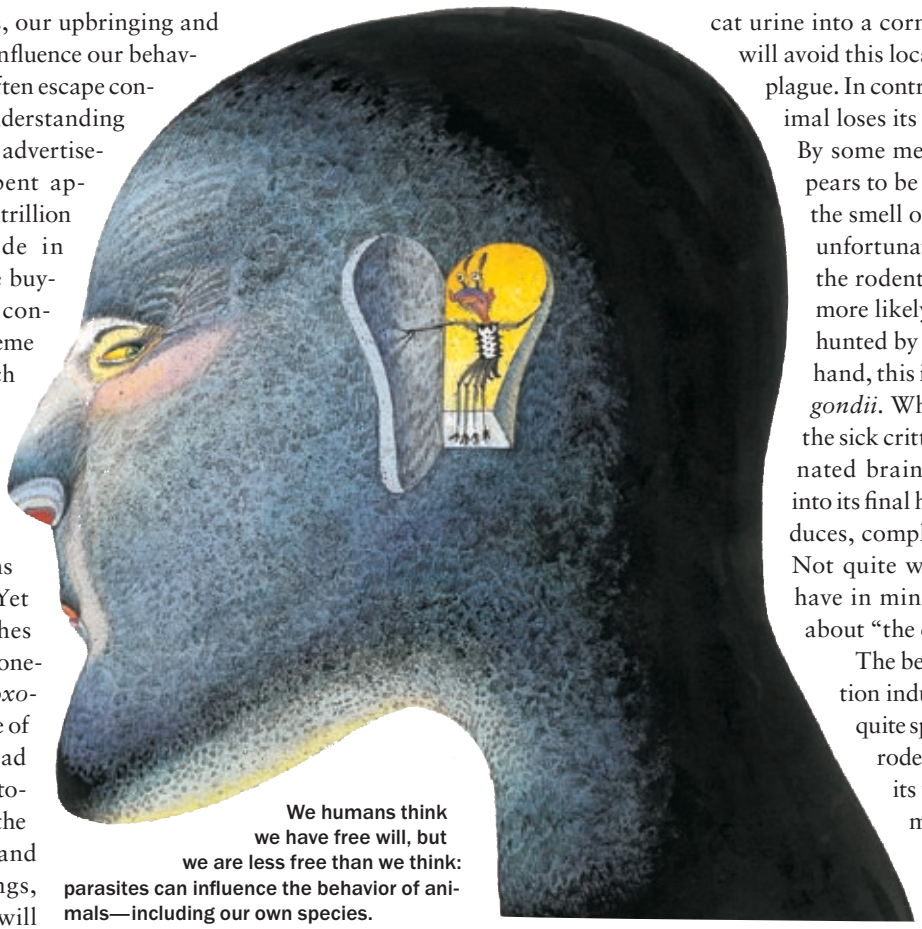
Some protozoa infect the brain of their host, shaping its behavior in ways most suited to the pathogen, even if it leads to the suicide of the host

BY CHRISTOF KOCH

THE ANCIENT DEBATE surrounding the existence of free will appears unresolvable, a metaphysical question that generates much heat yet little light. Common sense and volumes of psychological and neuroscientific research reveal, however, that we are less free than we think we are. Our genes, our upbringing and our environment influence our behaviors in ways that often escape conscious control. Understanding this influence, the advertisement industry spent approximately half a trillion dollars worldwide in 2010 to shape the buying decisions of consumers. And extreme dictatorships, such as that in North Korea, remain in power through the effective use of insidious and all-pervasive forms of propaganda. Yet nothing approaches the perfidy of the one-celled organism *Toxoplasma gondii*, one of the most widespread of all parasitic protozoa. It takes over the brain of its host and makes it do things, even actions that will cause it to die, in the service of this nasty hitchhiker. It sounds like a cheesy Hollywood horror flick, except that it is for real.

We know that illness in general can slow us down, incapacitate us and, in the worst case, kill us. Yet this organism is much more specific. Natural selection has given rise to pathogens that infiltrate the nervous system and change that system's wiring to achieve its ultimate purpose, replication—like a computer virus that reprograms an infected machine.

Such is the case with *T. gondii*. It sexually reproduces only in the intestines of cats yet can maintain itself indefinitely in any warm-blooded animal. Infected cats shed millions of their oocysts in their feces. Taken up by all kinds of animals, including dogs, rodents and humans, they infect muscle and the brain to escape attacks by the host's immune system. Hidden away, they remain dormant as cysts, surrounding themselves with a tough cell wall. Yet this quiet stage of infection, called toxoplasmosis, is deceptive. Violating all rules of good hospitality, these invaders make the host's brain do things counterproductive to its own survival.



We humans think we have free will, but we are less free than we think: parasites can influence the behavior of animals—including our own species.

Toxoplasmosis has been most thoroughly studied in rats and mice. Both species have a deep-seated, innate fear of cats for obvious reasons. Spray a bit of cat urine into a corner, and the rodent will avoid this location, well, like the plague. In contrast, an infected animal loses its innate fear of cats. By some measures, it even appears to be mildly attracted to the smell of felines. This is an unfortunate turn of events for the rodent, because it is now more likely to be successfully hunted by a cat. On the other hand, this is a great deal for *T. gondii*. When the cat devours the sick critter and its contaminated brain, *T. gondii* moves into its final host, where it reproduces, completing its life cycle. Not quite what the romantics have in mind when they write about "the circle of life"!

The behavioral manipulation induced by *T. gondii* is quite specific. The infected rodent doesn't look sick; its weight is normal; it moves about normally, possibly a bit more frantically than other mice; it grooms itself; and it interacts routinely with its conspecifics. Think how different this case is from what happens in rabies, another nasty infection. The animal loses its instinctual shyness, aggressively attacking others (the proverbial mad dog), thereby spreading the rabies virus through its bite. But because *T. gondii* can reproduce only in felines, it wants its host to be eaten by cats, not by just any carnivore. And be-

CHRISTOF KOCH (*Koch*); JACK UNRUH (*head and earwig*)

Infected rodents **lose their fear of cats.** By some measures, they even appear to be mildly attracted.

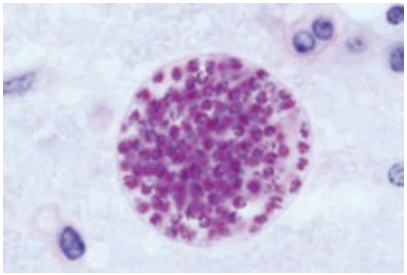
cause cats hunt live prey and do not eat carrion, *T. gondii* must not immediately kill its temporary host.

Rodents Aren't Superheroes

How does *T. gondii* effect its insidious changes in the host? Experiments by Joanne P. Webster of Imperial College London, Robert Sapolsky of Stanford University and others have shown that infected rats or mice do not turn into the murine equivalent of Siegfried, the hero of Wagner's *Ring* who knew no fear. No, they still avoid open spaces, remain nocturnal creatures, retain their aversion to the urine of other predators and learn to fear a tone associated with a foot shock. Might the protozoa have stunted their smell? After all, if they cannot smell anything anymore, they would not know how to avoid places smelling of cat urine. But infected mice still avoid food if it smells different—an aversion that arose partly because for centuries humans have been trying to control rodents by poison. The infected mice also respond appropriately to the smell of their littermates.

Clues about how the parasites affect the animal come from several observations. First, the density of cysts in the amygdala is almost double that in other brain structures involved in odor perception. Parts of the amygdala have been linked to anxiety and the sensation of fear. Second, the genome of *T. gondii* contains two genes related to mammalian genes involved in the regulation of dopamine, the molecule associated with reward and pleasure signals in the brain, including in ours. So perhaps the creepy protozoa makes suicidal activities, such as hanging around places frequented by cats, feel more pleasurable for the infected rodent?

What elevates this vignette about evolution and life in the wild to epic proportions for humanity is that about a tenth of the U.S. population is infected by *T. gondii* (in some countries, such as France, the infection rate is seven to eight times higher, possibly because of the widespread consumption of uncooked and undercooked meat). Human toxoplasmosis is usually considered to be symptom-free (what doctors refer to as asymptomatic). Exceptions are patients with a weakened immune system and the unborn (hence the need for pregnant women to avoid cleaning cat-litter boxes).



A cyst of *Toxoplasma gondii* resides in the brain. Can these silent invaders, which remain for life in the brain of the infected individual, control us without our awareness?

Science has known for a long time that schizophrenic patients are two to three times more likely to carry antibodies to *T. gondii* than are controls who are not schizophrenic. Furthermore, antipsychotic drugs that block the action of dopamine, such as haloperidol, commonly used in the treatment of schizophrenia, are also effective in combating toxoplasmosis in both rats and people. And some infected adults go on to develop psychotic symptoms similar to schizophrenia. Little is known about the mode or site of action of this pathogen in the human brain. The exact link between *T. gondii* and psychiatric diseases is tantalizing but remains murky.

Recent claims go so far as to argue for a role of *T. gondii* in shaping distinct cultural habits, depending on the rate of infection in the population. A prospective study tracking the road safety in Czech recruits during their 18 months of compulsory military draft found a rate of accidents six times higher in affected drivers. Are the young men with toxoplasmosis infection simply slowed down? Or do they drive more aggressively?

In my November 2009 column, I described the discovery by cognitive neuroscientists that the feeling of freely willing an action (called authorship or agency) is a subjective, conscious sensation no different, in principle, from the conscious awareness of seeing the azure blue sky or feeling the sharp pain of a toothache. When I engage in a dangerous pursuit, such as taking the end of the rope on a steep section of a granite wall in Yosemite Valley while climbing, I feel as if "I freely decided" to do so, whatever this might mean in a metaphysical sense. Yet my action is most likely caused by an inexhaustible multiplicity of factors not accessible to my conscious introspection, including, yes, possibly some tiny single-celled parasites lodging in my brain and making me act out their silent commands. The wonder of it all. M

CHRISTOF KOCH is Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology. He serves on *Scientific American Mind*'s board of advisers.

(Further Reading)

- **Bugs in the Brain.** Robert Sapolsky in *Scientific American,* Vol. 288, No. 3, pages 94–97; March 2003.
- **The Effect of *Toxoplasma gondii* on Animal Behavior: Playing Cat and Mouse.** Joanne P. Webster in *Schizophrenia Bulletin,* Vol. 33, No. 3, pages 752–756; 2007.
- **Manipulation of Host Behavior by *Toxoplasma gondii:* What Is the Minimum a Proposed Proximate Mechanism Should Explain?** Ajai Vyas and Robert Sapolsky in *Folia Parasitologica,* Vol. 57, No. 2, pages 88–94; 2010.

Colors Out of Space

Colors can change with their surroundings and spread beyond the lines

By Stephen L. Macknik and Susana Martinez-Conde

It was just a colour out of space—a frightful messenger from unformed realms of infinity beyond all Nature as we know it; from realms whose mere existence stuns the brain and numbs us with the black extra-cosmic gulfs it throws open before our frenzied eyes.

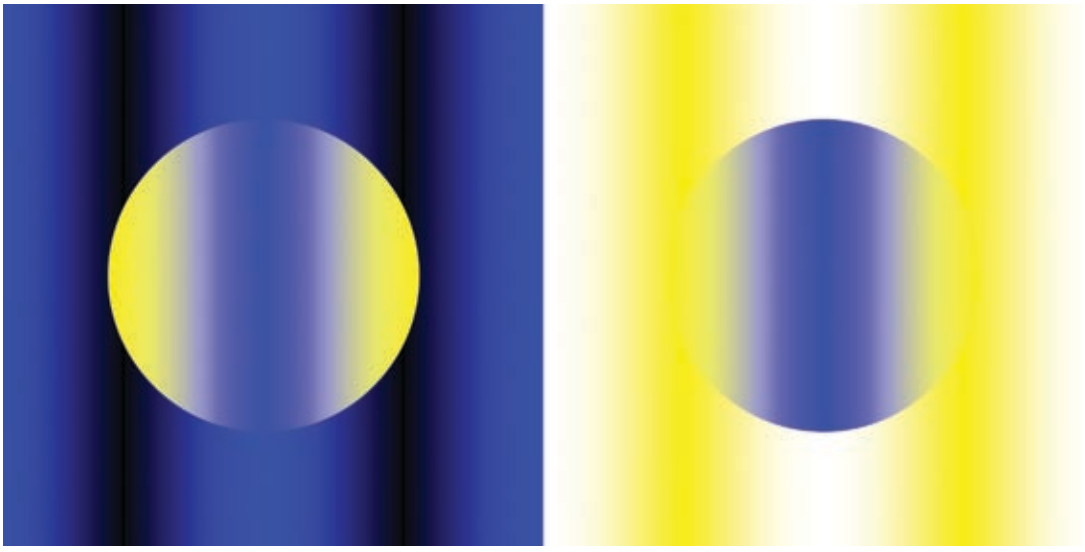
Science-fiction author H. P. Lovecraft considered *The Colour Out of Space* his best story. In this 1927 classic tale of cosmic horror, a small Massachusetts farming community faces unspeakable evil from the outer reaches of the universe. The extraterrestrial villain is not a face-hugging or chest-bursting alien but something far more terrifying: a weird color.

Slowly but surely the otherworldly color mutates and destroys crops, insects, wild animals and livestock. It impregnates the land and the water. The unfortunate farmers who encounter the bizarre hue fall prey to insanity and untimely death.

And you thought vision research was for wimps.

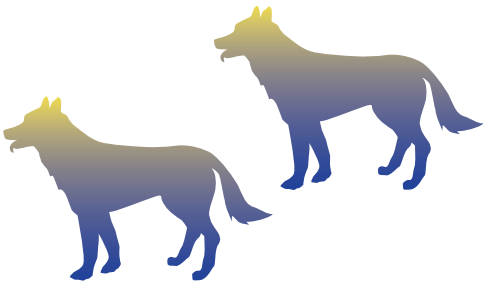
This article features some of the most spectacular color phenomena this side of the galaxy. You won't see any extraterrestrials, but many strange illusions arise from taking colors out of place and putting them in an unusual context. Use caution: the peculiar shades and tints you are about to experience could blow your mind.

STEPHEN L. MACKNIK and SUSANA MARTINEZ-CONDE are laboratory directors at the Barrow Neurological Institute in Phoenix. They are authors of the book *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee (http://sleightsofmind.com), published by Henry Holt & Co., 2010.



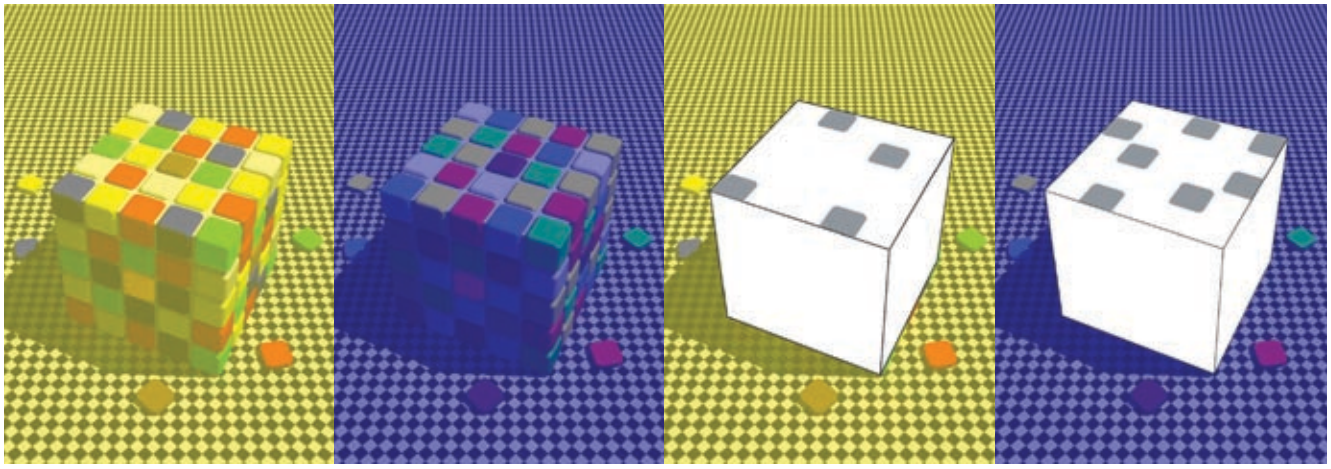
YELLOW MOON AND BLUE MOON Here we have two moons out of space. One yellow and one blue. Or are they? Actually both moons are exactly the same color in this illusion by psychologist Akiyoshi Kitaoka of Ritsumeikan University in Japan; only the surrounding colors are different. If you don't believe it, cut out the two moons—you'll find them to be identical. The appearance of colors is all about their context.

COURTESY OF AKIYOSHI KITAOKA *Ritsumeikan University*



REX AND FIDO

Legend has it that Rome was founded by warring twin brothers, Romulus and Remus, born to a vestal virgin named Rhea Silvia and fathered by Mars, the god of war. Vestal virgins, as it turns out, are not supposed to conceive children, even if the father is a god. The family shame was too much for Rhea's father, who killed her and then condemned the twin baby boys to die of exposure. The wolf Lupa found the boys and adopted them. But hey, what about Lupa's biological pups, Rex and Fido, younger brothers to the feral Romans? These nonidentical twins (*left*) become identical when the background is removed (*right*). Had this pair been born before their mother discovered Romulus and Remus, surely Rome would have gone to the dogs.



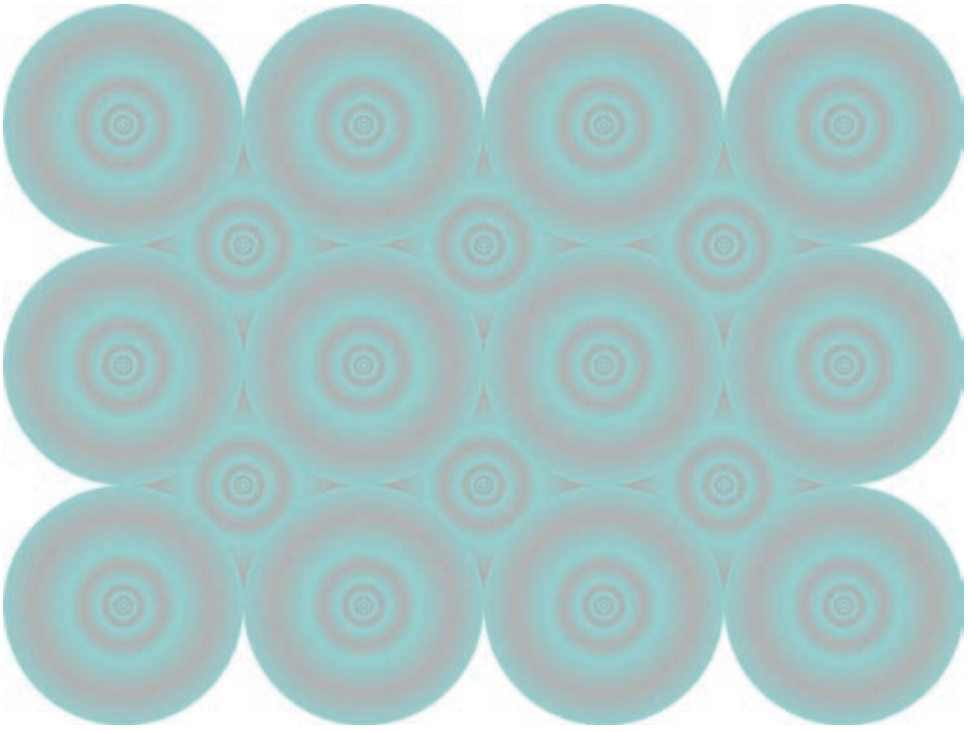
RUBIK'S FOLLY

Rubik's Cube is a three-dimensional puzzle in which the player rotates the tiled faces of a cube until each face shows the same color on all nine tiles. Sound easy? Only if the lighting conditions are stable. As this illusion by Beau Lotto and Dale Purves of Duke University shows, if the lighting changes, it can be hard to know which color is which. The masked version of the illusion (*above, right*) reveals that the blue squares on the left and the yellow squares on the right are actually all gray when viewed under white light. Color perception is not based strictly on the wavelengths of the light that strikes your retina; instead the brain assigns colors based on the lighting conditions and uses the wavelengths only as a guideline to determine which objects are redder or bluer than other objects in the same scene.

EYE SHADOW

It looks like this Japanese *manga* girl has one blue eye and one gray eye. In fact, both eyes are exactly the same shade of gray. The girl's right eye only looks the same as the turquoise hair clip because of the reddish context. Part of the process of seeing color is that three different kinds of photoreceptors in the eye are tuned to three overlapping families of color: red, green and blue (which are activated by visible light of long, medium and short wavelengths). These signals are then instantaneously compared with signals from nearby regions in the same scene. As the signals are passed along to higher and higher processing centers in the brain, they continue to be compared with larger and larger swaths of the surrounding scene. This "opponent process," as scientists call it, means that color and brightness are always relative.

ADAPTED FROM WWW.MOILLUSIONS.COM (*dogs*); DALE PURVES *Duke University* (*cubes*); COURTESY OF AKIYOSHI KITAOKA (*eye shadow*)



RED RINGS

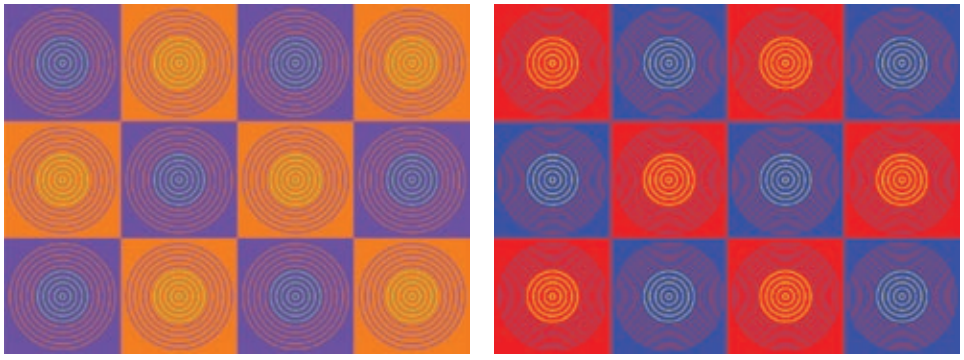
This image by Kitaoka contains a number of blue-green circular structures. The red rings are purely a creation of your brain.

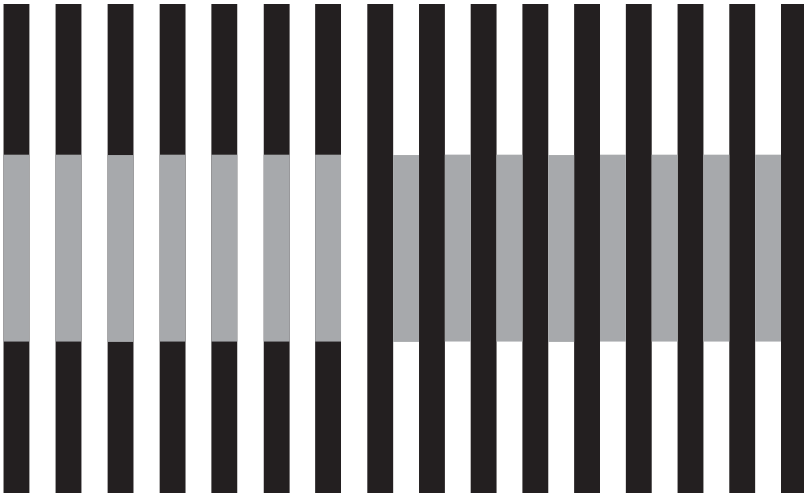
A process called color constancy makes an object look the same under different lighting conditions, even though the color of the light reflecting from the object is physically different. Color constancy is an incredibly important process that allows us to recognize objects, friends and family both in the firelight of the cave and in the bright sun of the savanna.

Because the rings here are drawn in shades of blue, the brain mistakenly assumes that the image is illuminated by blue light and that the physically gray rings inside the blue structures must therefore be reddish. The visual system subtracts the blue "ambient lighting" from the gray rings, and gray minus blue results in a pastel red color.

MULTICOLORED RINGS

Here is another example of how the brain determines color depending on the context. In the bull's-eye structures in the left checkerboard, the center rings look either green or blue, but they are all the same color (turquoise). The center rings in the right checkerboard are all the same shade of yellow. Unlike the previous images, this type of color illusion is difficult to explain by an opponent process because the apparent color of the rings is more similar than dissimilar to the background.



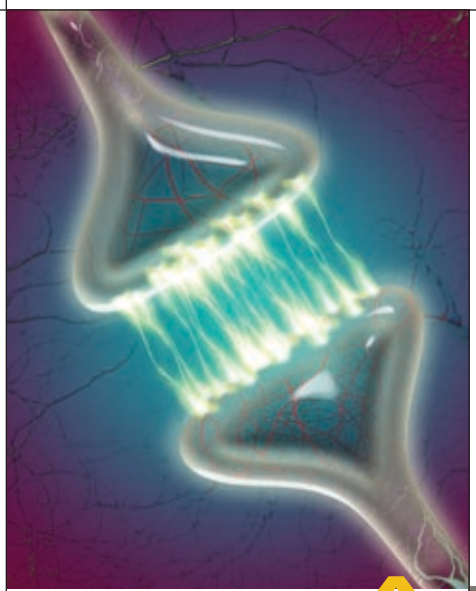


WHITE'S EFFECT

In 1979 Michael White of the Tasmanian College of Advanced Education described an illusion that changed everything in visual science. The gray bars on the left look brighter than the gray bars on the right. In fact, all the gray bars are physically identical. Before White discovered this effect, all brightness illusions were thought to result from opponent processes—that is, a gray object should look dark when surrounded by light and light when surrounded by dark. But in this illusion the lighter-looking gray bars are surrounded by white stimuli, and the darker-looking gray bars are surrounded by black. The brain mechanisms underlying White's effect remain unknown.

COURTESY OF AKIYOSHI KITAOKA

(calendar)



MIKE AGLIOLO *Photo Researchers, Inc.* (*synapse*); AGE FOTOSTOCK (*spice*); ANDREI NACU *iStockphoto* (*eye*); AGE FOTOSTOCK (*hands*)

May

10 What does your brain do when you memorize something? Find out at the monthly **Brains and Behavior Distinguished Lecture Series** hosted by Georgia State University, when biologist Mary Kennedy discusses the complex brain pathways that allow us to create memories. In her lab at the California Institute of Technology, Kennedy has identified and sequenced the structure of individual proteins critical for this pathway, and she is modeling how these molecules help form memories.
Atlanta
http://neuroscience.gsu.edu/lecture_series.html

19–21 Chronic pain can be mentally and physically debilitating. Opioids effectively alleviate pain, but they can be highly addictive. Recently, however, pain researchers discovered a potential way around this problem: they found that implanting opioids under the skin reduced cravings. At the **American Pain Society** annual meeting, attendees will address new treatment options and explore the consequences of pain, such as the possibility of developing mood and sleep disorders or abnormal levels of certain brain hormones, such as dopamine and serotonin.
Austin
www.ampainsoc.org/meeting

June

What do eating curry and suffering from a stroke have in common? Research shows that the curry spice turmeric may have beneficial effects on the brain after a stroke. Scientists at the Salk Institute for Biological Studies recently developed a synthetic derivative of turmeric, which dramatically improved the neurological deficits in animal models of stroke and traumatic brain injury. Canada's **Stroke Month**, sponsored by the Heart and Stroke Foundation, aims to educate people of the signs and treatment for strokes and to promote healthy living as a way to reduce risk.
Canada
www.heartandstroke.com


Turmeric

Ongoing
Eyes are not only windows to the soul; they are also windows to the brain. When information in light hits and enters the eye, however, it is highly distorted and the brain must sort out the confusion. At the New York Hall of Science's exhibit **Seeing the Light**, visitors can use interactive computer displays to experience how humans see and perceive color and light and how optical illusions can fool the human eye.
Queens, N.Y.
www.nysci.org/explore/exhibitions/SeeingLightSummary

● *Compiled by Victoria Stern. Send items to editors@SciAmMind.com*

ROUNDUP

Behind the Human Connection

Explore the neurobiology of the human bond through a museum exhibit, a lecture series and a scientific conference.

Ongoing
Communication has many faces. We can share our ideas, feelings and passions through written and spoken words, artistic expression, subtle gesture and touch. At the Liberty Science Center's **Communication** exhibit, visitors can explore the origins of human language, as well as how the brain responds to a range of words and sounds and how we bond using different modes of self-expression.
Jersey City, N.J.
www.lsc.org

May 10
What motivates students to strive for an A? Why do people experience that midafternoon energy slump during the workday? As part of the **University of California, San Diego, weekly seminar series,** neurobiologist Larry Swanson will describe how neural networks can control our emotional and motivational behaviors. For instance, in recent work, Swanson mapped out pathways in the brain that regulate shifts in our emotions throughout the day.
La Jolla, Calif.
http://neurograd.ucsd.edu/events

June 22–25
Are women more prone to stress than men? Studies appear to say so. Women are twice as likely to suffer from depression, post-traumatic stress disorder and other stress-related issues. And now scientists have revealed a neurological basis for this claim. Neurologists recently discovered that female rats are wired to have greater sensitivity to stress. At the **International "Stress and Behavior" Neuroscience and Biopsychiatry Conference**, participants will discuss the latest findings on this cumbersome emotion, uncovering the wide-reaching effects that stress can have on our neurochemistry, relationships and memory.
New Orleans
www.stressandbehavior.com

The Unleashed Mind

Highly creative people often seem weirder than the rest of us. Now researchers know why

By Shelley Carson

He is one of the world's best known and most successful entrepreneurs, with hundreds of patents to his name—including the Segway scooter. But you will never see Dean Kamen in a suit and tie: the eccentric inventor dresses almost exclusively in denim. He spent five years in college before dropping out, does not take vacations and has never married. Kamen presides (along with his Ministers of Ice Cream, Brunch and Nepotism) over the Connecticut island kingdom of North Dumpling, which has "seceded" from the U.S. and dispenses its own currency in units of pi. Visitors are issued a visa form that includes spaces on which to note identifying marks on both their face and buttocks.

Kamen, who works tirelessly at inspiring kids to pursue careers in science and engineering, is one of many highly creative people whose personal behavior sometimes strikes others as odd. Albert Einstein picked up cigarette butts off the street to get tobacco for his pipe; Howard Hughes spent entire days on a chair in the middle of the supposedly germ-free zone of his Beverly Hills Hotel suite; the composer Robert Schumann believed that his musical compositions were dictated to him by Beethoven and other deceased luminaries from their tombs; and Charles Dickens is said to have fended off imaginary urchins with his umbrella as he walked the streets of London. More recently, we have seen Michael Jackson's preoccupation with rhinoplasty, Salvador Dalí's affection for dangerous pets and the Icelandic singer Björk dressed for the Oscars as a swan.

It isn't just average Joes who perceive highly creative individuals as eccentric. These individuals often see themselves as different and unable to fit in. The latest findings in brain imaging, creativity research and molecular biology suggest that these perceptions are not just based on a few anecdotal accounts of "weird" scientists and artists. In fact, creativity and eccentricity often go hand in hand, and researchers now believe that both traits may be a result of how the brain filters incoming information. Even in the business world, there is a growing appreciation of the link between creative thinking and unconventional behavior, with increased acceptance of the latter.

FEDERICO JORDÁN *Corbis*

Eccentric people may inherit the unconventional modes of thinking and perceiving associated with schizophrenia without inheriting the disease itself.

Making the Connection

The incidence of strange behavior by highly creative individuals seems too extensive to be the result of mere coincidence. As far back as ancient Greece, both Plato and Aristotle made comments about the peculiar behavior of poets and playwrights. (Aristotle was also the first to note the relation between creativity and depression, an association that has been substantiated by modern research.) More than a century ago Italian criminologist Cesare Lombroso catalogued the bizarre behavior of creative luminaries in his book *The Man of Genius* and attributed this behavior to the same hereditary "degeneration" that marked violent criminals.

In the past few decades psychologists and other scientists have explored the connection using empirically validated measures of both creativity and eccentricity. To measure creativity, researchers may look at an individual's record of creative achievements, his or her involvement in creative activities or ability to think creatively (for example, to come up with new uses for ordinary household items). To measure eccentricity, researchers often use scales that assess schizotypal personality.

Schizotypal personality can appear in a variety of forms, including magical thinking (fanciful ideas or paranormal beliefs, such as Schumann's belief that Beethoven channeled music to him from the grave), unusual perceptual experiences (distortions in perception, such as Dickens's belief that he was being followed by characters from his novels), social anhedonia (a preference for solitary activities—Emily Dickinson, Nikola Tesla and Isaac Newton, for example, favored work over socializing), and mild paranoia (unfounded feelings that people or objects in the environment may pose a threat, such as Hughes's legendary distrust of others).

Schizotypal personality is a milder version of the clinical psychiatric condition called schizotypal personality disorder, which is among a cluster of personality disorders labeled "odd or eccentric" in the American Psychiatric Association's *Diagnostic and Statistical Manual of Mental Disorders*. The schizotypal diagnosis grew out of large epidemiological studies in which researchers noticed that the relatives of individuals diagnosed with schizophrenia were more likely to exhibit odd behaviors and beliefs than relatives of those not afflicted with schizophrenia. Schizotypal people, for instance, may dress in an idiosyncratic style; their speech patterns may be somewhat out of the ordinary; they may respond ineptly in social situations; their emotional responses may be inappropriate; they may believe in supernatural phenomena such as telepathy and omens; and they may be hard to get close to—both physically and emotionally. In short, schizotypal individuals are eccentric.

Not all schizotypal people have a personality disorder, however. They are often very high functioning, talented and intelligent. Many of my students at Harvard University, for example, score far above average on schizotypal scales, as well as on creativity and intelligence measures.

Nature or Nurture?

The first scientific evidence of a connection between schizotypal personality and creativity came from a 1966 study by American behavioral geneticist Leonard Heston. In this classic study, Heston reported that children adopted away from their schizophrenic biological mothers at birth were more likely to pursue creative careers and interests than children adopted away from non-afflicted mothers (thus lending support for Lombroso's theory that the bizarre behaviors that often accompany creativity are inherited).

Harvard researcher Dennis Kinney and his team replicated Heston's study 40 years later and suggested that schizotypal individuals may inherit the unconventional modes of thinking and perceiving associated with schizophrenia without inheriting the disease itself. In this study, Kinney and his colleagues rated 36 adopted offspring of schizophrenic parents and 36 matched control subjects adopted from nonschizophrenic parents using the Lifetime

FAST FACTS

Creative Eccentrics

1» **People who are highly creative often have odd thoughts and behaviors—and vice versa.**

2» **Both creativity and eccentricity may be the result of genetic variations that increase cognitive disinhibition—the brain's failure to filter out extraneous information.**

3» **When unfiltered information reaches conscious awareness in the brains of people who are highly intelligent and can process this information without being overwhelmed, it may lead to exceptional insights and sensations.**

Known for their quirks as well as their accomplishments (*clockwise from upper left*): Emily Dickinson, Dean Kamen, Albert Einstein, Björk, Charles Dickens, Michael Jackson, Isaac Newton, Howard Hughes and Salvador Dalí.

BETTMANN/CORBIS (*Dickinson, Dickens and Hughes*); KEVIN COOLEY *Redux Pictures (Kamen)*; HULTON-DEUTSCH COLLECTION/CORBIS (*Einstein*); REUTERS/CORBIS (*Björk*); STEVE AZZARA *Corbis/Sygma (Jackson)*; CORBIS (*Newton*); PATRICK GUIS *Kipa/Corbis (Dalí)*

Creativity Scales. They found that the adopted offspring of schizophrenic individuals who themselves displayed signs of schizotypal personality had higher scores for creativity than the control subjects. The Kinney group also made a new discovery: some of their control subjects who did not have a family history of schizophrenia met the profile for schizotypal personality—and they too scored higher for creativity than other control subjects.

Taking the reverse approach, recent studies by British investigator Daniel Nettle and Australian researchers David Rawlings and Ann Locarnini have confirmed that creative individuals tend to score higher on scales of schizotypal personality than less creative individuals. In my research at Harvard, done in part with my colleague Cynthia A. Meyersburg, I have found that study participants who score high in a measure of creative achievement in the arts are more likely to endorse magical thinking—such as belief in telepathic communication, dreams that portend the future, and memories of past lives. These participants are also more likely to attest to unusual perceptual experiences, such as having frequent déjà vu and hearing voices whispering in the wind.

In two reviews of schizotypy and creativity—published in 1989 and 1997, respectively—both Robert Prentky, now a forensic psychologist at Fairleigh Dickinson University, and J. H. Brod of the University of Oxford concluded that not only do highly creative people display more of the traits associated with schizotypy but that the combination of creativity and schizotypy tends to run in families, again pointing toward a genetic component.

How could weird thoughts and behaviors enhance a person's ability to think creatively? My research suggests that these manifestations of schizotypal personality in and of themselves do not promote creativity; certain cognitive mechanisms that may underlie eccentricity could also promote creative thinking, however. In my "shared vulnerability" model of how creativity and eccentricity are related, I theorize that one of these underlying mechanisms is a propensity for cognitive disinhibition.

Too Much Information

Cognitive disinhibition is the failure to ignore information that is irrelevant to current goals or to survival. We are all equipped with mental filters that hide most of the processing that goes on in our brains behind the scenes. So many signals come in through our sensory organs, for example, that if we paid attention to all of them we would be overwhelmed. Furthermore, our brains are constantly accessing imagery and memories stored in our mental files to process and decode incoming information. Thanks to cognitive filters, most of this input never reaches conscious awareness.

There are individual differences in how much information we block out, however; both schizotypal and schizophrenic individuals have been shown to

(The Author)

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Reduced cognitive filtering could explain the tendency of highly creative people to focus intensely on their inner world at the expense of social and even self-care needs.

have reduced functioning of one of these cognitive filters, called latent inhibition (LI). Reduced LI appears to increase the amount of unfiltered stimuli reaching our conscious awareness and is associated with offbeat thoughts and hallucinations. It is easy to see that allowing unfiltered information into consciousness could lead to strange perceptual experiences, such as hearing voices or seeing imaginary people.

Cognitive disinhibition is also likely at the heart of what we think of as the aha! experience. During moments of insight, cognitive filters relax momentarily and allow ideas that are on the brain's back burners to leap forward into conscious awareness, in the same manner that bizarre thoughts surface in the mind of the psychotic individual. Consider this example from Sylvia Nasar's 1998 book *A Beautiful Mind,* about Nobel Prize winner (and diagnosed with schizophrenia) John Forbes Nash. When asked why he believed that aliens from outer space were contacting him, he responded: "Because the ideas I had about supernatural beings came to me the same way that my mathematical ideas did. So I took them seriously." (Nash's case illustrates how the cognitive mechanism of the eureka moment is similar to the delusional experience called thought insertion, in which individuals suffering from psychosis believe that outside forces have placed thoughts in their brains. Most people suffering from psychosis or schizophrenia do not produce ideas that are considered creative, however. The ability to use cognitive disinhibition in a creative way depends on the presence of additional cognitive abilities associated with a high level of functioning.)

Reduced cognitive filtering could explain the tendency of highly creative people to focus intensely on the content of their inner world at the expense of social or even self-care needs. (Beethoven, for example, had difficulty tending to his own cleanliness.) When conscious awareness is overpopulated with unusual and unfiltered stimuli, it is difficult *not* to focus attention on that inner universe.

In 2003 my colleague Jordan Peterson and I reported on research we conducted at Harvard and the University of Toronto, where we found that highly creative individuals are more likely to display cognitive disinhibition when compared with those who are less creative. In a series of studies, we tested several hundred subjects on a latent inhibition task (a measure of how easily subjects ignore stimuli to which they have already been exposed). We also measured creativity in several different ways, including divergent thinking tasks (which require a large number of responses or solutions to a problem), openness to experience (the personality trait most highly predictive of creativity), the Creative Personality Scale, and the Creative Achievement Questionnaire (a measure of lifetime creative achievement). When we looked at high scorers on each of these creative measures, we found that they were more likely to have lower scores on the latent inhibition task (indicating cognitive disinhibition) than were the less creative subjects. We think that the reduction in cognitive inhibition allows more material into conscious awareness that can then be reprocessed and recombined in novel and original ways, resulting in creative ideas.

People who score high for creative achievement in the arts are more likely to believe in telepathic communication, dreams that foretell the future, and past lives.

GETTY IMAGES

Brain-imaging and electroencephalography (EEG) studies support the theory that highly creative individuals tend to experience more cognitive disinhibition than do less-creative control groups. Beginning in the late 1970s, researcher Colin Martindale of the University of Maine initiated a series of EEG studies related to creativity. He and his colleagues found that highly creative people tend to produce more brain waves in the alpha range (a frequency of eight to 12 hertz, or cycles per second) during creative tasks than do less creative people. Martindale and his group interpreted alpha power as a marker of decreased cortical arousal and defocused attention and suggested that creative people were allowing more information into their conscious awareness during creative work.

Andreas Fink and his group at the University of Graz in Austria, who replicated Martindale's findings in a set of studies over the past five years, have a different interpretation of the increased alpha waves associated with creativity. They say increased alpha activity indicates that the brain is focusing on internally generated stimuli rather than on the outside world. This interpretation explains the tendency of creative people to focus on their inner lives, which is also a sign of schizotypal personality.

Other brain research, published in 2009 by John Kounios of Drexel University and Mark Beeman of Northwestern University, has examined the aha! moment in greater detail. Kounios and Beeman had subjects solve word-association problems while their brain patterns were recorded using either functional magnetic resonance imaging or EEG. (For example, think of a word that can form a compound word with all three of the following words: crab, pine, sauce. The answer is "apple.") Subjects signaled the exact moment the answer came to them, and whether they had come to the solution through trial and error or in a sudden rush of insight. The results indicate that a period of alpha activity precedes a burst of gamma activity (characterized by brain waves in the bandwidth above 40 Hz) at the moment of insight. Kounios and Beeman surmise that alpha activity focuses attention inward, whereas the gamma burst coincides with the arrival of the solution into conscious awareness.

Another brain-imaging study, done in 2010 by investigators at the Karolinska Institute in Stockholm, suggests the propensity for both creative insights and schizotypal experiences may result from a specific configuration of neurotransmitter receptors in the brain. Using positron-emission tomography, Örjan de Manzano, Fredrik Ullén and their colleagues examined the density of dopamine D2 receptors in the sub-

RICHARD MORRELL *Corbis*

Are You a Creative Eccentric?

To explore the connection between creativity and eccentricity, researchers often use questionnaires that ask about personal experiences and traits. Answer yes or no to each of these sample questions:

1. Do you often have ideas without knowing where they came from?
2. Do you consider yourself a highly logical person?
3. Do you often think or speak using metaphors?
4. Do you have a broad range of interests?
5. Do you have trouble spending time alone without turning on the TV or other electronic devices?
6. Do you believe in telepathic communication?
7. Have you ever felt the presence of someone in the room with you when you knew you were alone?
8. Do you believe that your dreams may sometimes be previews of future events?
9. Do you believe that certain events or objects are signs that may have been provided to help you make important decisions?
10. Do you believe there may be forces at work in the world that cannot be detected with scientific instruments?
11. Do you often feel like a square peg in a round hole?

Scoring

Count the number of yes answers for questions 1, 3 and 4. Add those to the number of no answers for questions 2 and 5. Higher scores (up to a maximum of 5) are more indicative of creative thinking patterns.

Now count the number of yes answers for questions 6 through 10. Higher scores make it more likely that you have schizotypal personality, which is associated with odd or eccentric behavior.

People who score high on the first five questions tend to also score high on the second set of questions. A yes answer to question 11 is related to both creative thinking and schizotypal personality.

The ascendancy of innovative technology as a key factor in economic growth has elevated creativity from merely a positive trait to a highly sought-after commodity.

cortical region of the thalamus in 14 subjects who were tested for divergent-thinking skills. The results indicate that thalamic D2 receptor densities are diminished in subjects with high divergent-thinking abilities, similar to patterns found in schizophrenic subjects in previous studies. The researchers believe that reduced dopamine binding in the thalamus, found in both creative and schizophrenic subjects, may decrease cognitive filtering and allow more information into conscious awareness.

Several studies have linked gene variations that are associated with the neurotransmitter dopamine to both creativity and eccentricity. Hungarian researcher Szabolcs Kéri, who reported in 2009 that highly creative achievers were more likely to have a variant of the *neuregulin 1* gene previously associated with schizophrenia, speculated that this gene variation facilitates cognitive disinhibition. These findings support the theory that cognitive disinhibition may be affected by genetic variations and that it may be one factor that predisposes an individual to both creative thought and eccentricity.

The Importance of Intelligence

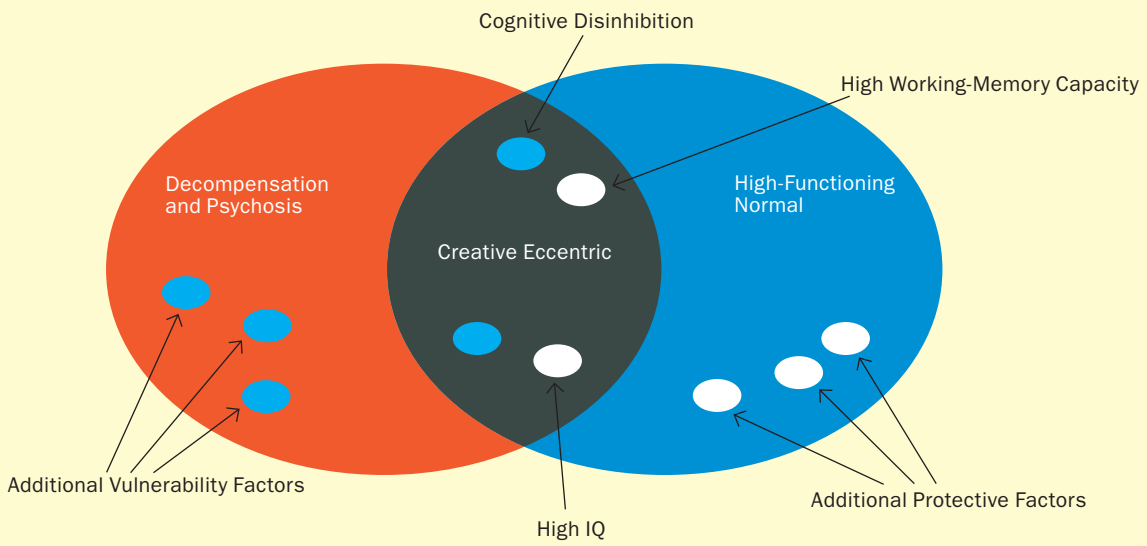
Clearly, however, not all eccentric individuals are creative. Work from our lab indicates that other cognitive factors, such as high IQ and high working-memory capacity, enable some people to process and mentally manipulate extra information without being overwhelmed by it. Through a series of studies, we have, in fact, shown that a combination of lower cognitive inhibition and higher IQ is associated with higher scores on a variety of creativity measures.

The shared vulnerability model suggests that at least a subgroup of highly creative individuals may share some (but not all) biological vulnerability factors with individuals who suffer from psychotic illnesses, such as schizophrenia. This vulnerability may allow the highly creative person access to ideas and thoughts that are inaccessible to those of us with less porous mental filters.

For several years I have included a question in my creativity research that asks "Do you often feel

The Shared Vulnerability Model

In the author's model of why creativity and eccentricity often coincide, the oval at the left represents people whose biological vulnerability factors (gene variations, for example) impair their ability to filter out unusual thoughts and may (given enough of these vulnerabilities) even cause psychotic illnesses. The oval at the right represents high-functioning normal people, whose biological makeup helps to protect them from mental illnesses. At the intersection of these two groups lie creative eccentrics, whose high IQ and high working-memory capacity help to shield them from being overwhelmed by a flood of bizarre thoughts and sensations and instead allow them to use those stimuli as inspiration for great works of art and science.



Training programs can help stimulate creative thinking.

like a square peg in a round hole?" Participants who score high on the Creative Achievement Questionnaire have answered "yes" significantly more often than those who have low scores in creative achievement. In fact, one participant—a Hollywood screenwriter—answered "no" but then wrote below the question: "I don't feel like a square peg trying to fit into a round hole. I feel like an octagonal peg with conical appendages."

The good news is that the plight of square pegs may be improving. The ascendancy of innovative technology as a key factor in economic growth has elevated creativity from merely a positive trait to a highly sought-after commodity in the global market. Many leading corporations—such as Coca Cola, DuPont, Citigroup and Humana—now have chief innovation officers on their leadership teams. Prestigious business schools—such as Harvard, Stanford, Columbia and Yale—have added courses on creativity to their curricula. And Fortune 500 companies, including PepsiCo, Bristol-Meyers Squibb, Aetna and Marriott, now routinely put employees through creativity training programs. Trainers in these classes use a variety of tools and techniques to help noneccentrics open their minds to "out of the box" thoughts and stimuli that might otherwise be ignored or suppressed.

As the market value of creative thinking increases, the round-hole world may continue to make adjustments to accommodate and assimilate eccentrics. Such accommodations already exist in communities with high concentrations of artists, writers, scientists and computer geeks. Managers within these communities tolerate bizarre clothing choices, disregard of normal social protocols and nontraditional work schedules in the interest of promoting innovation. At Dean Kamen's company, Deka Research & Development, for example, not only is denim well accepted but employees are allowed—even expected—to solve problems and complete tasks in whatever way works best for them.

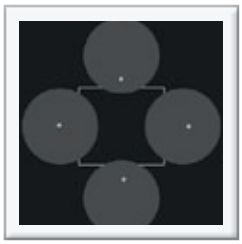
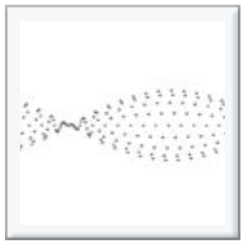
Square pegs (and octagonal pegs with conical appendages) no longer have to work so hard at fitting in. It is high time. Indeed, we all owe a deep debt of gratitude to those whose creative work has been accomplished at the expense of square-peg feelings of alienation and ostracism. The creative efforts of eccentrics add richness, beauty and innovation to the lives of those of us who have fit somewhat more comfortably into our round holes. M

➥For tips on how to maximize your own creativity and imagination, see slide show at **Scientific American.com/mind/may2011/creativity**

(Further Reading)

- **Creativity in Offspring of Schizophrenic and Control Parents: An Adoption Study.** D. K. Kinney, R. Richards, P. A. Lowing, D. LeBlanc, M. E. Zimbalist and P. Harlan in *Creativity Research Journal,* Vol. 13, No. 1, pages 17–25; January 2001.
- **Decreased Latent Inhibition Is Associated with Increased Creative Achievement in High-Functioning Individuals.** S. H. Carson, J. B. Peterson and D. M. Higgins in *Journal of Personality and Social Psychology,* Vol. 85, No. 3, pages 499–506; September 2003.
- **The *Aha!* Moment: The Cognitive Neuroscience of Insight.** J. Kounios and M. Beeman in *Current Directions in Psychological Science,* Vol. 18, No. 4, pages 210–216; August 2009.
- **Genes for Psychosis and Creativity: A Promoter Polymorphism of the *Neuregulin 1* Gene Is Related to Creativity in People with High Intellectual Achievement.** S. Kéri in *Psychological Science,* Vol. 20, No. 9, pages 1070–1073; 2009.
- **Thinking Outside a Less Intact Box: Thalamic Dopamine D2 Receptor Densities Are Negatively Related to Psychometric Creativity in Healthy Individuals.** Ö. de Manzano, S. Cervenka, A. Karabanov, L. Farde and F. Ullén in *PLoS One,* Vol. 5, No. 5, page e10670; 2010.
- **Creativity and Psychopathology: A Shared-Vulnerability Model.** S. H. Carson in *Canadian Journal of Psychiatry,* Vol. 56, No. 3, pages 144–153; 2011.

GETTY IMAGES

10 TOP ILLUSIONS

Balls that roll uphill, bathtubs that stretch and shrink, freaky faces and throbbing hearts. Welcome to the year's best visual tricks

By Susana Martinez-Conde and Stephen L. Macknik

A Japanese miner climbs onto the stage, his helmet light bobbing and a pickax slung over his shoulder. He swings the pick a few times before kneeling to inspect something unusual and then worries at some loose rubble with his hands. Suddenly his face lights up, and he turns to the audience, his newfound riches held forward in his open hands. "I have discovered a new supermagnet that attracts wood," he announces. Okaaaay....

A video begins playing overhead, and the audience sees four wood balls rolling uphill in open defiance of the laws of gravity. Pulled by a magnet? Not really. The "miner" is mathematical engineer Kokichi Sugihara of the Meiji Institute for Advanced Study of Mathematical Sciences in Kawasaki, Japan, and his magnetlike slopes illusion is the winner of the 2010 Best Illusion of the Year Contest. The trick is exposed when the video shows Sugihara's slopes from a different vantage point: the wood balls are actually rolling down, not up. The slopes are cleverly designed to produce the antigravity illusion when seen from a specific point of view.

Sugihara's invention exemplifies several of the most popular themes in illusions today. It relies not only on a trick of perspective but also on perceptual ambiguity. There is more than one way to perceive the "magnetic" slopes, but our visual system's expectations make us prefer one interpretation—and illusions are a way to fool the brain into revealing those systems. "We are surrounded by many industrial products that are made with right angles, such as desks, boxes and buildings," Sugihara explains. When confronted with an image in which multiple interpretations are possible, we choose the version that allows us to see rectangular solids. In Sugihara's prizewinning illusion, none of the columns that support the ramps are vertical. Yet we interpret them all as perfectly straight.

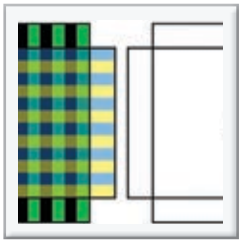
As with many of the newest illusions, Sugihara's impossible-motion demonstration is dynamic: to fully appreciate the magic, you need to see the balls moving. Al-

AND THE WINNER IS ... Mathematical engineer Kokichi Sugihara (*far left*) raises his pickax in victory as the master of ceremonies, vision scientist Stuart Anstis of the University of California, San Diego, announces the winner of the 2010 Best Illusion of the Year Contest. *Scientific American* was the premier sponsor of the contest.

MAKING MAGIC James Randi (*left*)—magician, escape artist and skeptic known as the Amaz!ng Randi—demonstrated magic tricks during the vote counting at the 2010 illusion contest. On hand to help was cognitive psychologist Daniel J. Simons (*right*), author of the monkey business illusion.

KOKICHI SUGIHARA (*magnetlike slopes*); BART ANDERSON (*counterintuitive illusory contours*); JAN KREMLACEK (*two sinusoids: 6–1 perceptions*); LYDIA MANIATIS (*stretching out in tub*); PETER MEILSTRUP AND MICHAEL SHADLEN (*steerable spiral*); ALAN STUBBS (*finalists and Randi/Simons, bottom*)




DANIEL SIMONS (*monkey business*); KOHSKE TAKAHASHI, RYOSUKE NIIMI AND KATSUMI WATANABE (*blurry heart*); PETER THOMPSON (*fat face thin*); PETER TSE (*attention-biased afterimage rivalry*); MAARTEN WIJNTJES AND SYLVIA PONT (*illusory gloss*); KOKICHI SUGIHARA (*magnetlike slopes, bottom*)

though illusionists continue to produce classical illusions using still photographs or even just a few lines on paper, computer and video technologies have made it possible to create increasingly complex moving-picture illusions. Several of the top 10 illusions of 2010 are animations that cannot be shown here, but you can see them in action at http://illusionoftheyear.com.

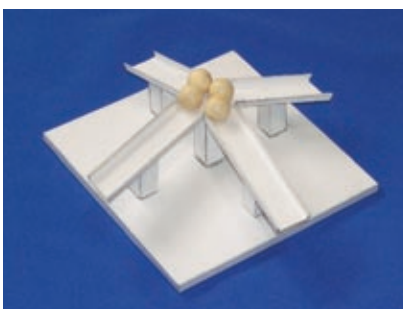
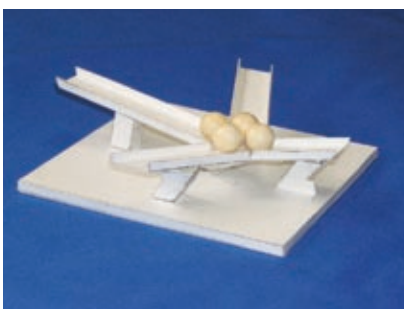
Because illusions enable us to see things that do not match physical reality, they are critically important to understanding the neural mechanisms of perception and cognition. The annual Best Illusion of the Year Contest celebrates the inventiveness of illusion creators around the world: researchers, software engineers, mathematicians, magicians, graphic designers, sculptors and painters fascinated with mapping the boundaries of human perception.

Whereas scientists once created illusions from simple lines and shapes and artists focused on making eye-popping illusions, the overlap between science and art is now greater than ever. Scientists are using graphic-design tools to make their illusions more artistic, and artists have grown more knowledgeable about the neuroscience behind the magic.

Illusions competing in the contest must be novel—that is, previously unpublished or published no earlier than the year preceding the contest. An international panel of experts selects the 10 illusions that are the most counterintuitive, spectacular, beautiful and significant to the understanding of the human mind and brain. The creators are invited to present their awe-inspiring brain twisters at an awards gala where the audience votes to choose the first-, second- and third-place winners: the "Oscars" of illusion.

Anyone can submit an illusion to the contest, which is sponsored by *Scientific American*. Instructions are posted at http://illusionoftheyear.com/submission-instructions. The 2011 event is scheduled for Monday, May 9, at the Philharmonic Center for the Arts in Naples, Fla. Please join us and vote for the best illusion of the year! **M**

SUSANA MARTINEZ-CONDE and STEPHEN L. MACKNIK are laboratory directors at the Barrow Neurological Institute in Phoenix. They are authors of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee, and serve on *Scientific American Mind*'s board of advisers.

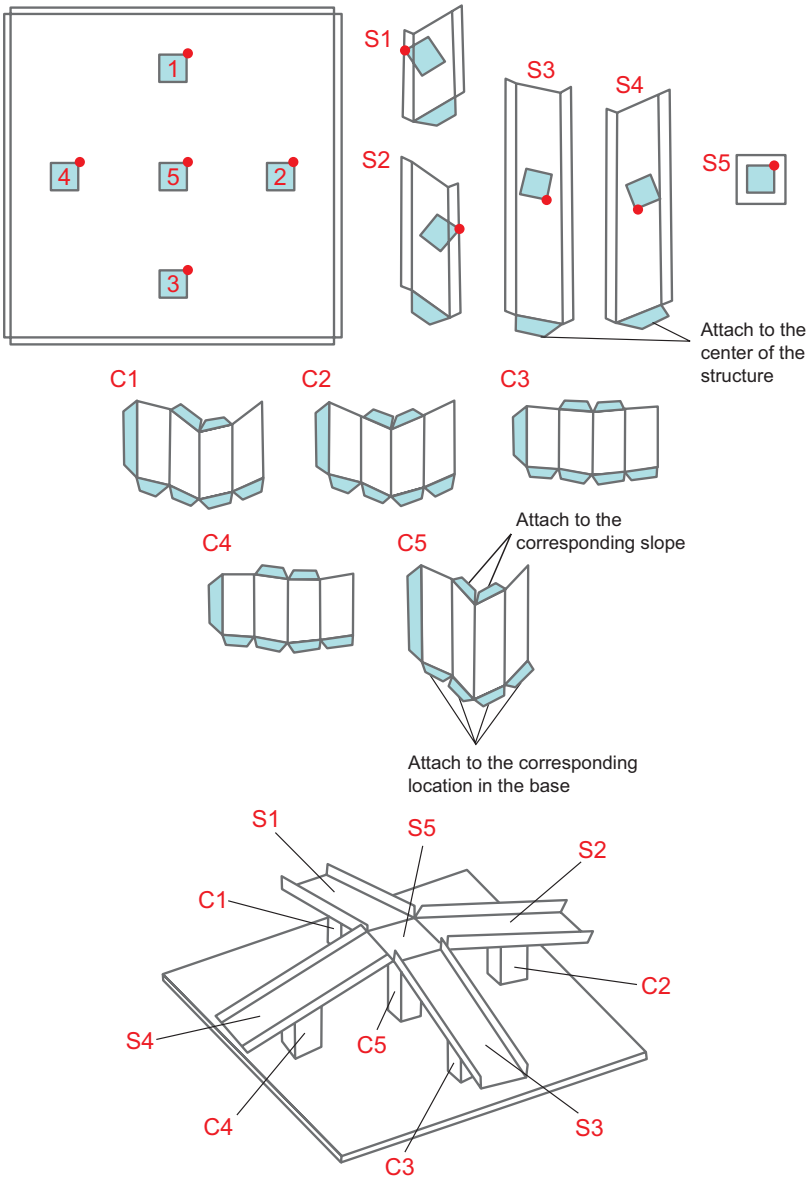




1st Place

Impossible Motion

In the magnetlike slopes illusion, wood balls appear to roll up four ramps in defiance of gravity. In reality, the balls roll down the ramps, but when viewed from a specific vantage point the configuration of the supporting columns makes it look like the center column is the tallest.

Japanese mathematical engineer Kokichi Sugihara discovered the illusion using a computer program designed to read 3-D line drawings. He tested the program by feeding it images of impossible, Escher-esque objects. He expected the program to respond with an error message; instead the software interpreted some of the images as peculiar 3-D solids. Sugihara assumed he had a bug in his code but soon realized that the software was recognizing objects that were only impossible from a certain point of view. Delighted, he set out to construct the actual objects and added motion later to enhance the illusion. You can watch an animation of the illusion at http://illusionoftheyear.com/2010/impossible-motion-magnet-like-slopes.



Make Your Own Magnetlike Slopes

You can make your own gravity-defying slopes at home. Print the patterns on heavy paper or cardstock, cut out the individual parts (base, columns and slopes) and fold them as shown.

Assemble the parts by gluing the slopes to the corresponding columns and then gluing the columns to the base in the positions shown. For example, column C1 should be glued to slope S1 and then mounted on the base at position 1. Glue the columns to the slopes at the angles indicated by the square tab drawn on the rear center of each slope. The glued edge of each column should be positioned at the corner indicated by the red dot on both the corresponding slope and the base. Columns C1 and C2 should extend partly beyond the outside edges of slopes S1 and S2. The columns should lean, and all four slopes should be almost horizontal with a very gentle tilt toward the center (as shown in the photograph on the bottom right of the preceding page, where slope S1 is at the right).

Rotate the structure until you find the viewpoint from which all five columns look parallel (with the corner of the base between columns C3 and C4 closest to you). Then amaze your friends by rolling balls or marbles up the ramp. Hint: The effect is stronger if you close one eye.

➥For more instructions on how to create this illusion yourself, visit **ScientificAmerican.com/mind/may2011/magneticslopes**

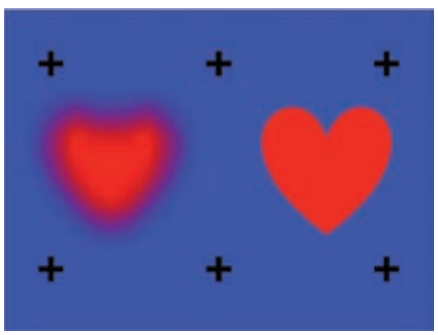
FAST FACTS

Seeing Is Believing

1» **Because illusions trick us into seeing things that do not match physical reality, they give us insights into how our brain works.**

2» **Classical illusions rely on simple lines and shapes, but computer and video technologies are making it possible to create increasingly complex moving-picture illusions.**

3» **The Best Illusion of the Year Contest finds the top 10 illusions created by scientists and artists.**



Be Still My Heart

The blurry heart illusion is simple yet powerful. Shifting your gaze from one cross to the next makes the blurry heart wobble, but the heart with sharp contours remains stationary. The blurred edges appear to move in a direction opposite to your eye movement. Created by vision scientists Kohske Takahashi, Ryosuke Niimi and Katsumi Watanabe of the University of Tokyo, this illusion works because the blurred edges—when viewed with your peripheral vision—activate motion-detecting neurons as you move your eyes around on the page. Placing a red heart on a blue background enhances the effect, for reasons that are still unknown. "The illusion is so simple, and the illusory effect so large and robust, that we were surprised nobody had reported this illusion previously," its creators explain.

ILLUSTRATION BY MELISSA THOMAS; COURTESY OF XOANA G. TRONCOSO AND KOKICHI SUGIHARA (*instructions*); FROM "ILLUSORY MOTION INDUCED BY BLURRED RED-BLUE EDGES," BY K. TAKAHASHI, R. NIIMI AND K. WATANABE, IN *PERCEPTION*, VOL. 39, 2010 (*heart*)

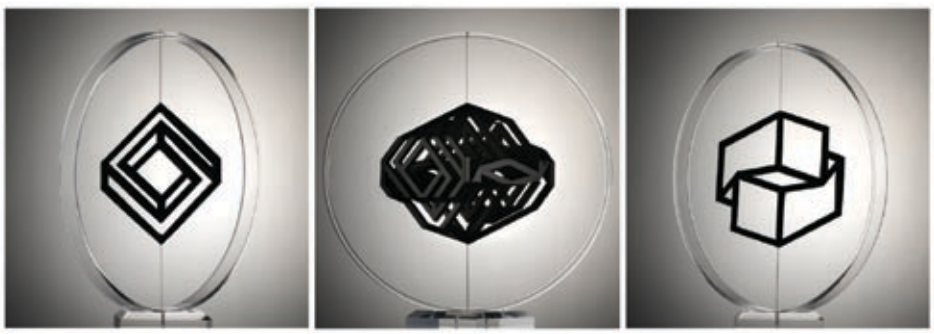
Six in One

The third-place winner in the 2010 illusion contest relies on perceptual ambiguity. "Our brain is able to reconstruct different learned interpretations, but only one can be perceived [at any given moment]," explains Jan Kremlacek of Charles University in Prague, who created the illusion he calls two sinusoids: 6–1 perceptions. Kremlacek combined stationary and moving sinusoids in an animation that can be perceived in any of six different ways: for example, as a rotating double helix, a waving ribbon, or a set of dots bouncing up and down. You can view it at http://illusionoftheyear.com/2010/two-sinusoids-6-1-perceptions.

Kremlacek's illusion is too dynamic to show here, but it harks back to a simple sketch by English artist W. E. Hill entitled *My Wife and My Mother-in-Law,* which was reproduced in the magazine *Puck* in 1915 and described in 1930 by experimental psychologist Edwin Boring of Harvard University. In Boring's words, the drawing (*above, left*) "shows in one figure the left profile of a young woman, three-quarters from behind. The other figure is an old woman, three-quarters from the front. The ear of the 'wife' is the left eye of the 'mother-in-law'; the left eyelash of the former is the right eyelash of the latter; the jaw of the former is the nose of the latter; the neck-ribbon of the former, the mouth of the latter."

Boring's vivid description of the equivocal face launched a thousand experiments in perceptual alternation. Almost 40 years later vision scientist Gerald H. Fischer of Newcastle University in England introduced a third figure, representing a father, to create a triple-ambiguous image (*above, right*).

Pushing the multiambiguity envelope further, Gideon Caplovitz and Peter Tse of Dartmouth College created a four-way illusion in 2006. You can see it at http://illusionoftheyear.com/2006/the-bar-cross-ellipse-illusion. That record stood until Kremlacek created his six-in-one sinusoids.



GUIDO MORETTI (*trophies*); LYDIA MANIATIS (*tubs*)

The "Oscars" of Illusions

The first-, second- and third-place winners of the contest receive trophies designed by Italian sculptor Guido Moretti. Fittingly, the "Guidos" are beautiful illusions themselves. For example, Moretti's ambiguous and impossible trophy shown here can look like three different structures, depending on the viewer's vantage point. "My sculptures are like no other known geometrical solid, but they look just like a cube, a pyramid or another known or absurd solid," Moretti says. "This means that three observers at three different points would see three different solids."

The Long and Short of It

Perceptual ambiguity also lies at the heart of an illusion called stretching out in the tub. From one vantage point, the tub looks long and narrow. But viewed from another angle, it is smaller and squarer.

As with Sugihara's gravity-defying slopes, the tub illusion depends on the viewer's false assumptions about perspective. And like Sugihara, vision researcher Lydia Maniatis of American University in Washington, D.C., discovered the effect serendipitously. Walking down the street one day, she noticed an odd effect as she passed a bathtub company's billboard: as she proceeded from one end of the huge image to the other, the bathtub seemed, impossibly, to stretch and shrink. Intrigued, she walked past the street-level ad again and again, focusing on the dramatic changes in the appearance of the tub.

From one end, the foreshortened tub looked like a large sink. But as Maniatis approached the far end, the tub percept slowly dominated. Her visual system made assumptions about the identity of the object from each angle, giving rise to a different 3-D percept at each location along the image.

For her contest entry, Maniatis re-created the illusion using a different bathtub picture. You can see her entry, along with a video of the billboard that inspired it, at http://illusionoftheyear.com/2010/stretching-out-in-the-tub.

The Invisible Gorilla

In a famous experiment done in 1999, Daniel J. Simons and Christopher F. Chabris, both then at Harvard University, asked subjects to watch two groups of people dribbling and passing a basketball among themselves. Three players wore white shirts; three wore black. The watchers were asked to count the number of passes by the players in white shirts. About halfway through the exercise, a person wearing a gorilla suit walked into the ball-passing scene, beat its chest while facing the camera, then walked out. Simons and Chabris were shocked to discover that 50 percent of the people counting passes failed to notice the gorilla. Their spectacular demonstration became an instant classic, spreading like wildfire to conferences, university courses and textbooks. It is an excellent example of attention bias, a phenomenon in which the brain ignores information that is not relevant to its current task.

The gorilla illusion is so well known that Simons, now at the University of Illinois, decided to create a variation for the 2010 illusion contest. He appeared at the gala dressed as a gorilla, flinging bananas to the audience before he took the stage. "You are all good vision scientists," he said. "You know that when people are passing basketballs, you should be looking for gorillas." The audience roared with laughter at the inside joke. People can only experience the invisible gorilla illusion once. After you know to look for a gorilla, you never miss it again.

Does knowledge of the impending occurrence of unexpected events help you detect other unexpected events? Simons's latest demonstration, called the monkey business illusion, shows the answer to be no. People who know to look for a gorilla are of course more likely to spot the gorilla, but the gorilla is not truly unexpected. These same expert viewers will fail to notice other unexpected events even more than viewers who are unfamiliar with the task.

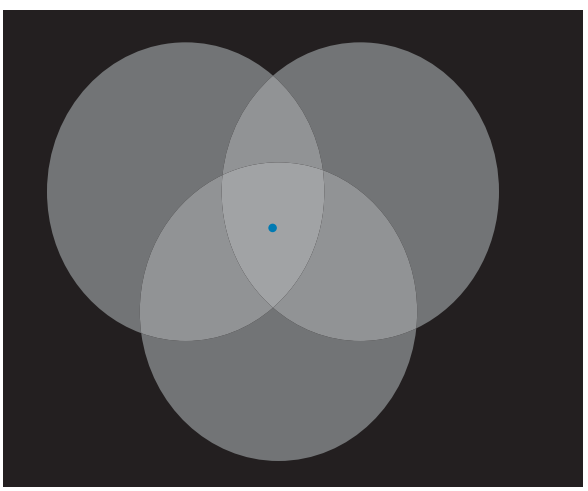
The harder you pay attention during a task, the more powerfully your visual system suppresses distracting information, as we have shown in experiments conducted with neuroscientist Jose-Manuel Alonso and his colleagues at the State

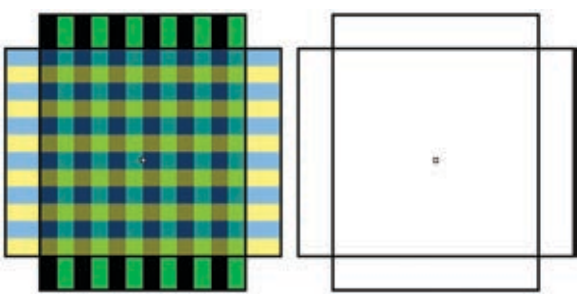
Attention to Afterimages

At the 2005 illusion contest Tse presented one of the simplest but most important illusions ever discovered: three semitransparent overlapping circles (*at right*). Look carefully at the blue dot at the center of the three intersecting disks while directing your attention to each of the three disks in turn. If you are paying attention to the bottom disk, for example, you will see that it looks brighter than the other two disks. The same is true when you turn your attention to one of the other disks. Before Tse's discovery of this illusion, neurophysiologists believed that people cast a spotlight of attention on a specific location, leaving the rest of the world in relative darkness. Tse showed that the spotlight concept was literally true, not just a useful metaphor.

Now, five years later, Tse has shown that attention bias can also affect the perception of afterimages, the illusory images that linger after you look at a bright light or stare at a picture for a while. Focus your gaze on the center of the checkered pattern (*below, left*) for one full minute, then shift your eyes to the empty rectangles at the right. You will see a colorful afterimage filling in the formerly empty frames. Pay attention to the vertical rectangle, and you will see an afterimage that matches it. Pay attention to the horizontal rectangle, and you will see a different afterimage. You can go back and forth between the two afterimages simply by shifting your attention from one rectangle to the other.

Afterimages help scientists understand how neurons in our eyes and brains temporarily cease responding to an unchanging stimulus. It is during this temporary period before the neurons reset to their normal, responsive state that we can see afterimages. Neuroscientists know that retinal neurons play a role in the perception of afterimages, but it has been difficult to demonstrate the importance of neural processing at higher levels in the visual pathway from the eye to the brain. Tse's new illusion unequivocally proves that afterimages can be strongly modulated by cognitive processes such as attention.





University of New York, College of Optometry. The more you watch out for the gorilla that you expect to appear, the more you will miss other changes that are unexpected. Spoiler alert: if you want to see the illusion before we reveal those unexpected changes, go now to http://illusionoftheyear.com/2010/the-monkey-business-illusion.

As the gorilla-clad Simons explained, there are several changes that most people overlook when they watch the monkey business illusion: the background of the image changes color from red to gold, and one of the three black-shirted players leaves the game in midplay by discreetly backing out of the scene.

Simons had one final surprise: "Did any of you spot a pirate?" Simons asked the audience. The spectators groaned, rolled their eyes and shook their heads at yet another impossible oversight. But the undetected pirate was not in the video. Simons pointed to stage right, where a spotlight now beamed on a pirate, previously unnoticed yet completely out in the open for all to see, who was holding a sword to the neck of one of us (Macknik, in his role as the contest's technical director).

Still frames from the illusion show (*a*) the scene before the gorilla appears, (*b*) the gorilla entering and one of the players in black backing out of the scene, (*c*) the gorilla thumping its chest, (*d*) the gorilla exiting, and (*e*) the scene after the gorilla has left. The color of the curtain has changed, and now only two black-shirted players remain.

Face or Vase?

Magician Victoria Skye created this version of the classic face-vase illusion using Randi's portrait. Skye's illusion served as the backdrop for the Amaz!ng Randi's performance.

Face the Facts

Peter Thompson of the University of York in England revolutionized the field of face perception when he created the Margaret Thatcher illusion (*above*) in 1980. The top and bottom rows of Thatcher images are identical to each other but flipped vertically. The top row looks like two upside-down Thatchers, no problem there. But the bottom row looks like a Thatcher on the left and a horrible mutant on the right. The reason is that whereas the left column depicts normal faces (although the upper face is upside down), the right column shows Frankenstein-ish composites of Thatcher with eyes and mouths flipped vertically. The Thatcher at the upper right

does not freak you out, because the eyes and mouth are right side up (although the overall face is upside down), and your face-perception neurons therefore see them as "normal" (even though they do not match the rest of the face). The bottom right image, on the contrary, is creepy because the eyes and mouth are upside down and thus all wrong, despite the fact that the face as a whole is right side up.

Thompson's latest puzzle, the fat face thin illusion (*above*), was one of the 2010 contest finalists. Whereas the Margaret Thatcher illusion showed that faces are more difficult to recognize upside down and that sometimes we misperceive the facial expressions of inverted faces, the new illusion demonstrates that the internal features of a face—such as the eyes, nose and mouth—can distort our perception of face shape: when the face is upside down, it appears to be slimmer.

(Further Reading)

- **105 Mind-Bending Illusions.** *Scientific American Reports* special issue, Vol. 18, No. 2; Summer 2008.
- **169 Best Illusions.** *Scientific American Mind* special issue, Vol. 20, No. 1; Summer 2010.
- **The Invisible Gorilla: And Other Ways Our Intuitions Deceive Us.** Christopher Chabris and Daniel Simons. Crown Archetype, 2010.
- **Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions.** Stephen L. Macknik and Susana Martinez-Conde, with Sandra Blakeslee. Henry Holt, 2010.

PETER THOMPSON; FROM *PERCEPTION*, VOL. 9; 1980, PUBLISHED BY PION LIMITED, LONDON (*Thatcher*); DAN KITWOOD *Getty Images* (*fat/thin faces*); VICTORIA SKYE (*face or vase*)

Obsessions Revisited

Scientists are taking a fresh look at obsessive-compulsive disorder, identifying its likely causes—and hints for new therapies

By Melinda Wenner Moyer

One day 12-year-old Elizabeth McIngvale became obsessed with the number 42, which happened to be her mother's age at the time, 11 years ago. When she washed her hands, she had to turn the sink on and off 42 times, get 42 pumps of soap and rinse her hands 42 times. Sometimes she decided that she actually needed to do 42 sets of 42. When she dressed, she put her right leg in and out of her pant leg 42 times, then the left. Even getting up from a chair took 42 attempts. She was afraid that if she did not follow her self-prescribed ritual, something terrible would happen to her family—they might die in a car accident, for instance. "Everything I did was completely exhausting and grueling," she recalls. "I was probably doing 12 to 13 hours a day of rituals."

McIngvale was diagnosed with obsessive-compulsive disorder (OCD), a psychiatric illness that afflicts 2 to 3 percent of Americans, not all of them as severely as McIngvale. Individuals with OCD experience debilitating recurrent and persistent thoughts, or obsessions, which they try to suppress or eliminate with rituals, known as compulsions. Compared with people who have other anxiety or mood disorders, adults with OCD are more likely to be single and unemployed. In fact, OCD is among the 10 most disabling medical and psychiatric conditions.

Current psychotherapy techniques and drugs help reduce or extinguish obsessive thoughts, but only rarely do patients overcome the disorder. Part of the problem, scientists now believe, is that researchers have had little grasp of OCD's true nature. Now, however, they may be reaching a turning point in their understanding, a change they hope will lead to new therapies.

Identifying the neural circuits involved provides possible targets for medicines. With the help of genetic studies, researchers have learned that a brain-signaling chemical, or neurotransmitter, called glutamate plays a role, for example. Glutamate drives a brain circuit involved in making decisions that are associated with positive outcomes—one that operates abnormally in individuals with OCD. Perturbations of the immune system can also affect the same neuronal wiring, predisposing some people to OCD and related conditions. "This circuitry, which we're defining, is important for lots of different things that cross diagnoses," says Benjamin Greenberg, a research psychiatrist at Brown University. The new data point away from the long-held notion that OCD results mainly from anxiety. Instead the disorder seems to spring from a drive to revisit thoughts and perform tasks over and over again.

Repetition and Reward

For centuries scientists have sought the roots of the affliction we now know as OCD. In the 1600s people who suf-

CORBIS

The essence of obsessive-compulsive disorder is now thought to be a repetitious stuttering of thoughts or actions, such as organizing and reorganizing a closet.

TRIA GLOVAN Getty Images

fered from repetitive obsessions and compulsions were assumed to be afflicted with "religious melancholy." By the mid-20th century psychiatrists in the tradition of Sigmund Freud described OCD symptoms as signs of "neuroses" that result from repressed instinctual or sexual drives. Vaguely echoing the Freudian view, the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM*), the "bible" of mental health diagnoses, currently classifies OCD as an anxiety disorder based on the persistent nervousness that patients typically display.

That thinking has begun to change, however. In a 2007 international survey, 60 percent of 187 authors of OCD publications challenged this rationale, with many arguing that no data show that anxiety actually causes the disorder. They believe anxiety is more of a sidelight than a defining feature of OCD, and as a result, studying and treating anxiety may not be the best way forward. Instead, these experts contend, researchers should consider OCD as a problem based on urges that cause repetitive thoughts and behaviors. With that understanding, they think OCD should be officially grouped with illnesses such as body dysmorphic disorder (BDD), a preoccupation with an imagined defect in appearance [see "Imagined Ugliness," by Susanne Rytina; Scientific American Mind, April/May 2008]; Tourette's syndrome, which causes physical and vocal tics; and hypochondriasis, excessive fear about having a serious illness. After all, these three disorders often develop in concert: about one third of BDD patients and up to half of Tourette's sufferers also have OCD; meanwhile up to 15 percent of OCD patients are hypochondriacs.

This proposed new grouping—which could be penned in the next iteration of the *DSM* due out in 2013—may even have an important biological basis. Relatives of people with OCD are more likely than average to have Tourette's and BDD, suggesting that these ailments may have common genetic roots. (OCD itself is known to run in families: relatives of people with OCD are eight times more likely than others to also have the disorder.) And genetic clues are beginning to reveal the biology of OCD.

Some of the new insights confirm what we already suspected. Psychiatrists know that serotonin reuptake inhibitors (SRIs), drugs that increase the amount of the neurotransmitter serotonin (a regulator of mood, appetite and sleep) outside of neurons, are among the most effective medications for OCD; that fact suggests that serotonin signaling could be malfunctioning in OCD. A statistical analysis in 2008 added weight to this idea. In that study, James Leckman and his colleagues at the Yale University Child Study Center analyzed data from 19 studies involving 1,797 individuals with OCD and 3,786 people who did not have the disorder.

The researchers looked at variation in a single gene—the one for the serotonin transporter, a protein that mops up serotonin from between neurons. When too much of this protein is made, too little serotonin is left in the spaces

FAST FACTS

Compulsive Circuitry

1» **Scientists are now challenging the long-held notion that anxiety is the defining feature of obsessive-compulsive disorder (OCD).**

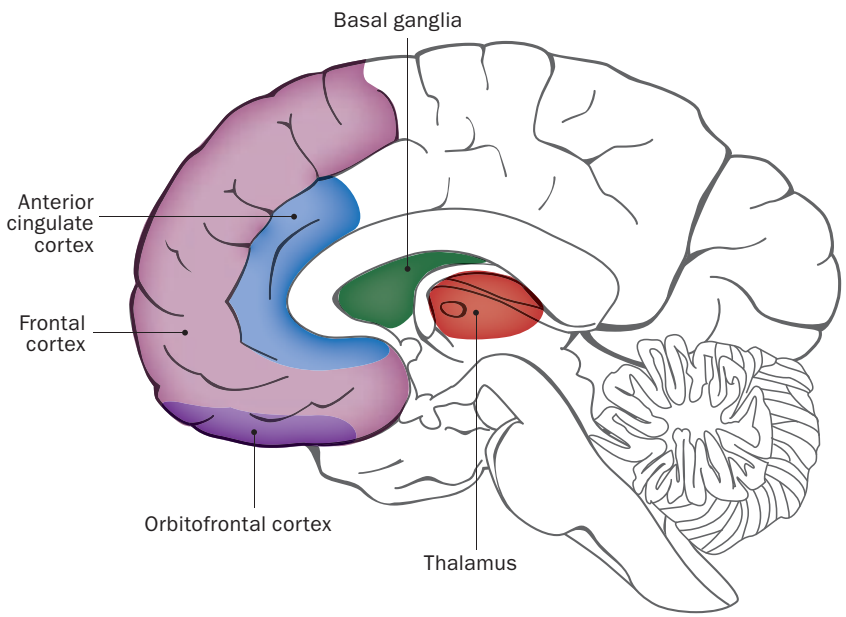
2» **The neurotransmitter glutamate plays a role in OCD. It is critical to a brain circuit involved in making rewarding decisions that is abnormal in OCD patients.**

3» **Immune system abnormalities could predispose some individuals to OCD by perturbing the same brain network.**

between neurons, suppressing signaling. The researchers found that certain variations in the gene that increase the production of the protein are indeed more common in some OCD patients—in particular, Caucasians and those with child-onset OCD. In a 2005 experiment radiologist Georg Berding and his colleagues at Hannover Medical School in Germany reported that the serotonin transporter also binds abnormally to serotonin in unmedicated Tourette's patients and that BDD is sometimes successfully treated with SRIs as well.

Although the effectiveness of SRI drugs suggested that serotonin (and dopamine, another brain chemical) played a role, researchers have long suspected that glutamate might be important, too, based on the fact that these neurotransmitter systems frequently work together. Glutamate is the brain's primary excitatory neurotransmitter: it tends to stimulate (rather than inhibit) neuronal signaling. As it turns out, glutamate facilitates neuronal communication in brain regions that have been implicated in OCD. Several family genetic studies, including one published in 2002 by psychiatrist Edwin Cook, Jr., and his colleagues at the University of Chicago and the University of Michigan at Ann Arbor, have associated OCD with variations in the gene for a protein that removes glutamate from outside neurons. And in 2007 neurobiologist Guoping Feng, now at the Massachusetts Institute of Technology, and his colleagues reported that turning off a structural protein in mice that regulates activity at the glutamate receptor led to compulsive grooming.

Among other functions, glutamate fuels a brain circuit involved in making decisions that will lead to positive, or rewarding, outcomes, particularly when the choice requires sifting through data and experience. The so-called cortical-basal ganglia circuit comprises the orbitofrontal cortex (OFC), a decision-making hub; the striatum, a section of the basal ganglia involved in learning and the experience of reward; the thalamus, a region that filters facts and other data; and the anterior cingulate cortex, which detects errors. Mutations in the glutamate transporter gene might impair the protein's ability to regulate activity in this circuit, leading to nonsensical decisions and behaviors. Although investigators are loath to propose a precise mechanism, glitches in this neural wiring could alter a person's ability to sift through information or make decisions based on experience, leading them to sometimes see danger when none is present—and obsess over it. Other anomalies could in theory alter the experience of reward, such that repetitive behaviors trigger it.



Obsessions and compulsions may stem from glitches in a brain circuit governing decision making and reward. The circuit includes the orbitofrontal cortex, a decision-making hub; part of the basal ganglia that mediates rewarding feelings; the fact-filtering thalamus; and the anterior cingulate cortex, which monitors mistakes.

Relatives of people with OCD are more likely than average to have Tourette's syndrome and body dysmorphic disorder.

In any event, these brain regions and their communications suffer a range of abnormalities in OCD. In a 2009 statistical analysis of 21 studies comparing the brains of mentally healthy people with those of OCD patients, psychiatrist Bruno Aouizerate and his colleagues at the University of Bordeaux in France reported that the OFC and part of the anterior cingulate cortex tend to be smaller in OCD patients. And in a 2008 study neuropsychologist Barbara Sahakian and her co-workers at the University of Cambridge used functional MRI scans to show that 14 OCD patients had reduced OFC activation, compared with

(The Author)

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MELISSA THOMAS

control subjects, while performing a computer task that required them to update their behavioral responses based on new information.

Imaging studies hint that the repetitive thoughts and behaviors that characterize disorders such as Tourette's and BDD are similarly driven by problems with this brain circuit. In Tourette's patients, data published in 2008 point to abnormalities in the connections between different nodes in the circuit; these are formed by so-called white matter, which is made up of the long axons that link one neuron to another. And a 2010 study hints that an abnormally small OFC and anterior cingulate cortex may underlie some cases of BDD.

Infectious Behavior?

Recent work has implicated another possible culprit in OCD: the body's immune system. For instance, a 2002 study reported that mice missing a gene involved in immune function demonstrated OCD-like behaviors. Molecular geneticist Mario R. Capecchi and his colleagues at the University of Utah bred mice lacking a gene for a protein called *Hoxb8* that was known to regulate the development of body shape in mice. Previous research had shown that the gene also helps to maintain myeloid progenitor cells, which mature into immune cells in the brain called microglia. The researchers were curious to see what happened to mice in the gene's absence. They found that the mice were surprisingly healthy—but groomed themselves and one another twice as often as mice typically do.

The immune system may play a role in compulsions. Mice lacking one type of immune cell groomed themselves excessively.

In a follow-up study published in May 2010 Capecchi's team discovered that these *Hoxb8*-deficient mice had 15 percent fewer microglia in their brains than normal, confirming that *Hoxb8* is important for microglia development. Then, when the scientists replaced the missing microglia by giving the mice bone marrow transplants, the rodents groomed themselves the ordinary amount, hinting that an adequate number of microglia are critical for staving off the repetitive actions characteristic of OCD. No one is yet sure of the connection between microglia and the disorder, but in addition to scavenging infectious material, microglia may also release immune chemicals called cytokines that control activity at neuronal junctions known as synapses [see "The Hidden Brain," by R. Douglas Fields, on page 52]. These immune cells are abundant in the cortical-basal ganglia circuit and make direct contact with synapses. Other studies reveal that microglia regulate neuronal cell death during development, and the absence of normal cellular pruning may create structural oddities that spawn behaviors characteristic of OCD.

Other types of abnormal immune responses seem to incite OCD as well. In 1998 pediatrician Susan Swedo of the National Institutes of Mental Health (NIMH) identified a group of children who had acquired OCD or related tic disorders immediately after suffering group A streptococcus infections, the cause of strep throat. Her work suggests that in the process of fighting the infection, the brain can accidentally develop antibodies against—and begin attacking—basal ganglia neurons, which are mistaken for the bacteria. These immune attacks may ultimately disrupt the cortical-basal ganglia circuit, leading to OCD symptoms. Swedo has found that severe tics characteristic of Tourette's disorder can also appear suddenly after strep throat infections.

The overactive immunity described in strep sufferers contrasts with the apparent underactive immunity Capecchi's group saw in their hyperhygienic rodents. Other studies that have assessed the levels of immune cells and proteins in patients with OCD have produced similarly conflicting results, suggesting that either overly vigorous or weakened immunity could put a person at risk. That said, most OCD cases are probably not caused by infection or immune system irregularities. "There are so many patients [with strep infections], and not all of them get obsessive," says Aye-Mu Myint, a neuroimmunologist at Ludwig Maximilian University in Munich.

Studies suggest that either overly vigorous or weakened immunity could put a person at risk for obsessive behavior.

Tweaking Treatments

Currently one of the most effective treatments for OCD is a therapy known as exposure and response prevention (ERP). The idea is simple: therapists repeatedly expose patients to the objects or other stimuli that trigger their repetitive behaviors—by making them touch toilets, say—without letting them perform their associated compulsions. Eventually the patients realize that nothing bad happens when they fail to perform their rituals, and "the stimulus is not linked to generating anxiety in the same way it was," says psychiatrist Helen Blair Simpson of Columbia University and also director of the New York State Psychiatric Institute's Anxiety Disorders Clinic. Simpson and her colleagues, along with researchers at the University of Pennsylvania,

HEIDI AND HANS-JUERGEN KOCH

have studied the effects of ERP in clinical trials. In one collaborative study published in 2005, they found that about 60 percent of patients who started ERP treatment improved. The severity of their symptoms, as measured through tests, typically diminished by up to 55 percent, with improvements—such as the reduced need to engage in rituals—seen in as little as four weeks.

Adherence can be a problem, though. Eight of the 37 subjects withdrew from the trial after learning that they were assigned to ERP, and another eight dropped out in the middle of the therapy. "The side effect of the therapy is anxiety," Simpson says, even though the therapy reduces such distress in the long run.

Using exposure and response prevention, a therapist might ask a patient who repeatedly checks the stove before she leaves the house to practice checking the stove only once.

The second-line therapies for OCD patients are SRIs. But the drugs typically take eight to 12 weeks to start working, if they ever do: on average, they reduce the severity of symptoms by only 20 to 40 percent. Combining SRIs with antipsychotic medications can, in some instances, boost response rates, as can using SRIs while undergoing ERP.

Individuals who do not respond well to SRIs might one day benefit from medications that calm glutamate activity in the brain. Several open-label trials and case reports have shown that drugs such as topiramate and riluzole—which work, in part, by blocking specific glutamate receptors—can improve symptoms when taken with SRIs. Scientists are now conducting placebo-controlled trials of these drugs to see how well they perform on their own. Another drug, D-cycloserine, which has been shown to help rats overcome conditioned fears by enhancing activity at receptors for the neurotransmitter N-methyl-D-aspartic acid, is now being tested in OCD patients in combination with ERP in hopes that it will help patients respond to therapy more quickly.

Greenberg and his colleagues are also studying whether deep brain stimulation (DBS)—a proven treatment for Parkinson's disease that involves inserting electrodes into the brain—could treat OCD. A handful of small trials suggest DBS reduces symptoms for some people with severe OCD, perhaps by normalizing the cortical-basal ganglia circuit. "We've found that DBS seems to actually restore rhythmic activity in these areas," says Anthony Grace, a neuroscientist at the University of Pittsburgh. In the ongoing trial, Greenberg is stimulating nerves that link to various parts of this circuit, pinpointing which components are the most important for regulating symptoms. "It gives us a tool to study the disease," says Suzanne Haber, a neuroscientist at the University of Rochester.

Researchers suspect that OCD may represent a cluster of different conditions rather than just a single disorder; after all, sufferers may exhibit disparate obsessions and compulsions with activities such as hoarding, cleaning, ordering and checking. "We're assuming that OCD is one thing, and it probably is not," says Gerald Nestadt, director of the Johns Hopkins University Obsessive-Compulsive Disorder Program. If a compulsion to order things, say, has a different biological cause than does obsessively collecting objects, researchers would like to identify those separate OCD conditions and tailor treatments to each one. To explore this approach, the NIMH is developing mental health research guidelines that will help scientists better identify relevant OCD subtypes and classify patients for research studies. As part of this program, Greenberg and his colleagues currently have a $10.5-million grant to identify the specific brain networks that affect treatment responses.

Some of these new and future approaches may ultimately benefit patients such as McIngvale. Thanks to ERP, McIngvale, now 23, is pursuing her Ph.D. in social work and is the spokesperson for the International OCD Foundation. She still contends with hand-washing compulsions, which she tries to hide from her colleagues, and struggles to stop herself from repeating fruitless tasks that consume her day. "There is no cure [for OCD]," she admits. But someday, McIngvale hopes, treatments stemming from a better understanding of OCD may make her life easier. She may even forget why she ever cared about the number 42. M

(Further Reading)

- **Recent Advances in the Genetics of Obsessive-Compulsive Disorder.** Jack F. Samuels in *Current Psychiatry Reports,* Vol. 11, No. 4, pages 277–282; August 2009.
- **Obsessive-Compulsive Disorder and Its Related Disorders: A Reappraisal of Obsessive-Compulsive Spectrum Concepts.** D. L. Murphy et al. in *Dialogues in Clinical Neuroscience,* Vol. 12, No. 2, pages 131–148; 2010.
- **OCD? Your Immune System Could Be to Blame.** Mitch Leslie in *ScienceNow;* May 27, 2010. Available at **http://news.sciencemag.org/sciencenow**
- **Should an Obsessive-Compulsive Spectrum Grouping of Disorders Be Included in DSM-V?** Katharine A. Phillips et al. in *Depression and Anxiety,* Vol. 27, No. 6, pages 528–555; 2010.

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AGE FOTOSTOCK

Control Yourself!

Cocktail or cola? Banana or banana split? Understanding how we handle such decisions makes it easier to keep our cravings in check

By Wilhelm Hofmann and Malte Friese

Most of us start out with the best of intentions. Then we walk right past the fruit bowl in search of the devil's food cake. Or drink one glass of wine too many. Or, after yet another glass, kiss that co-worker at the holiday party. Unfortunately, life constantly presents us with situations that pit our well-reasoned resolutions against the promise of immediate pleasure. As screen legend Mae West once purred, "I generally avoid temptation unless I can't resist it." Withstanding temptation takes self-discipline—no easy trick when immediate gratification plumps our sense of well-being. But it is well worth the effort. Self-control saves us and other people from embarrassing or, worse, damaging consequences.

So why do we so often succumb to the siren song and act against our own self-interests? Scientists have tried for decades to understand this all too human conundrum. Sigmund Freud, the founder of psychoanalysis, viewed all behavior as fallout from conflicts among the id, the ego and the superego. In 1986 psychologist Icek Ajzen of the University of Massachusetts Amherst and economist Thomas J. Madden of the University of South Carolina developed a well-known explanation—the theory of planned behavior—in which all our actions derive from our intentions alone. More recently, though, researchers have turned to models that explain self-control—or a lack thereof—as the outcome of a battle between two emotional systems: our impulses and our powers of reflection.

These dual-system models, particularly one developed in 2004 by psychologists Fritz

Mental strain, stress and the influence of alcohol can impair an individual's ability to bypass temptation.

Strack and Roland Deutsch of the University of Würzburg in Germany, are fairly straightforward: our impulsive self makes fast associations—vending machine equals chocolate. It scans the environment for potentially pleasurable stimuli and sets habitual actions in motion. The strength of these urges varies from one individual to another and from one situation to the next. Personality (are you a risk taker?), current needs (are you hungry?) and prior experiences (did your parents give you chocolate as a reward?) all influence the strength of the impulse. Reflective thought, on the other hand, draws on reasoning and planning; it comes into play whenever someone sets a long-term goal, such as losing weight. Compared with impulses, reflection is resource-intensive, demanding time and memory, but it affords us a good measure of control over our actions.

Because our impulses and our reflections engage different information-processing pathways, dual-system models neatly explain why we are very much of two minds when it comes to temptation. The classic image of an angel on one shoulder and a devil on the other fits well with what researchers have learned: the two systems compete for control over our response to some want; the winner is whichever one experiences greater activation under the circumstances. It is easier to ignore a weak impulse than a strong one (try food shopping on an empty stomach). At the same time, it is easier to engage the reflective system if it clearly recognizes undesirable behavior. Its potency depends on how strongly a person identifies with his or her long-term goals and how firmly those goals are held in working memory, among other factors.

FAST FACTS

Impulses vs. Intentions

1» **Two different information-processing systems in the brain battle for control of our response to temptation: impulses aimed at immediate gratification, and reason, which helps us pursue long-term objectives.**

2» **Stress, emotional strain, alcohol and other drains on cognitive resources, such as working memory, can render us less able to withstand temptation.**

3» **Fortunately, a number of training methods can bolster self-control. It is possible to strengthen our mental resources and turn our impulses for good.**

Explanation in Brief

Self-control is the exertion of willpower in the interest of long-term objectives.

Ego depletion: Activities that require mastery or otherwise tax our self-control render us less able to resist temptation in subsequent activities, even if the two tasks are unrelated.

Just Say No

Indeed, a range of influences can help or hinder self-control. In the 1970s psychologist Walter Mischel and his co-workers at Stanford University investigated under what circumstances elementary school pupils were able to resist a small but immediate reward—a piece of candy—in exchange for a larger one later. Among other things, they found that the children were better able to delay gratification—that is, put off the smaller reward and wait for something bigger—when the candy was hidden. Concealing the candy was enough to dampen the children's impulses. But self-control is not always so easy as out of sight, out of mind. More recent studies have demonstrated that mental strain, stress and the influence of alcohol can impair an adult's ability to bypass temptation.

Roy F. Baumeister and his colleagues at Florida State University did groundbreaking research in this area in the 1990s. They tested the idea that mental challenges sap the energy required to maintain self-control, much as physical challenges deplete muscle strength. They reasoned that any activity requiring a certain level of mastery would weaken an individual's self-control in subsequent tasks. Imagine, for example, that you have a job interview at 11 A.M. Naturally, you want to convey a positive image of yourself—an exercise that demands a fair amount of composure. According to Baumeister's theory, after the interview, you would be less able to resist the urge to have french fries at lunch; after a morning at home, though, you might easily forgo the fries and opt for a healthy salad.

In 1998 Baumeister and his associates performed an intriguing experiment in which they presented subjects with freshly baked chocolate-chip cookies—

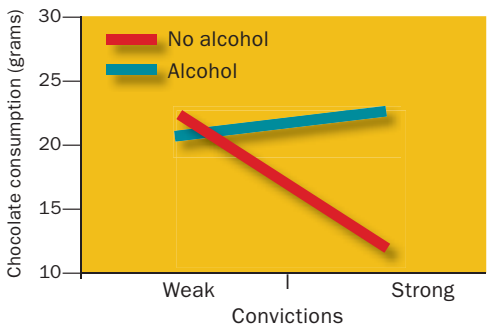
10 Tips to Increase Self-Control

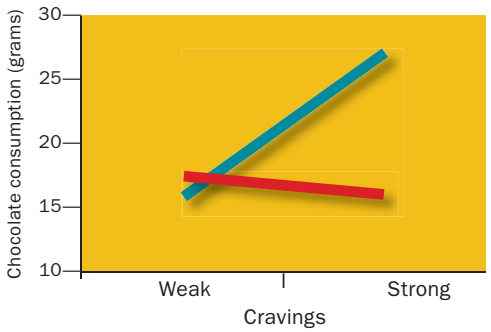
1. **Become aware of the risks** and long-term negative consequences of undesirable behavior.
2. **Increase your personal engagement** by, for example, telling friends about your goals.
3. **Transform abstract overarching objectives** into intermediate steps or milestones.
4. **Take pleasure in achieving partial successes** and reaching intermediate milestones.
5. **Formulate "if then" resolutions** to deal with critical situations.
6. **Replace old bad habits** with new good ones.
7. **Change your impulses** by learning to associate the mere sight of temptations with negative stimuli.
8. **Identify situations** that pose a particular risk and avoid them as much as possible.
9. **Train your working memory.**
10. **Plan enough breaks** and relaxation periods to prevent depletion of your mental resources.

ostensibly as part of a taste test. They allowed only some participants to try the cookies; others were given radishes. In a later session they asked the subjects to try to solve what were actually insoluble problems. It turned out that individuals who had been forced to withstand the cookie temptation gave up on the problems more readily—on average after only eight minutes. In contrast, those permitted to stuff their face with cookies held out for almost 19 minutes. A control group, made up of subjects who received neither cookies nor radishes, worked for more than 20 minutes before quitting the problems.

Researchers have dubbed this phenomenon, in which external circumstances alter our capacity for self-control, short-term ego depletion. Following the lead of Baumeister and others, we hypothesize that impulses hold greater sway over our behavior when our powers of reflection have fewer resources to draw on. Using a variety of scenarios, we have explored how our ability to act in accordance with long-term goals depends on whether we possess the mental reserves needed to meet them. For instance, we have found that people are often unsuccessful at turning down chocolate—even if they are trying to diet or believe sweets are unhealthy—when they are under the influence of alcohol.

In this experiment, half the participants drank 0.3 liter of vodka and orange juice some 15 minutes before the test; the other half received unadulterated orange juice. We gave all the subjects questionnaires to learn about their consciously held attitudes toward sweets. We also administered the Implicit Association Test (IAT), developed by Anthony Greenwald and his co-workers at the University of Washington, to gauge the extent to which individual subjects associated chocolate with something pleasant—and so how strongly they might be tempt-





In their experiment, the authors were able to predict the chocolate consumption of hungry test subjects based solely on their resolutions: those who did not want to eat very much, for instance, typically did not. After they drank alcohol, though, the strength of the participants' impulses became the dominant influence. Those who liked chocolate, regardless of their intentions, ate more than those who did not.

(The Authors)

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GETTY IMAGES (*tree pose*); COURTESY OF WILHELM HOFMANN AND MALTE FRIESE (*graphs*)

People who have a robust working memory and good inhibitory brakes are better at keeping their resolutions.

ed to eat it. We found that it was easy to predict how much a person would eat based solely on their attitudes, provided they had not consumed alcohol. No matter how much the chocolate tempted them, the sober subjects were typically able to stick to their convictions. Among tipsy subjects, however, the more they liked chocolate, the more they ate [*see illustration on preceding page*].

Of course, short-term ego depletion is not the whole story. Drunk or sober, some people seem remarkably disciplined, whereas others have never met a temptation they didn't like. Various cognitive functions probably account for such differences. Working memory—which seems to govern whether we are able to focus our attention on some aim—most likely plays a role. Far more important may be inhibitory control—that is, the mental brakes we possess to rein in our most pressing desires. After all other control mechanisms have failed—the potato chip hovers near our lips or the cigarette is already lit—inhibitory control can offer us a last-second reprieve. Numerous studies have shown that people who have strong cognitive control—a robust working memory and good inhibitory brakes—are better equipped to keep their resolutions. Poorly developed cognitive control, on the other hand, often correlates with impulsive behavior.

Taking Charge

The dual-system models offer valuable insight into self-control and impulsive behavior: people are generally able to work toward long-term goals—losing weight, quitting smoking, finding a new job—so long as they are not mentally or emotionally taxed, in which case cravings, and the old habits that go with them, grab the wheel. As the studies we have discussed show, self-control can run aground for a variety of reasons, among them a lack of awareness or the presence of overpowering urges. Alternatively, a person might face tremendous strain, which chips away at otherwise intact inhibitory brakes; other individuals might simply lack the cognitive control needed to stop them from acting on impulse. In the final analysis, self-control always depends on the interplay of all these factors and possibly others as well.

Fortunately, there are effective methods to bolster self-control [*see box on preceding page*]. Traditional approaches generally attempt to strengthen a person's resolve by equipping them with knowledge,

Measuring Impulses

An Implicit Association Test (IAT) allows psychologists to draw conclusions about people's underlying biases. The authors used an IAT to determine the extent to which their test subjects associated chocolate with something pleasant. (You can explore some of your own unconscious associations at Project Implicit: https://implicit.harvard.edu/implicit/demo/takeatest.html.)

Round 1: We asked participants to press a specific computer key on the left side of the keyboard when they saw images of either chocolate or pleasant objects.

Round 2: Next, we had them press a computer key on the right side of the keyboard when they saw images of either chocolate or unpleasant objects.

We concluded that individuals who, on average, pressed the key in round 1 faster than they did in round 2 had a positive emotional reaction to chocolate; those who pressed the key faster in round 2 were deemed to have a negative emotional response to chocolate.

GETTY IMAGES

Keeping Resolutions

StickK.com—founded by Dean Karlan, an economics professor at Yale University, Ian Ayres, a law professor at Yale, and Jordan Goldberg, a student at the Yale School of Management—helps people to achieve long-term goals of all kinds. Individuals who want to change a particular behavior join at no cost and set a goal (such as losing 10 pounds or quitting smoking). Next, they establish a desired time frame and specific milestones, along with a monetary wager that goes to charity or a friend—or even an enemy—in case they fail to meet their goal. They also appoint a judge to decide whether the milestones and mission are accomplished and to report back to the Web site or to family members and friends via e-mail. As of January 2011, StickK users had made some 60,000 so-called commitment contracts, worth nearly $6 million in bets. The site calculated that these resolutions led to more than a million cigarettes not smoked and nearly 150,000 workouts completed.

www.stickK.com

which stands to reason if they fail to see the consequences of their behavior: "You must not smoke, because it will harm you." Such tactics do not help, though, if the person understands the risks and is nonetheless not motivated—or has no plan—to act otherwise. In these cases, it is often useful to have them formulate small intermediate steps toward their long-term objective, thereby building up so-called implementation intentions. These mini milestones are concrete "if then" resolutions that link critical situations to some desired behavior: "If I am offered a cigarette, I will politely say no." Many studies have demonstrated the efficacy of implementation intentions, which have been developed by Peter Gollwitzer of the University of Constance in Germany.

Yet another approach aims to train the impulsive system so that it no longer handicaps our pursuit of long-term objectives and may even help. Practitioners repeat neutral or good habits until they eventually replace more deleterious ones—for example, ordering nonalcoholic beer at a restaurant instead of spirits. Such training programs can cause real stress at first, but consistent repetition usually leads to a tipping point, after which the impulsive system automatically triggers the desired response. Dutch psychologist Reinout Wiers and his colleagues at the University of Amsterdam have found that even simple exercises can serve to retrain our impulses. The researchers asked alcohol-dependent patients to repeatedly move a joystick in a certain direction to signal rejection whenever they saw a photograph of alcohol on a computer screen. When they tested the program at a substance abuse clinic, the results were promising: one year after discharge the recidivism rate among patients drilled on the computer was lower than that among those who received only standard treatment.

Still other strategies target working memory in an attempt to fortify weak cognitive control. Torkel Klingenberg and his team at the Karolinska Institute in Stockholm have tested this idea in children and the elderly, but such a program might also aid in adults lacking self-discipline. The surest ploy may simply be avoiding temptation wherever possible. You are unlikely to wrestle with self-control if you steer clear of potentially compromising circumstances in the first place.

But of course, that is not always possible. So the next time you face the choice between short-term gratification and a long-term goal, think about the battle going on in your brain between impulses and reflective thoughts. It might just help you to muzzle your cravings. M

(Further Reading)

- **Implementation Intentions: Strong Effects of Simple Plans.** Peter M. Gollwitzer in *American Psychologist,* Vol. 54, No. 7, pages 493–503; 1999.
- **Increased Prefrontal and Parietal Brain Activity after Training of Working Memory.** Pernille J. Olesen et al. in *Nature Neuroscience,* Vol. 7, No. 1, pages 75–79; 2004.
- **Reflective and Impulsive Determinants of Social Behavior.** Fritz Strack and Roland Deutsch in *Personality and Social Psychology Review,* Vol. 8, pages 220–247; 2004.
- **The Strength Model of Self-Control.** Roy F. Baumeister et al. in *Current Directions in Psychological Science,* Vol. 16, No. 6, pages 396–403; 2007.
- **Impulse and Self-Control from a Dual-Systems Perspective.** Wilhelm Hofmann et al. in *Perspectives on Psychological Science,* Vol. 4, No. 2, pages 162–176; 2009.
- **Retraining Automatic Action-Tendencies to Approach Alcohol in Hazardous Drinkers.** Reinout W. Wiers et al. in *Addiction,* Vol. 105, No. 2, pages 279–287; 2010.

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Why Johnny Can't **Name His Colors**

The way we commonly use color and number words in English makes it unnecessarily difficult for kids to learn the concepts

By Melody Dye

Subject 046M, two years old, was seated nervously across from me at the table, his hands clasped tightly together in his lap. He appeared to have caught an incurable case of the squirms. I resisted the urge to laugh and leaned forward, whispering conspiratorially. "Today we're going to play a game with Mr. Moo." I produced an inviting plush cow from behind my back. "Can you say hi to Mr. Moo?"

At the Stanford University lab in which I work with cognitive scientist Michael Ramscar, we study how children go about what is arguably the most vital project in their schooling—learning language. Over the past several years we have been particularly taken with the question of how kids learn a small but telling piece of that vast complex: color words. We want to know how much they know, when they know it and whether we can help them get there faster.

046M ("M" for male) was off to a good start. I arranged three color swatches in front of him. "Can you show me the red one?" He paused, then pointed to the middle rectangle. "Very good!" I said, beaming. "Now, what about the one that's blue?"

(The Author)

MELODY DYE is a cognitive science researcher at Stanford University.

The test was not designed to trip kids up. Far from it—we tested only basic color words, and we never made them pick between confusable shades, such as red and pink. To an adult, the test would be laughably easy. Yet after several months of testing two-year-old children, I could count my high scorers on one hand. Most would fail the test outright. 046M, despite his promising start, proved no exception.

There is a surprising disconnect between what children seem to know about colors and numbers and what they actually know when tested. Nailing down just what "red" or "three" means is a difficult hurdle in mastering language, and even older children sometimes slip up and reveal a less than expert grasp of the concept. We discovered in our lab that the way we use color and number words in everyday English actually impedes kids' learning.

Parents see their children's color and number knowledge as developmental milestones for good reason—once these concepts are mastered, a whole world of nuanced comprehension opens up for their kids. Our research reveals that if we understand how the developing brain makes sense of speech, we can help children reach these milestones more painlessly. By phrasing things slightly differently, adults can help youngsters to grasp colors and numbers—and therefore advance to a higher understanding of language—much earlier in life.

Each week in Mind Matters, www.ScientificAmerican.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. Mind Matters is edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, where he edits the Sunday Ideas section.

Red Apples, Blue Skies

Before our testing begins, a research assistant will explain to the child's parents that we will be testing color words. Responses are typically enthusiastic. "Oh, that's great! Margie's got her colors down pat." At that point we level with them: if they want to be present during the study, they will have to be blindfolded. Such measures may seem extreme—but then again, so were the reactions we

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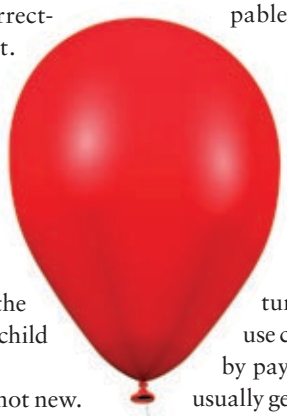
got from parents during the pilot study, as they watched their little ones fail to pick out the right hue, over and over again. The reactions ran the short line from shocked to terrified, and back again. Some parents were so dismayed they started impatiently correcting their children midtest. One mother, in particular, could not seem to stop herself and took to nervously grabbing her little boy's hand whenever it started to veer away from the correct choice.

Then, inevitably, came the posttest breakdown: "Is my child color-blind?"

The baffled response is not new. Charles Darwin was startled by his own children's failings when it came to color, writing in 1877: "They could not name the colors, although I tried repeatedly to teach them." About a century later developmental psychologists began to systematically determine what it was that made learning color words so hard for kids. The obvious hypotheses were soon ruled out. First, children are not color-blind. They can perceptually distinguish colors within a few months of birth. Nor do kids lack experience with color words, which are highly frequent in speech and some of the first words in children's vocabularies.

A typical toddler, for example, can use colors appropriately in common phrases, such as "yellow banana," "blue sky" and "red fire truck," and can even correctly answer familiar questions such as "What color is a tomato?" This apparent mastery is why parents are so often convinced their kids are color experts. But they might be far less confident if they realized that blind children are capable of much the same feat. It turns out that kids can learn to use color words in context simply by paying attention to how things usually get talked about—for instance, the word "red" tends to come up a lot with "fire trucks" but not so much with "ice cream."



If you say "the balloon is red," you will have helped narrow "red" to being an attribute of the balloon and not some general property of the world at large.

Take away that crucial context, and most two- and three-year-old kids are stumped—they cannot correctly identify colors in a lineup or accurately use color words in novel scenarios. What is more, psychologists have found that even after hours and hours of repeated training on color words, these kids' performance typically fails to improve noticeably, and children as old as six continue to make major errors naming colors. This last fact is seriously bizarre when you consider all the other things that children at that age can do: ride a bike, tie their shoes, read the comics and—mistake a blue cupcake for an orange one? Really?

Really. And that is where 046M and his color-naming compatriots came in. Armed with the tools of cognitive psychology, we decided it was high time to figure out why it takes so long for children to learn colors, of all things, and whether we could shortcut the process.

The Grass Is Green

Psychologists before us have pointed out that part of what makes color learning difficult is that we are constantly surrounded by a vast array of hues. This overwhelming ubiquity is not a feature of other common words, such as nouns. Imagine, for example, that a child is trying to learn to distinguish "dog" from "bear." The learning problem is not so difficult in this case: unless you are watching *Old Yeller,* dogs will tend to be seen and talked about in contexts in which bears are not present, and vice versa.

Contrast this with the problem of learning color words. Whenever a three-year-old hears "red," it can be virtually guaranteed that there will be a kaleidoscope of other colors present. Sorting out which hues are "red" and which are "orange" is much harder than figuring out which furry beasts are "bears" and which are "dogs." This may explain why children, across every language studied, invariably learn their nouns before their colors.

As it happens, English color words may be especially difficult to learn, because in English we throw in a curveball: we tend to use color words "prenominally," meaning before nouns. For instance, we will often say things like "the red balloon," instead of using the postnominal construction, "the balloon is red." Our study set out to determine if our choice of word placement could actually influence kids' ability to learn colors.

Sentence construction matters, in theory, because of the way attention

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FAST FACTS

Cracking the Color Code

1» Learning the meaning of color and number words is difficult for children, in part because of how we use these words in everyday English.

2» Parents can help their children grasp these concepts more quickly by stating the color or number after the noun it describes, such as "the balloon is red."

3» Kids who master colors and numbers at an earlier age go on to do better in school later in life.

works. In conversation, people have to track what is being talked about, and they often do this visually. If I were to start blathering about "the old mumpsimus in the corner," you would probably begin discreetly looking around for the mystery person or object.

Kids do the same thing, only more avidly, because they have much, much more to learn about. That means that when you stick the noun before the color word, you can successfully narrow their focus to whatever it is you are talking about before you hit them with the color. If you say "the balloon is red," for example, you will have helped narrow "red" to being an attribute of the balloon and not some general property of the world at large.

From what we can decipher, children also figure out that the "red" in "the red balloon" has to do with the balloon, but they interpret it differently. When we say "the balloon is red," they learn that "red" is the name of a property, such as "wet" or "sharp," whereas when we say "the red balloon," they learn that "red" is more like a proper name, such as "Tom" or "Heather." Knowing someone's name does not usually tell you very much—it is just a label that happens to get attached to a person—but knowing whether someone is funny or boring or whether a dish is mild or spicy tells you a lot. Whether kids learn "red" as something like a name or something like a property depends entirely on how their attention is directed when they hear it.

Helping Kids Learn Hues

Our hypothesis as we set up the study, therefore, was that using color words after nouns should make colors far easier to learn and kids far faster at learning them. To test this hunch, we took 34 two-year-olds and gave them some quick training on color words. Either we trained them with prenominal sentences (the standard variety) or postnominal sentences (helpful, we hoped). In both cases, we would simply show them familiar objects and say encouraging things such as "this is a blue crayon" or "this crayon is yellow."

As we reported in August 2010 in *Cognitive Science*, the kids who got the postnominal training improved significantly over their baseline test scores, whereas the ones who got the prenominal training still looked just as confused as ever. Given that previous studies had not found much improvement after hundreds of explicit training trials, it was hard to believe that such a simple manipulation could make such a clear difference. And yet it did.

Recently we ran a similar experiment using numbers instead of colors, which we will be presenting at conferences this summer. We tested 56 youngsters on number comprehension with questions such as "Look, hearts; can you show me four?" and "Can you show me four hearts?" We then trained the kids on number words, one group prenominally and one postnominally. Here again the sentence construction made all the difference. After only 15 minutes of training, youngsters who learned postnominally ("Flowers! There are six") dramatically improved their test scores, averaging 30 percent better in both reliability and accuracy. Those who we trained prenominally ("There are six flowers") showed no improvement.

Considering that early number comprehension is a good indicator of how well children will do in math later in life, helping kids learn numbers at a younger age could very well have a long-lasting influence. Which brings me to the simple, take-home point: if you want your two-year-old to match colors with aplomb and count with ease, watch your tongue. It might seem faster to ask Johnny not to pop "the red balloon," but it may be better for him if you rephrase: "I mean, the balloon that is red." M

Pass the **Blue**

In English, we tend to say adjectives before nouns ("the green grass"), but that prenominal construction can make it harder for kids to learn their colors and numbers than if we were to say things such as "the grass is green." Many other languages naturally use the latter construction, however, placing adjectives after the nouns they describe. Does that mean a child growing up in a French- or Spanish-speaking household will grasp the concept of colors more easily?

The short answer is we do not know. Studies have not yet been done comparing color learning between prenominally biased languages and postnominally biased ones. But the outcome of such a study might not be so predictable, because many of those languages come with curveballs of their own. In Spanish, for instance, speakers often casually omit nouns in conversation. Whereas English speakers will ask for the "blue bowl," Spanish speakers can just as gracefully demand "the blue." —*M.D.*

(Further Reading)

- **The Effects of Feature-Label-Order and Their Implications for Symbolic Learning.** Michael Ramscar, Daniel Yarlett, Melody Dye, Katie Denny and Kirsten Thorpe in *Cognitive Science*, Vol. 34, No. 6, pages 909–957; August 2010.
- **How Children Learn to Value Numbers: Information Structure and the Acquisition of Numerical Understanding.** Michael Ramscar, Melody Dye, Hanna Muenke Popick and Fiona O'Donnell-McCarthy. Proceedings volume of the 33rd annual meeting of the Cognitive Science Society, Boston, July 2011.

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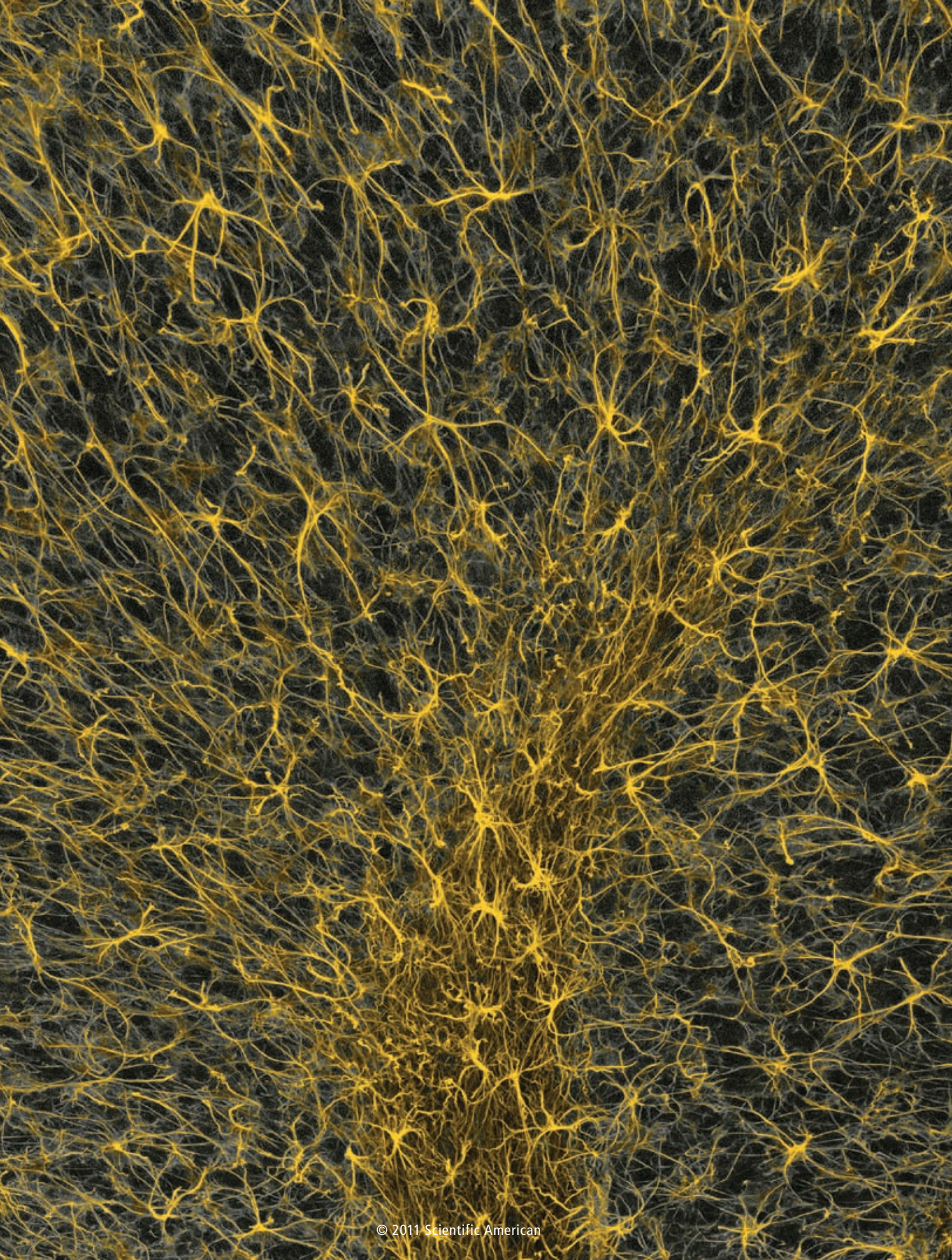
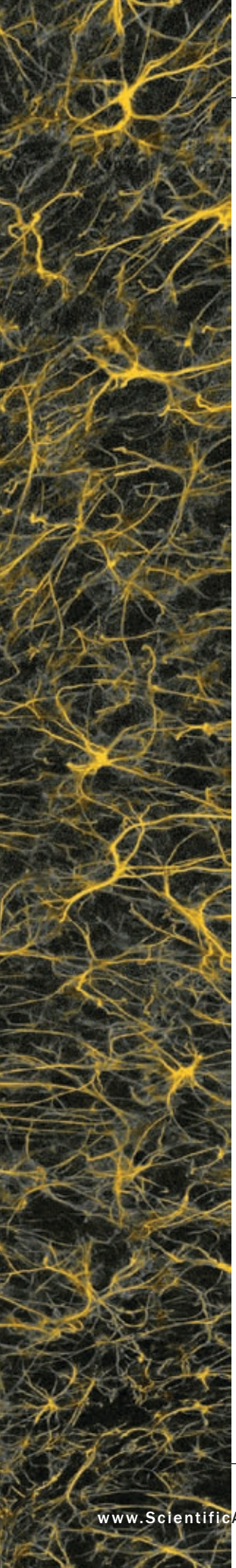




THOMAS DEERINCK *National Center for Microscopy and Imaging Research/SPL/Photo Researchers, Inc.*

The Hidden Brain

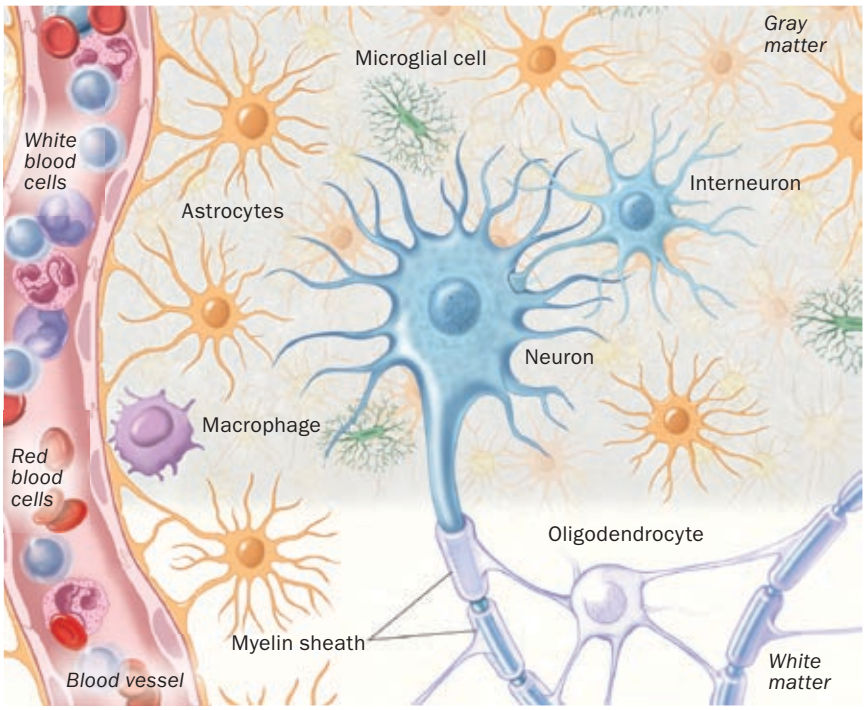
Flashy neurons may get the attention, but a class of cells called glia are behind most of the brain's work—and many of its diseases

By R. Douglas Fields

A light micrograph reveals a weblike pattern of cells called astrocytes in the cerebellum, a brain structure involved in motor control.

Powerhouses of the Brain

Once dismissed as mere packing material, glia make up 85 percent of the cells in our brain and are now known to control many of the brain's functions. Astrocytes ferry nutrients and waste and mediate neuronal communication. Oligodendrocytes coat axons with insulating myelin, boosting signal speeds. Microglia fight infection and promote repair; when they fail, so does the brain.



Sitting in a darkened lab at the National Institutes of Health in 1999, my colleague Beth Stevens and I prepared to send a mild electric current through fetal mouse neurons in a cell culture. We were using a new microscope technique that would let us see electrical activity as a bright fluorescence emitted from a dye we had added to the culture, and we were hoping to find out if another kind of cell common in the nervous system would react in some way—Schwann cells, odd-looking cells that fabricate insulation around neurons. We didn't really expect them to; Schwann cells cannot communicate electrically. I flipped the switch. The neurons immediately glowed. But then the Schwann cells began to glow as well. It was as if they were talking back.

The most mysterious substance on earth is the stuff between your ears, and much of the intrigue exists because many long-held beliefs about how the brain works have turned out to be wrong. Like medieval astronomers who were shocked to learn that the earth is not the center of the universe, neuroscientists today are facing a similar revelation about neurons.

Until recently, our understanding of the brain was based on a century-old idea called the neuron doctrine. This theory holds that all information in the nervous system is transmitted by electrical impulses over networks of neurons linked through synaptic connections. But this bedrock theorem is deeply flawed. New research proves that some information bypasses the neurons completely, flowing without electricity through networks of cells called glia. The studies are upending our understanding of every aspect of brain function in health and disease, bringing answers to long-standing riddles about how we remember and learn.

Glial cells interact with neurons, control them, work alongside them—and the functions of these strange-looking cells are myriad. Star-shaped astrocytes ferry neurotransmitters, food and waste. Cephalopodlike oligodendrocytes and sausage-shaped Schwann cells wrap themselves around neurons like sheaths, speeding their electrical transmissions and helping control muscle contractions throughout the body. Microglia, ranging in form from multibranch to ameboid, are the brain's first responders to injury and disease, killing invading germ cells and beginning the process of repair.

Especially exciting is new research showing the central role of glia in information processing, neurological disorders and psychiatric illness. Some glial cells speed information between distant regions of the brain, helping us master complex cognitive processes. Others break down as they age and in their failure bring dementia. This research has great implications not only for understanding how the brain works but also for developing new treatments for neurological and psychological illnesses.

FAST FACTS

The Silent Majority

1» **Neurons make up only 15 percent of our brain cells. Glial cells make up the rest.**

2» **Glial cells can control communication between neurons and play a central role in learning, but for years they were dismissed as mere putty.**

3» **Most neurological and some psychological disorders involve glia, so new therapies are targeting these cells.**

FROM "DO ALL OF THE NEUROLOGIC DISEASES IN PATIENTS WITH DNA REPAIR GENE MUTATIONS RESULT FROM THE ACCUMULATION OF DNA DAMAGE?" BY P. J. BROOKS, TSU-FAN CHENG AND LORI COOPER, IN *DNA REPAIR*, VOL. 7, NO. 6; JUNE 1, 2008

Oligodendrocytes lay down multiple layers of myelin around axons, increasing signal speed up to 50-fold. Recent work suggests that neural impulses can stimulate myelination.

And all this comes down to a class of brain cells dismissed for 100 years as mere putty. In the 19th century, when pioneering scientists first trained microscopes on gray matter, they were amazed to find a cell unlike any other in the body: the neuron. At one end of this dazzling cell was a long, wirelike structure called the axon that carried electrical impulses to a cluster of transmission terminals. At the opposite end, the neuron sprouted busy, rootlike dendrites that received signals from the axons of other neurons, ferried across the space that separated them—the synapse—by tailor-made chemicals. Neurons were scattered sparsely throughout the brain like juicy raisins, but few cared to examine the seemingly bland dough in which they were embedded.

But, as Sherlock Holmes observed, "There is nothing more deceptive than an obvious fact," and the fact that scientists were ignoring is that neurons make up only 15 percent of our brain cells; the other 85 percent were considered little more than packing material. Indeed, 19th-century German pathologist Rudolf Virchow, one of the first to study glia, likened this brain matter to connective tissue and dubbed it *nervenkitt,* meaning nerve putty or cement, which in English became "neuroglia," from the Greek root for glue.

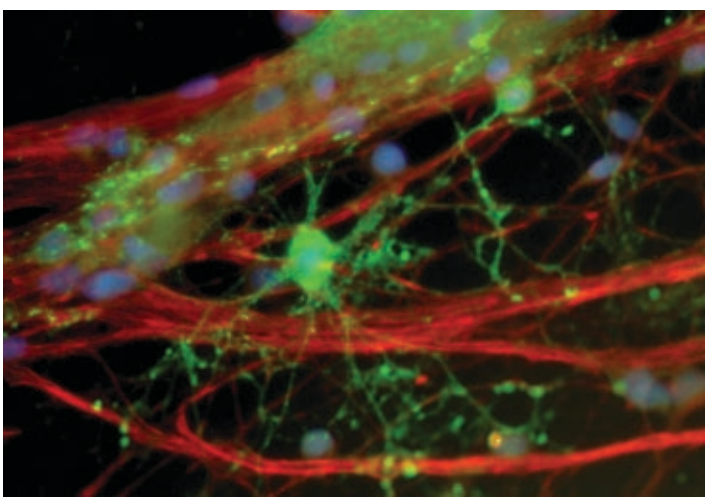
Few scientists are drawn to brain research to study glue. We still have no singular noun equivalent to neuron when we speak about an individual glial cell. Virchow barely distinguished between the different sorts of glia. And none of this mishmash of bizarre-looking cells had any of the telltale features essential for neuronal communication, such as axons, dendrites or synapses, so scientists had no reason to suspect that glia might be communicating in secret and doing so in an unexpected way.

A Language of Their Own

Neurons use both electricity and chemistry to convey information, with electricity transmitting impulses along the wirelike axon and chemicals carrying those signals across the synapse to another neuron. The recipient neuron then fires an electrical impulse and relays the signal to the next neuron in the chain.

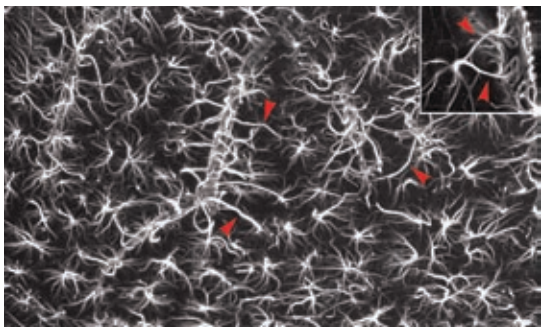
Our understanding of the brain was based on a century-old idea: the neuron doctrine. But this theorem is deeply flawed.

Only in the past few years have scientists come to realize that the glial cells called astrocytes can control synaptic communication. So named because early anatomists thought they resembled stars, astrocytes were at first thought to be responsible only for housekeeping functions such as transporting nutrients from the bloodstream to the neurons and carrying waste in the opposite direction. These functions were surmised from the way many astrocytes cling to blood vessels with some of their arms and reach deep into brain tissue with others, tightly grasping neurons and their synapses. Only later did scientists come to see that neurons are utterly dependent on glia to fire their electrical impulses and to pass messages to one another across synapses. A clue that this dependency might be the case was the discovery of the same neurotransmitter receptors on glia as on neurons. As it happens, glia were listening to neurons and talking among themselves without using electricity at all.



This light micrograph of rat brain cells shows the first steps in myelin formation. Multiple arms from an oligodendrocyte (*green*) have grasped axons (*red*) and have begun wrapping them with layers of the insulator.

ALAN HOOFRING (*myelin*); VARSHA SHUKLA *National Institutes of Health (myelin culture)*



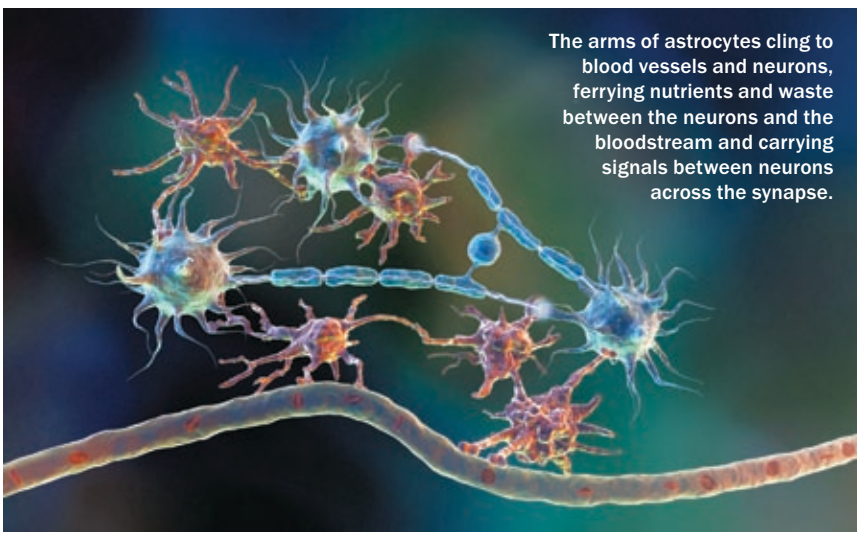
Astrocytes regulate blood flow according to neuronal demand. Here they cluster around a vessel in the brain.

This discovery awaited the invention of new tools allowing electrical activity to be seen as flashes of light. The microelectrodes that neuroscientists typically use to probe neuronal function are deaf to glial communication. But video and laser-illuminated microscopes developed in the 1980s and 1990s let researchers monitor neuronal firing by adding tracer dyes to the cells. Like the fluorescent fluid in a glow stick, these dyes shone when ions such as calcium entered neurons as their axons carried a signal, causing the dye to generate light. Very quickly those of us using these new methods saw that when we stimulated a neuron to fire an impulse, the neuroglia, hidden in plain sight, flashed back. Glia had sensed the electrical activity in neurons, and somehow calcium ions had flooded into them as well, producing the same green glow.

The new technique also revealed that glia communicate with one another in the same way. Scientists observed that when neurotransmitters released by neurons stimulated receptors on glia, the glia released neurotransmitters as well. And the release stimulated a chain reaction as the message was passed to other glia. The glial communication is stunningly evident as a wave of fluorescent light sweeping from one glial cell to the next after a neuron has fired and released a neurotransmitter [*see illustration on page 59*].

This finding led to a bigger question: whether glial networks use the information gleaned about neuronal communication at a synapse to manage neuronal signaling at synapses in distant parts of the brain. If so, glia might have a central part in information processing itself.

Unlike neurons, which communicate across chains of synapses, glia broadcast their signal widely, like cell phones.



The arms of astrocytes cling to blood vessels and neurons, ferrying nutrients and waste between the neurons and the bloodstream and carrying signals between neurons across the synapse.

Recent research provides tantalizing evidence of such a role. Using a laser to stimulate a calcium wave in an astrocyte next to an axon, a team led by neurobiologist Norio Matsuki of the University of Tokyo reported earlier this year that neurotransmitters released from the astrocyte boosted the strength of an electrical impulse in the axon. A 2005 study led by neurobiologist Philip Haydon, now at Tufts University, showed that astrocytes provide a nonelectrical pathway for communication between synapses in a brain area governing memory, the hippocampus. After responding to the neurotransmitter glutamate released from one synapse, astrocytes released a different neurotransmitter, adenosine, affecting the strength not only of its neuronal neighbor but of distant synapses as well. By controlling data processing at synapses, glia participate in aspects of vision, memory, muscle contraction and unconscious brain functions such as sleep and thirst.

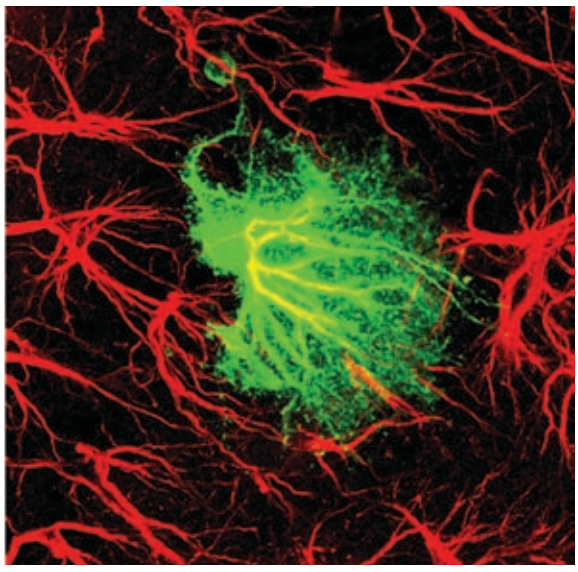
The pace and breadth of glial communication provide another bit of evidence that glia play a part in information processing. Unlike neurons, which communicate serially across chains of synapses, glia broadcast their signals widely, like cell phones. Neurons' electrical communication is quite rapid, zipping through neural networks in mere thousandths of a second, but the chemical communication of glia is very slow, spreading as a tidal wave through neural tissue at a pace of seconds or tens of seconds. Rapid response is critical for certain functions—reflexive recoil from a pain stimulus, for example—but many important processes in the brain occur over longer periods.

Not the least important of these is learning. New human brain-imaging techniques have revealed that after learning to play a musical instrument or to read or to juggle, structural changes occur in brain areas that control these cognitive functions. Remarkably the changes are seen in regions where there are no complete neurons: the "white matter" ar-

FROM "SIGNALING AT THE GLIOVASCULAR INTERFACE," BY M. SIMARD, G. ARCUINO, T. TAKANO, Q.-S. LIU AND M. NEDERGAARD, IN *JOURNAL OF NEUROSCIENCE*, VOL. 23, NO. 27; OCTOBER 8, 2003 (*top*); HYBRID MEDICAL ANIMATION/PHOTO RESEARCHERS, INC. (*bottom*)

eas, formed from bundles of axons coated with myelin, a white electrical insulator. Previously all theories of learning held that we incorporate new information solely by strengthening synaptic connections, but there are few synapses in white matter. Clearly, something else is happening.

Findings from my lab in the past 10 years concern two different types of glial cells that cling to axons and coat them with myelin insulation—oligodendrocytes in the brain and Schwann cells in the body. Like an octopus, each cellular tentacle of an oligodendrocyte cell grips an individual segment of an axon and wraps up to 150 layers of compacted cell membrane around it in the way an electrician wraps tape around a wire. This insulation changes how impulses travel through axons, increasing the transmission speed by up to 50 times.



A new way of dyeing astrocytes shows what they look like for the first time. Here dye fills all the extensions of one cell (*green*), giving it a bushy look. The older method reveals only the cells' skeletons (*red*).

And much like astrocytes at synapses, these myelin-forming glia could sense the impulses transmitted through axons. This capability was a puzzle at first, because such glia are far from the synapses where neurotransmitters are released. But my lab recently discovered that axons also release neurotransmitters through channels in their membrane that open when the axon fires. I was able to see the release of one such neurotransmitter—adenosine triphosphate, or ATP—by fitting my microscope with an extremely high-gain night-scope image intensifier that can detect single photons. For my experiment, I exploited the chemical reaction that produces a firefly's telltale green flash. I took the protein and enzyme from the tail of a firefly and added them to cultures containing mouse neurons. The firefly proteins require one more ingredient before they can glow: ATP, normally supplied by firefly cells. When I stimulated the mouse axons with a mild electric shock, they released ATP, eliciting a burst of photons.

The formation of myelin in response to stimuli likely means that early life experience plays a big role in brain development. By increasing the speed of information transfer between parts of the brain involved in mastering complex cognitive tasks, these glial cells are essential to learning, too.

How the Brain Goes Awry

Glial cells have also emerged as major actors in a host of neurological and psychological illnesses ranging from epilepsy to chronic pain to depression. Indeed, recent research has found that many neurological disorders are in fact disorders of the glia, in particular a class of cells called the microglia, which serve as the brain's defense against disease. These specialists seek out and kill invading germs and promote recovery from injury, clearing away diseased tissue and releasing powerful compounds that stimulate repair. And their function is a factor in every aspect of neurological illness.

New research suggests to some scientists that the dementia of Alzheimer's disease could be a direct outcome of microglia that have lost the ability to clear waste. Alois Alzheimer first noted that microglia surround the amyloid plaques that are the hallmark of the disease. Normally microglia digest the toxic proteins that form these plaques. But recent studies led by neuroscientist Wolfgang J. Streit of the University of Florida College of Medicine and others suggest that microglia become weaker with age and begin to degenerate. The atrophy is visible under a microscope. Senescent microglia in aged brain tissue become fragmented, losing many of their cellular branches.

The way Alzheimer's courses through the brain is one more sign of microglial involvement. Tissue damage spreads in a predetermined manner, beginning near the hippocampus and eventually reaching the frontal cortex. Streit's observations show that microglial degeneration follows the same pattern—and in advance of neuronal degeneration, suggesting that senescence of microglia is a cause of Alzheimer's dementia and not a response to neuron damage, as Alzheimer and most experts had presumed. This discovery may lead to new treatments for dementia, once researchers determine why microglia become senescent with age in some people but not in others.

The functions of the glial cells also account for why some people develop horrible chronic pain that does not relent after an injury has healed and sometimes even worsens. Doctors must use powerful narcotics such as morphine and other opiates to blunt the unrelenting pain in

(The Author)

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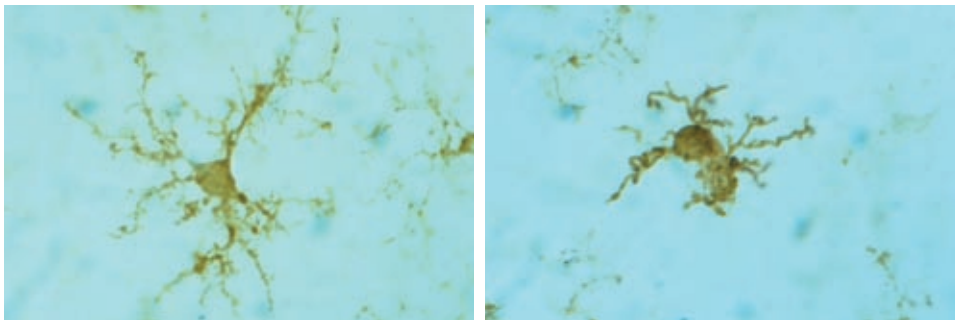
FROM *THE OTHER BRAIN*, BY R. DOUGLAS FIELDS, SIMON & SCHUSTER, 2011; COURTESY OF ULRIKA WILHELMSSON *University of Gothenburg* AND ERIC BUSHONG AND MARK ELLISMAN *University of California, San Diego*



Many diseases of the nervous system are disorders of the glia. Compared with a normal microglia cell (*left*), the armlike extensions of the aging microglia at the right appear shriveled, a sign of dementia.

such patients. These drugs lose their strength over time, necessitating higher doses for the same effects, which can lead to drug dependence [see "When Pain Lingers," by Frank Porreca and Theodore Price; SCIENTIFIC AMERICAN MIND, September/October 2009].

We now know that malfunctions of glial cells may account for both persistent pain and the diminishing power of some pain-relieving drugs. Research by Linda Watkins of the University of Colorado at Boulder, Kazuhide Inoue of Kyushu University in Fukuoka, Japan, and Joyce DeLeo of Dartmouth Medical School, among many others, reveals that microglia and astrocytes respond to the hyperactivity in pain circuits after injury by releasing compounds that initiate the healing process. These substances also stimulate neurons. Initially this heightened sensitivity is beneficial, because the pain forces us to protect the injury from further damage. With chronic pain, microglia do not stop releasing these substances even when healing is complete. But in recent studies pain in experimental animals was sharply reduced when the researchers blocked either the signals from neurons to glia or the signals that glia release. Scientists are now developing painkillers that target glia rather than neurons.

Glial cells also account for the ancient mystery of why spinal cord injury results in permanent paralysis. Martin Schwab of the University of Zurich and others have found that proteins in the myelin insulation that oligodendrocytes wrap around axons stop injured axons from sprouting and repairing damaged circuits. Blocking these proteins allows damaged axons to regrow in experimental animals. Clinical trials on patients with spinal cord injury are now under way.

That glia would play a central role in neurological illness is easy to understand because astrocytes and microglia are the first responders to disease. We have also long known that demyelinating disorders such as multiple sclerosis, which strips the myelin insulation from axons, cause severe disability. But it came as a recent surprise to find glia implicated in psychiatric illness. Recent work has linked chemicals called cytokines, which are released by immune system cells and microglia, to obsessive-compulsive disorder. In 2002 molecular geneticist Mario Capecchi and his colleagues in the department of human genetics at the University of Utah reported that mice with a mutation in the *Hoxb8* gene exhibited compulsive grooming and hair removal behavior similar to humans with obsessive-compulsive disorder. The only cells in the brain that have this gene are microglia. Then, in a 2010 study, the researchers harvested immature immune cells that will develop into microglia from normal mice and transplanted them into the mutants. The mice were cured of their compulsive grooming behavior. Presumably cytokines released from microglia excite brain circuits responsible for habit formation. [For more about habits, see "Obsessions Revisited," by Melinda Wenner Moyer, on page 36.]

Glial cells also account for the ancient mystery of why spinal cord injury results in permanent paralysis.

These illustrations of microglia in their resting state date from 1922.

Analysis of postmortem brain tissue has also linked oligodendrocytes and astrocytes to depression and schizophrenia by revealing reduced numbers of these cells. So have MRI examinations of people with schizophrenia, which show anomalies in subcortical white matter regions of the brain. Although psychiatric illnesses are likely to have many different causes, schizophrenia and several other mental illnesses have a strong genetic basis. If an identical twin develops schizophrenia, there is a 50–50 chance that the sibling will as well.

Some of the genes implicated in these mental illnesses are found only in oligodendrocytes; others control development of these myelin-forming glia. An analysis of 6,000 genes in tissue from the prefrontal cortex of people with schizophrenia by Yaron Hakak, then at the Genomics Institute of the Novartis Research Foundation in San Diego, revealed that 89 genes were abnormal; remarkably 35 of them are involved in myelination. Presumably these genetic abnormalities up-

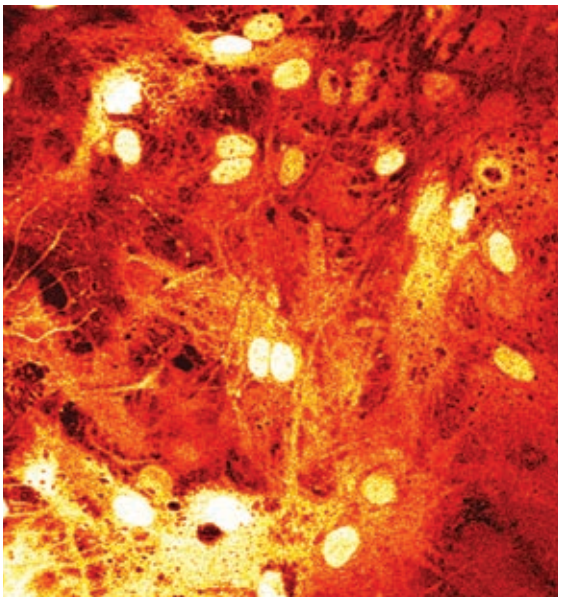
COURTESY OF WOLFGANG J. STREIT (*top left and right*); FROM *HISTOPATHOLOGIE DES NERVENSYSTEMS*, BY W. SPIELMEYER, VERLAG JULIUS SPRINGER, BERLIN, 1922 (*bottom*)

set such processes as synaptic function and myelin insulation, which in turn could disrupt information transmission in the higher-level cognitive circuits affected in psychiatric illnesses.

Roots of Mental Illness

Investigators have set out to learn why glial cells would cause these synaptic snafus. Consider that the biological basis for most mental illness is an imbalance in neurotransmitter chemicals in circuits controlling perception, emotion and thought. All drugs used to treat mental illness and most neurological diseases work by regulating the balance of neurotransmitters. The selective serotonin reuptake inhibitors (SSRIs) used to treat chronic depression and many other psychiatric conditions work by impairing removal of serotonin and dopamine from synapses, allowing these neurotransmitters to build up and in effect boosting the signal. In a similar way, all hallucinogenic drugs, from LSD to PCP, produce their mind-bending effects by altering the levels of neurotransmitters in specific neurological circuits. Regulating neurotransmitter levels at synapses is precisely what astrocytes do.

In theory, then, astrocytes are in a position to control the balance between mental health and madness. In a strange and largely forgotten coincidence, glia were the inspiration for the revolutionary idea that mental illness could have a biological cause and that psychiatric illness could be corrected with medical treatment, albeit a very peculiar one. In the 1930s Hungarian psychopathologist Ladislas von Meduna noticed during autopsies that the number of astrocytes was abnormally low in the cerebral cortex of people who had suffered from chronic depression and schizophrenia. Von Meduna and other pathologists also knew from examination of brain tissue obtained by biopsy that the number of astrocytes increases after epilepsy, presumably to regulate electrical activity when it spins wildly out of control.



As a result of nearby neural activity, calcium ions flow into a rat astrocyte, as revealed by an orange dye that glows in proportion to the amount of calcium present. The influx of calcium unleashes a burst of chemical communiqués among glial cells.

Von Meduna observed as well that people with epilepsy rarely suffered schizophrenia. He surmised that a deficiency in astrocytes was the biological reason for schizophrenia and chronic depression. By inducing a seizure in such people, he could correct the imbalance in astrocytes and cure patients suffering from these illnesses. He later wrote in his autobiography: "I published this work in 1932 without knowing that this would become the origin of shock treatment." How it works is still unclear, but electroshock therapy remains the most effective treatment for chronic depression in people who are not responsive to drugs.

The new awareness of glia in brain function suggests that drugs targeting glia might help treat mental and neurological illnesses. "Epilepsy is a prime candidate for glial-based therapeutics," says Haydon of Tufts. Recent studies by Haydon, Maiken Nedergaard of the University of Rochester Medical Center, Giorgio Carmignoto of the University of Padua in Italy, and many others are using calcium imaging and electrophysiology to show that when neuronal activity is heightened, glia release neurotransmitters that can either contribute to seizure activity or suppress it. New research also implicates glia in sleep disorders, a component of many mental illnesses. Haydon demonstrated the link in experiments on mice genetically altered to prevent their astrocytes from releasing neurotransmitters, disrupting sleep regulation.

Transformational moments are legendary in scientific history, but it is rare to witness one. Until quite recently, we neuroscientists had dismissed more than half of the brain as uninteresting—a humbling realization. We see only now that the glial and neuronal brains work differently, and it is their intimate association that accounts for the astonishing abilities of the brain. Neurons are elegant cells, the brain's information specialists. But the workhorses? Those are the glia. M

(Further Reading)

- **White Matter Matters.** R. Douglas Fields in *Scientific American,* Vol. 298, No. 3, pages 54–61; March 2008.
- **Training Induces Changes in White-Matter Architecture.** J. Scholz, M. C. Klein, T.E.J. Behrens and H. Johansen-Berg in *Nature Neuroscience,* Vol. 12, No. 11, pages 1370–1371; November 2009.
- **Nonsynaptic Communication through ATP Release from Volume-Activated Anion Channels in Axons.** R. Douglas Fields and Yingchun Ni in *Science Signaling,* Vol. 3, Issue 142, ra73; October 5, 2010.
- **Change in the Brain's White Matter.** R. Douglas Fields in *Science,* Vol. 330, pages 768–769; November 5, 2010.
- **Action-Potential Modulation during Axonal Conduction.** Takuya Sasaki, Norio Matsuki and Yuji Ikegaya in *Science,* Vol. 331, pages 599-601; February 4, 2011.
- **The Other Brain.** R. Douglas Fields, Simon and Schuster, 2011.

FROM "VISUALIZING CALCIUM SIGNALING IN ASTROCYTES," BY R. DOUGLAS FIELDS, IN *SCIENCE SIGNALING*, VOL. 3, NO. 147; NOVEMBER 9, 2010

Distance Therapy Comes

Recent studies show that psychotherapy delivered through

Gabriela (not her real name), a 42-year-old investment counselor, has been receiving therapy by computer chat for more than a year now. She fell into a deep depression after her last breakup and needed an ear she could count on to be consistently supportive and objective. She had face-to-face therapy years ago after she lost a child, and she thinks it is overrated. With chat therapy, she can look back at the e-trail and relive therapeutic moments. She can also see her progress in black and white.

Linda (also not her real name), 57 and divorced, has been receiving chat therapy for more than two years. She participates in one session a week and pays less than half what she would pay for an in-person encounter. "And there's no wasting time on chitchat about the weather," she says. "We get right down to business." Her therapist has helped lift her out of a debilitating depression that began when she was trying to console a grieving friend. But she has never seen her therapist; she has never even heard his voice.

As for the distance aspect of these therapeutic conversations, both Gabriela and Linda have similar and somewhat curious perspectives. As Linda put it, "What distance? He's right here in my own house! There's an immediacy to our interaction, and I've shared things with him I've never shared with any other therapist." Gabriela says that in face-to-face therapy she sometimes edited what she was saying to avoid negative facial reactions by the therapist; chat therapy has allowed her to be "completely honest."

Linda and Gabriela are each clients of therapist Carl Benedict, who is based in Hagerstown, Md. Linda is 2,653 miles away in San Diego, Calif.,

FAST FACTS

Remote Consultations

1» Research now demonstrates that psychotherapy delivered via e-mail, video, chat, voice or texting can effectively treat cognitive, emotional and behavioral disorders.

2» Even brief therapeutic communiqués using mobile phones can help combat eating disorders, alcohol abuse, cigarette smoking and anxiety, among other problems.

3» The number of electronic tools for treating mental health troubles is rapidly increasing.

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# of Age

electronic devices can benefit patients

By Robert Epstein

and Gabriela is 4,235 miles away in Munich, Germany.

Can therapy really be effective over a distance of thousands of miles? What is distance, anyway? Can geographical distance be great and psychological distance small? As a research psychologist with a long-standing interest in technological issues, I decided to review the state of the field.

Researchers, patients and mental health practitioners have long applauded some aspects of therapy at a distance: it is low-cost and easy to schedule, protects clients' privacy, shields both therapist and client from the possibility of physical or sexual abuse, and makes expertise available for rare conditions wherever it is needed [see "The Promise of E-Therapy," by Beryl Lieff Benderly; Scientific American Mind, December 2005]. Now new research demonstrates that distance therapy is, in fact, effective. Indeed, much of the skepticism that has long surrounded these modes of treatment is disappearing.

In their office in Second Life, a virtual world (*left*), therapists DeeAnna Merz Nagel and Kate Anthony train other professionals to conduct e-therapy. In a mock chat therapy session (*right*), "Clara" counsels "Mary."

Avalanche of Evidence

Studies have repeatedly verified the power of therapy delivered by remote means: chat, e-mail, video, phone and texting. Azy Barak, a counseling psychologist at the University of Haifa in Israel, has compiled a list of studies and commentaries on e-therapy that contains 983 articles dating to 1993. Most of the articles are recent [*see box on opposite page*]. In 2008 Barak and his colleagues analyzed the results of 92 studies that collectively evaluated nearly 10,000 people who had had some form of electronically delivered therapy and determined that it is about as effective as the face-to-face variety.

In 2009 psychologist Lisa K. Richardson of Murdoch University in Australia and her colleagues, reviewing 148 articles published since 2003, noted that some studies were flawed methodologically (mainly because they lacked randomized controlled trials) but nonetheless concluded that "high levels of satisfaction and acceptance with tele-mental health have been consistently demonstrated among patients across a variety of clinical populations and for a broad range of services." In another review article from 2009 psychologists at the University of Southern Indiana and the University of Manchester in England concluded that e-therapists and their clients can form real, meaningful therapeutic alliances and that many traditional face-to-face therapists underestimate the warmth and depth of the connections that are formed.

Even more impressive, psychologists Kristin Heron and Joshua Smyth of Syracuse University found in a 2010 study that "momentary" therapeutic interventions using mobile phones are helpful in the treatment and management of eating disorders, alcohol abuse, cigarette smoking, anxiety and other problems. Because such brief communiqués are easy and cheap to deliver, they are ideal boosters for traditional treatment. Imagine helpful periodic tweets from your therapist arriving within hours or even minutes of when you might have lost your temper or reached for a cigarette.

Given the positive findings, the professional associations have been coming onboard. The American Counseling Association, the National Association of Social Workers and other societies now have official e-therapy guidelines for practitioners, and the American Psychological Association has given therapy at a distance tacit approval: the organization now matter-of-factly mentions e-therapy in the introduction to its code of ethics as one of several therapeutic modalities. According to clinical psychologist Gerald P. Koocher of Simmons College, "the important thing is that you're practicing competently, no matter how you're delivering the therapy."

No One Knows You're a Dog

That said, e-therapy still presents special problems. Although empirical data are not yet available to decide the issue, 2005 and 2009 position statements issued by the American Psychiatric Association claim that distance therapy most likely works best when the initial contact is face-to-face. One client I spoke to, Annie (not her real name), a 45-year-old from Boston, wanted to continue her treatment for an eating disorder after her therapist, Karen Koenig, moved to Florida. The therapy has continued smoothly by phone, but Annie doubts it could have started that way. A singular bond with a provid-

(The Author)

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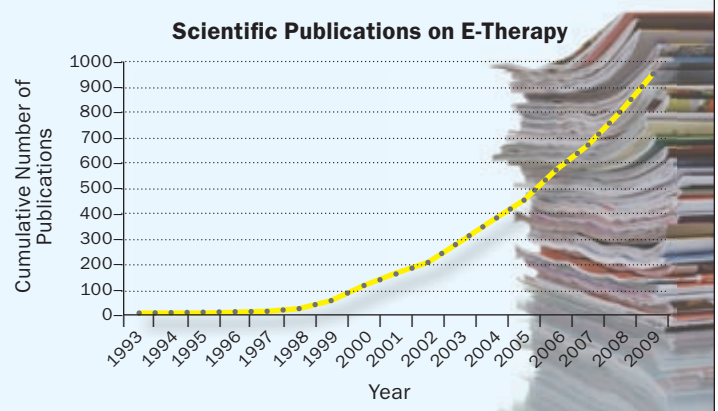
COURTESY OF LINDEN RESEARCH, INC. (*Second Life screenshot*); COURTESY OF *THERAPY ONLINE: A PRACTICAL GUIDE*, BY K. ANTHONY AND D. M. NAGEL, SAGE PUBLICATIONS, 2010 (*transcript*)

Counting on E-Therapy

Nearly 1,000 articles about e-therapy have appeared in scientific journals since 1998, about two thirds of them within the past five years. Before 1998 there were only five or six articles on the topic.



Graph based on "References: Internet-Assisted Therapy & Counseling," compiled by Azy Barak (http://construct.haifa.ac.il/~azy/refthrp.htm)

er often forms in person, even if little is said in the encounter.

The challenge, Koocher suggests, is figuring out what works for whom. Some people might take a therapist more seriously if signs of authority are present: a jacket and tie, for example, or a conservative-looking office with framed diplomas on the wall. "If you really need to be in a room with a therapist," he says, "remote treatment is probably not for you, even if you have a great Skype connection."

Koocher worries, too, about the potential for fraud, recalling a cartoon in which one dog is talking to another while typing on a keyboard. The caption reads, "On the Internet, nobody knows you're a dog." Organizations such as the International Society for Mental Health Online and the newly formed Online Therapy Institute are giving consumers ways of verifying that online therapists are licensed and qualified. But cyberspace is vast and largely unregulated, with ample room for charlatans. One recent survey of 136 Web sites offering counseling found low compliance with standards recently established by the National Board for Certified Counselors.

Licensing regulations create a quagmire as well, because therapists are licensed to practice only in their own state. Does texting or Skyping from an office in a state qualify as practicing in that state? If not, malpractice suits filed against therapists delivering treatment across state lines could freeze all exchanges with remote patients. Umbrella organizations such as the Association of State and Provincial Psychology Boards are trying to iron out these matters. Another downside to distance: a far-flung therapist is in a poor position to handle mental health emergencies.

It's Only the Beginning

But even as I was becoming more confident about the legitimacy and staying power of e-therapy, I realized that the same forces rapidly spawning these new therapeutic modalities will soon make them seem passé. Research has shown, for example, that blogging and computer games can be therapeutic for some disorders, perhaps because they give people ways of releasing pent-up tensions. Sophisticated artificial-intelligence software is now augmenting or administering some forms of treatment, reducing the need for the human therapist. Autistic children are benefiting from specially designed smiley-faced robots that interact with the kids with a patience no human can muster.

Virtual-reality programs can help treat psychological problems such as phobias, eating disorders and post-traumatic stress disorder [see "Fantasy Therapy," by Nikolas Westerhoff; Scientific American Mind, October/November 2007]. People can also reap significant emotional and behavioral benefits from the activities of their avatars [see "Your Avatar, Your Guide," by Samantha Murphy; Scientific American Mind, March/April 2011], and two real therapists have now set up shop in the 90-million-strong Second Life virtual world, where their avatars are tending to other avatars—and the real people behind them.

Within the next five to 10 years upward of a billion people worldwide are expected to spend much of their time in virtual communities, where, undoubtedly, both human and software therapists will have no shortage of virtual customers. Meanwhile other nontraditional therapies are advancing, such as new pharmaceuticals and direct brain stimulation. Although traditional, face-to-face therapy will likely continue to be practiced for decades, it will undoubtedly play a smaller and smaller role in the extraordinary world of therapeutic intervention that lies ahead. M

(Further Reading)

- **A Comprehensive Review and a Meta-Analysis of the Effectiveness of Internet-Based Psychotherapeutic Interventions.** A. Barak, L. Hen, M. Boniel-Nissim and N. Shapira in *Journal of Technology in Human Services,* Vol. 26, pages 109–160; 2008.
- **Current Directions in Videoconferencing Tele-Mental Health Research.** L. K. Richardson, B. C. Frueh, A. L. Grubaugh, L. Egede and J. D. Elhai in *Clinical Psychology: Science and Practice,* Vol. 16, pages 323–338; 2009.
- **Therapy Revolution: Find Help, Get Better, and Move on without Wasting Time or Money.** R. M. Zwolinski and C. R. Zwolinski. Health Communications, 2009.
- **Therapy Online: A Practical Guide.** Kate Anthony and DeeAnna Merz Nagel. Sage Publications, 2010.
- **The Use of Technology in Mental Health: Applications, Ethics and Practice.** Kate Anthony, DeeAnna Merz Nagel and Stephen Goss. Charles C. Thomas, 2010.

HELDER ALMEIDA *iStockphoto (stack of journals)*

Can Positive Thinking Be Negative?

Research suggests limits to looking on the sunny side of life

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

"ACCENTUATE the positive," the 1944 song by Johnny Mercer and Harold Arlen cheerfully implored us. From Benjamin Franklin's 1750 *Poor Richard's Almanack* (which advised readers that "sorrow is good for nothing but sin") to today's parade of motivational speakers, Americans have long embraced an optimistic, "can-do" attitude toward life. Plug "positive thinking" into Amazon.com, and you will find a never-ending supply of products designed to help us see life through rose-colored lenses, including a "Power of Positive Thinking" wall calendar and an "Overcoming Adversity with Encouragement and Affirmation" poster series.

In fact, however, positivity is not all it is cracked up to be. Although having an upbeat attitude undoubtedly has its benefits, gains such as better health and wealth from high spirits remain largely undemonstrated. What is more, research suggests that optimism can be detrimental under certain circumstances.

Pluses of Pessimism

Despite the popular emphasis on positive thinking, academic psychology was for many decades centered on the negative. Even today a perusal of the typical psychology textbook reveals a predominance of topics dealing with the dark side of life—mental illness, crime, addiction, prejudice and the like—probably reflecting an aim to remediate these personal and social problems.

Then, in the late 1990s, a cadre of prominent psychologists led by University of Pennsylvania psychologist Martin E. P. Seligman established a field called positive psychology. This burgeoning discipline explores the causes and consequences of happiness, character strengths and virtues, resilience, and other important aspects of psychological adaptation and health. Not all positive psychologists push cheerfulness at any cost—in a 1990 book Seligman warned that optimism "may sometimes keep us from seeing reality with the necessary clarity." But many do advocate a perspective that implies that positive thinking is good for all of us, all of the time, noted Bowdoin College psychologist Barbara Held in a 2004 article.

In fact, much of the data supporting solid benefits from positive thinking is weak. According to a 2010 review by Cornell University psychologist Anthony Ong, although most studies show that optimistic people tend to be physically healthier than others and they may also live longer, these findings come from correlational studies, which examine statistical associations between positive thinking and life outcomes but cannot tell us about cause and effect. Thus, thinking positively might make us healthier, but

Pessimists were less prone to depression than were optimists after experiencing **negative events** such as a friend's death.

COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); COURTESY OF HAL ARKOWITZ (*Arkowitz*); GETTY IMAGES (*balloons*)

being healthier may instead lead us to think positively. Another interpretation of the same results: positive thoughts and good health are the result of a third factor—being highly energetic, say—that was not measured in most of these studies. The same ambiguity plagues most studies purporting to show that optimism can lift depressed moods or boost job performance.

Even if more optimistic results about optimism eventually surface, a rosy outlook is unlikely to benefit everyone. Defensive pessimists, for example, tend to fret a great deal about upcoming stressors such as job interviews or major exams, and they overestimate their likelihood of failure. Yet this worrying works for these individuals, because it allows them to be better prepared. Work by Wellesley College psychologist Julie Norem and her colleagues shows that depriving defensive pessimists of their preferred coping style—for example, by forcing them to "cheer up"—leads them to perform worse on tasks. Moreover, in a 2001 study of elderly community participants, Seligman and Brandeis University psychologist Derek Isaacowitz found that pessimists were less prone to depression than were optimists after experiencing negative life events, such as the death of a friend. The pessimists had likely spent more time bracing themselves mentally for unpleasant possibilities.

Another study calls into question the healing power of positive affirmations—those ubiquitous fixtures of pop psychology parodied by former comedian Al Franken as counselor Stuart Smalley ("I'm good enough, I'm smart enough, and doggonit, people like me"). In a study published in 2009 University of Waterloo psychologist Joanne Wood and her colleagues found that for participants with high self-esteem, repeating a positive affirmation ("I am a lovable person") multiple times indeed resulted in slightly better moods right afterward. But among those with low self-esteem, the positive affirmations backfired, resulting in worse moods. Wood and her colleagues conjectured that statements like Smalley's ring hollow in the minds of individuals with low self-esteem, serving only to remind them of how often they have fallen short of their life goals.

Positive thinking can often prod us to take reasonable risks. Too much optimism, however, could lead us to ignore real dangers.

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Too Much of a Good Thing?

Another potential hitch in the positive-thinking movement is that a sanguine attitude may be unhealthy when taken to an extreme, because it can become unhinged from reality. In a 2000 article University of Michigan psychologist Christopher Peterson, a founder of the positive psychology movement, distinguished realistic optimism, which hopes for the best while remaining attuned to potential threats, from unrealistic optimism, which ignores such threats.

A 2007 study by University of Virginia psychologist Shigehiro Oishi, University of Illinois psychologist Ed Diener and Michigan State University psychologist Richard Lucas reinforces Peterson's concerns. Using analyses from several large international samples, they found that although extremely happy people are the most successful in close interpersonal relationships and volunteer work, moderately happy people are more successful than extremely happy people financially and educationally and are also more politically active. Admittedly, Oishi and his colleagues measured happiness rather than optimism per se, although the two tend to be fairly closely associated. Still, their findings raise the possibility that although a realistically positive attitude toward the world often helps us to achieve certain life goals, a Pollyannaish attitude may have its costs—perhaps because it fosters complacency.

Positive thinking surely comes with advantages: it may encourage us to take needed risks and expand our horizons. But it has downsides as well and may not be for everyone, especially those for whom worrying and kvetching come naturally as coping mechanisms. Moreover, positive thinking may be counterproductive if it leads us to blithely ignore life's dangers. Finally, as journalist Barbara Ehrenreich warns in a 2009 book, the pervasive assumption that positive attitudes permit us to "think our way out of" illnesses such as cancer has an unappreciated dark side: it may lead people who fail to recover from these illnesses to blame themselves for not being more chipper. **M**

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Send suggestions for column topics to editors@SciAmMind.com

(Further Reading)

- **Positive Psychology: An Introduction.** M.E.P. Seligman and M. Csikszentmihalyi in *American Psychologist,* Vol. 55, pages 5–14; 2000.
- **The Negative Side of Positive Psychology.** B. S. Held in *Journal of Humanistic Psychology,* Vol. 44, No. 1, pages 9–46; January 2004.
- **Bright-Sided: How the Relentless Promotion of Positive Thinking Has Undermined America.** Barbara Ehrenreich. Metropolitan Books, 2009.

Looming Deadlines

How the pressure of a due date distorts our perception of time

BY WRAY HERBERT

THIS TIME OF YEAR is deadline season for many people. It seems that wherever we look, there is a clock or a calendar pressuring us to move faster and stop dawdling. For some it is the end-of-semester crush, with papers to write and books to digest and comprehend, whereas others are rushing to tidy up a hundred loose ends before that big family vacation. Whatever the precise reason, the lament is the same: so much to do, so little time!

But do we really have too little time? Are these deadlines really looming, or do we in fact have more leisure than we imagine? It is always tricky to think about time, and new research now suggests that deadline pressure might contribute to our distorted view of how much time we really need to get everything done.

Psychological scientist Gabriela M. Jiga-Boy of Swansea University in Wales studies the complex relation between effort and time perception. She and her colleagues—Anna E. Clark of the international research institute INSEAD and Gün R. Semin of Utrecht University in the Netherlands—wanted to see if the perceived difficulty and deadline pressure of a task might distort our perception of time. They were inspired by another line of research, which has shown that spatial perception is shaped by how effortful a task is: for example, we will perceive a hill as steeper than it really is if we are tired, old or burdened by a heavy weight. Jiga-Boy and her colleagues wondered if the same perceptual bias might skew the way we think about the near future, and they ran a series of experiments to explore this idea.

The experiments are fairly straightforward. In one, for instance, they asked a group of student volunteers to imagine that 28 events would occur at certain points in the future, without pinning the events to any exact dates. Some of these events were fairly effortless, such as getting tickets for a concert, whereas others were complex and effortful, such as planning a wedding. The volunteers

> The tasks that the students judged **complex and difficult** seemed more distant than did less demanding activities.

MATT MENDELSON (*Herbert*); CJ BURTON *Corbis (man and calendars)*

Simply **imposing a deadline** reversed the mind's relation between work and time. Difficult tasks loomed all too close.

were then asked to estimate how much work each of these activities would require of them. They were also asked: How far away does the day of the event feel to you?

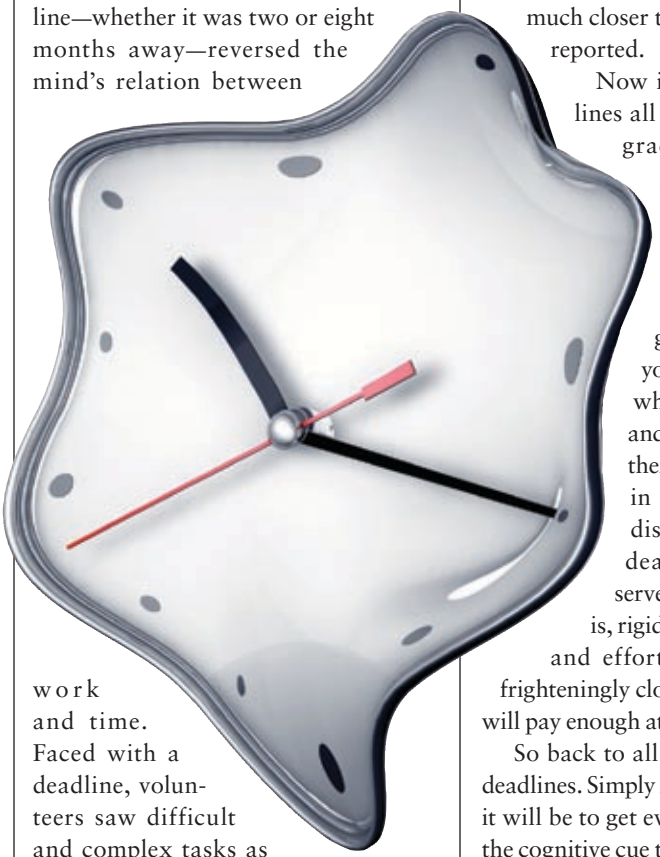
The idea was to see if the difficulty of the task affected perception of time, either stretching or compressing it. And it did, clearly. The tasks that the students judged complex and difficult—planning a wedding or an elaborate vacation—seemed more distant than did less demanding activities. In other words, our minds translate complexity and effort into time: a demanding task requires more time to complete, so its completion *must* be farther off.

The Clock Is Ticking

This logic is not sound, of course. It is the primitive mind simplistically equating effort and time. Just as anticipated exertion makes us see hills as steeper than they really are, so, too, do we perceive demanding tasks as stretching out farther into the future. But the mind learned to make these basic connections long before the modern world came up with things such as clocks and calendars—and final exams and vacation schedules and other deadlines. Jiga-Boy and her colleagues thought the imposition of such modern deadlines might alter this kind of time perception, a notion that they tested in a different set of experiments.

These experiments were similar to the ones described earlier, this time with deadlines added. For example, volunteers again visualized tasks of varying complexity, but some were given a deadline two months away, and others were given one eight months down the road. And again, all the volunteers were asked how far away the event felt to them.

The results, described in the December 2010 issue of the journal *Psychological Science*, were intriguing. In contrast to the earlier findings, now the more effortful events felt *closer* in time—not farther away. Simply imposing a deadline—whether it was two or eight months away—reversed the mind's relation between work and time. Faced with a deadline, volunteers saw difficult and complex tasks as looming all too close.



Finally, to check that the results indeed apply to real-world scenarios, Jiga-Boy and her colleagues recruited a new group of volunteers for one last test. The volunteers were told they were part of a health study and would be monitoring their food intake and reporting back to the researchers in a month. Some of the subjects were instructed to record what they ate on any two days and submit a half-page report, whereas others were asked to record their meals for two weeks and submit a 10-page report. When asked how far away the deadline seemed, those who had the more effortful task reported that the end of the month felt much closer than the other subjects reported.

Now imagine several deadlines all at once—final exams, graduation ceremonies, perhaps a wedding or a European vacation—not to mention all of your regular commitments, which do not go away. No wonder you are feeling quite overwhelmed. But Jiga-Boy and her co-workers believe there may be a silver lining in these findings. These distorted perceptions of deadline pressure may serve a good purpose. That is, rigid deadlines for complex and effortful tasks may loom frighteningly close for a reason—so we will pay enough attention to them.

So back to all those looming spring deadlines. Simply knowing just how hard it will be to get everything done is itself the cognitive cue that helps us to prepare and plan and keeps us conscientious so we can respond to the challenges that lie ahead. Thanks to the mind's tricks, all those term papers *will* get written and the vacation will get planned—just as they do every year. M

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

WRAY HERBERT is senior director for science communication at the Association for Psychological Science.

(Further Reading)

◆ **So Much to Do and So Little Time: Effort and Perceived Temporal Distance.** Gabriela M. Jiga-Boy, Anna E. Clark and Gün R. Semin in *Psychological Science,* Vol. 21, No. 12, pages 1811–1817; December 2010.

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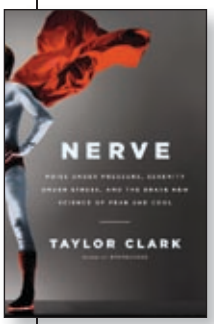
books

ANXIOUS WORLD

Nerve: Poise Under Pressure, Serenity Under Stress, and the Brave New Science of Fear and Cool



by Taylor Clark. Little, Brown, 2011 ($25.99)

What is the most common mental health issue in America? You might be tempted to say depression. But you would be wrong.

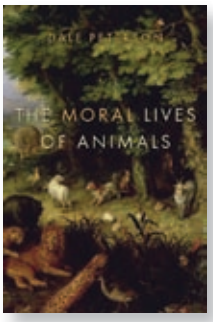
According to the Centers for Disease Control and Prevention, anxiety disorders now take the top spot, with 18 percent of Americans suffering from one. In his new book *Nerve,* journalist Taylor Clark begins by highlighting our extreme levels of anxiety, writing that the average high school student today has the same anxiety level as a psychiatric patient did in the 1950s and that Americans are five times as likely to suffer from anxiety as Nigerians, who arguably have more to fear.

Clark does not spend much time speculating on how we became a society awash in worry. He does something perhaps more significant—he clarifies what anxiety is and how we can treat it. There is, Clark says, a "nervous trinity" that can wreak havoc on our minds: anxiety, fear and stress. Fear primarily involves the amygdala, the emotional memory center of the brain. The amygdala evaluates the significance of a potential threat and triggers emotional responses such as freezing or fleeing. Anxiety is more of a cognitive problem, with a locus in the prefrontal cortex—a region of the brain that helps us plan ahead. Anxious people tend to focus on possible future threats, such as "Will I lose my job?" or "Will I get run over by a car?" Stress is harder to pin down but generally signifies the body's response to feeling overwhelmed and may show up as a range of physical and emotional symptoms, including worry, moodiness, depression or overeating.

Experiencing these feelings can make life miserable, but the good news is it is possible to overcome them. Clark relays the stories of people who have worked to beat their anxious tendencies and discusses techniques readers can use to do the same. For instance, he writes that simply accepting that bad things will happen and facing problems head-on can alleviate anxiety. To this end, Clark quotes philosopher Søren Kierkegaard as saying, "We cannot mature and be fully creative by burying or displacing anxiety, but only by moving through it." —*Frank Bures*

MAMMAL ETHICS

The Moral Lives of Animals



by Dale Peterson. Bloomsbury Press, 2011 ($26)

In the summer of 2000 scientists saw a young elephant collapse and die on a trail in the African forest. In the following hours, elephants passing by attempted to help and revive her by lifting her dead body off the ground.

In *The Moral Lives of Animals,* Tufts University lecturer Dale Peterson argues that this kind of behavior provides evidence that humans are not the only animals that developed a sense of morality—other mammals, among them elephants, dolphins and chimpanzees, also have strong impulses for cooperation, kindness and fairness. Peterson, a long-time collaborator of primatologist Jane Goodall, makes the case that the morality of animals, such as humans, requires obeying certain social rules and evolved as a means to mediate conflicts that inevitably arise within communities.

Peterson asserts that animals are capable of exhibiting moral behaviors because these behaviors do not require advanced intellectual capabilities—they only result from strong emotional

» Roundup: **Neuroscience of Bullying**

Three new books reveal how we deal with suffering and trauma.

A child who is bullied by her playmates may kick her kitten in retaliation. Passing pain to others is not just a human trait—payback can also be seen in many animals. In **Payback: Why We Retaliate, Redirect Aggression, and Take Revenge** (Oxford University Press, 2011), husband-and-wife team evolutionary biologist David Barash and psychiatrist Judith Lipton explain how we evolved such vengeful behavior, why it occurs (it turns out our brains are hardwired to redirect hostility), and how we can prevent it.

At age five Boris Cyrulnik was orphaned after his parents were deported to a concentration camp. In **Resilience** (Tarcher/Penguin, 2011), Cyrulnik, now a renowned neuropsychiatrist, relays his personal trauma as well as the stories of people who survived war, genocide and other painful experiences. Through his research, Cyrulnik discovers how resilient humans are. He reveals, for instance, that an abused child's brain can return to normal size if the child is placed with a loving foster family.

Humans have a tendency to dehumanize other humans. In **Less Than Human: Why We Demean, Enslave and Exterminate Others** (St. Martin's Press, 2011), David Livingstone Smith posits that this behavior is rooted in human nature. Smith, a professor of philosophy at the University of New England, explores the history, psychology, biology and philosophy of how humans perpetuated atrocities such as the Holocaust and the genocide in Rwanda. —*Victoria Stern*

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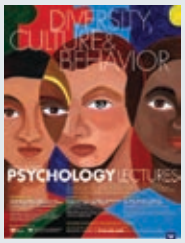
podcast



DISCOVERING US

Allen L. Edwards Psychology Lecture Series

University of Washington
Free podcasts available at www.uwtv.org

The question of what makes us us—what determines the choices we make, the world we see and the way we speak—is arguably one of psychology's greatest and most compelling mysteries. It is also a topic rife with groundbreaking research. And every year the University of Washington invites a handful of the world's leading psychologists to deliver lectures on the newest advances in behavioral research.

Named after Allen Edwards, a former Washington professor who revolutionized psychology research with novel statistical techniques, the series delves into a hodgepodge of topics, from addiction to vision. In one of the lectures in 2010, for instance, University of Oregon psychologist Philip Fisher explains that childhood neglect is often a stronger predictor of future behavioral problems than abuse. Most people "think about kids being at risk because of bad things that happen to them," he explains. But when there is an "absence of expected input from the world around them," Fisher says, the physiological systems involved in stress, mood and emotions shut down, leaving children unable to cope with everyday problems.

Watching hour-long research lectures might sound tedious, but the presenters find creative ways to keep the audience engaged. In her talk, Jennifer Fewell, a professor of life sciences at Arizona State University, illustrates the importance of insect social networking—the way ants or bees collectively work together, which Fewell believes can provide insight into individual behavior—using a professional basketball team, the Phoenix Suns. The Suns have been successful, in part, because point guard Steve Nash passes the ball quickly and never to just one teammate, making it difficult for defenders to know where it is heading, she says. But when superstar Shaquille O'Neal joined the team in 2008, the Suns immediately started losing, most likely because he destroyed the team's dynamics. "Everybody there on the floor knew where that ball was going to go—it was going to go to Shaq," she explains. "It's a good example that the success of an individual depends on the network, and the success of the network depends on the individual."

Among the most interesting recent lectures are two dedicated to our brain's unique capacity for language. "The truly amazing thing about humans is that we can transmit an essentially limitless set of meanings to other people," notes Lee Osterhout, a psychology professor at Washington, in one lecture. "We don't know where the limits are, if there are any." In a way, the lecture series as a whole makes this point: it is astounding how much knowledge each talk imparts about behavior through just an hour of spoken language.

—Melinda Wenner Moyer

responses: "A bully makes you angry. A cheater leaves you depressed." Some of Peterson's stories illustrate animal emotions vividly, such as accounts of elephants committing suicide. Peterson writes that loggers in Myanmar (Burma) capture and train elephants to help with timber extraction. The taming procedure can be so distressing to the animals that some cut off their own air supply by stepping on their trunks.

Peterson also presents evidence that mammals can distinguish right from wrong. For example, a primatologist at a Tanzanian research site once tried to distract a chimp by pretending he had seen something intriguing in the distance. The chimp fell for the deception and went to explore but soon returned and slapped the mischievous primatologist on the head. Peterson interprets the chimp's reaction as evidence that he recognized the researcher's deceit as immoral and punished him.

Although the underlying motivations for many of these behaviors are a matter of interpretation, *Moral Lives* is a thought-provoking read that glimpses into the minds and behaviors of mammals. *—Nicole Branan*

R. MICKENS *American Museum of Natural History*

event

BRAIN ON DRUGS

SciCafe

American Museum of Natural History
Free admission, www.amnh.org/SciCafe

It's 7 P.M. in the Gottesman Hall of Planet Earth at the American Museum of Natural History in Manhattan and almost time for the monthly SciCafe. Tonight's topic: the effects that illegal drugs such as methamphetamine and cocaine have on the brain.

The speaker is Columbia University psychologist Carl Hart. After a short introduction, Hart hits the audience with a doozy. "What many of us have been told is that drugs destroy brain cells," he pronounces. "But the dose that's required to do that is so excessive, we don't usually see it." In other words, he says, the doses of meth and cocaine that most drug abusers take are not enough to harm the brain.

To bolster his point, Hart mentions a famous 2004 study in the *Journal of Neuroscience* that found that the volumes of the brain's limbic lobes and hippocampi—regions responsible for emotion, behavior and memory—in chronic meth users were 11 and 8 percent smaller, respectively, than in people who did not use drugs. At the time, the *New York Times* explained this result as "a forest fire of brain damage," but Hart counters this argument, stating that "the notion that these folks exhibit brain deficits or cognitive impairment is simply not supported by the weight of the evidence." Changes in brain volume are not necessarily indicative of cognitive impairment, he adds. In fact, studies have consistently shown the doses of methamphetamine drug users take boost cognitive function, not the other way around.

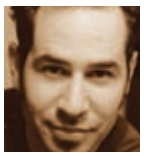
Hart's point is provocative, but that, he says, is entirely the point: "One of the instructions I was given when I accepted this invitation was, 'Don't bore people.'"

—Melinda Wenner Moyer

askthe**Brains**

Why can most people remember a color, but only a few can remember pitch?

—David Hardie, Perth, Australia



Robert O. Duncan, *a behavioral scientist at York College, the City University of New York, responds:*

ALTHOUGH MOST of us believe we are better at identifying colors than sounds, our ability to identify the exact frequency of light associated with a color is actually no better than our ability to name a pitch.

Our perception of visible light depends on context. You might go shopping for house paints, for example, and be shocked to find that the particular shade of white you selected in the store makes your kitchen look pink! You may have chosen the wrong shade of white because the ambient light in the store differs from that of your home. If we could accurately identify colors, we would never make such mistakes. People may think they are more adept at identifying colors, however, because they tend to associate hues with specific objects, which do not change. For instance, we will generally perceive an apple to be red because the light reflecting off its surface remains fairly constant from moment to moment.

In contrast, in hearing we identify objects, people and speech by the changes in frequency. For example, we can understand a sentence whether it is spoken by a girl with a high voice or a man with a low voice because the relative changes in frequency that occur as the girl and man recite the same words are about the same. In fact, speech and other sounds in the environment are always changing, which is likely why we have evolved to recognize changes in frequencies rather than any single pitch.

Although few people develop perfect pitch—the ability to precisely name the frequency of a sound—we have a remarkable ability to discriminate among different sounds. We can distinguish house cats from tigers, bicycles from motorcycles, and basketballs from Ping-Pong balls. We use the melodic properties of speech to discriminate a person's gender, identity and mood. We have an expansive musical memory that enables us to recall tens of thousands of melodies with ease. And with a modest degree of training, most musicians can develop relative pitch, the ability to identify an unknown tone in relation to a known tone.

Why do memories of vivid dreams disappear soon after waking up?

—Gil Greengross, via e-mail

Ernest Hartmann, *professor of psychiatry at Tufts University School of Medicine and director of the Sleep Disorders Center at Newton-Wellesley Hospital, explains:*

WE FORGET almost all dreams soon after waking up. Our forgetfulness is generally attributed to neurochemical conditions in the brain that occur during REM sleep, a phase of sleep characterized by rapid eye movements and dreaming. But that may not be the whole story.

Perhaps the most compelling explanation is the absence of the hormone norepinephrine in the cerebral cortex, a brain region that plays a key role in memory, thought, language and consciousness. A study published in 2002 in the *American Journal of Psychiatry* supports the theory that the presence of norepinephrine enhances memory in humans, although its role in learning and recall remains controversial.

A lack of norepinephrine, however, does not completely explain why we forget dreams so easily. Recent research suggests that dreaming lies on a continuum with other forms of mental functioning, which are all characterized by activity in the cerebral cortex. On the one side of this continuum is concentrated, focused thought; dreaming and mind wandering lie on the other, with some overlap among the types. The dreaming/reverie end involves some of the most creative and "far out" material. This type of less consciously directed thinking, however, is not easy to remember. Can you recall where your mind wandered while you were brushing your teeth this morning?

Many of our thoughts are lost, not just those we have while dreaming. We tend to recall only things that we think about often or that have emotional significance.

In general, we are very good at forgetting nonessentials. In fact, many of our thoughts, not just those we have while dreaming, are lost. We tend to recall only things that we think about often or that have emotional significance—a problem, a date, a meeting. Mulling over important thoughts activates our dorsolateral prefrontal cortex (DLPFC), a brain region that facilitates memory.

Although most dreams vanish, certain ones tend to remain. These dreams were so beautiful or bizarre, they captured our attention and increased activity in our DLPFC. Thus, the more impressive your dream or thought, the more likely you are to remember it. M

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

COURTESY OF ROBERT O. DUNCAN; COURTESY OF ERNEST HARTMANN

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Head Games

Match wits with the Mensa puzzlers

1 SQUARE RIDDLE

What is the missing letter?

C	Y	U	L	E	E	U	L
O		V		P		?	
A	N	S	O	T	H	Z	Z

2 PARTIAL QUOTE

The following is a Shakespeare quotation with its vowels and punctuation removed and the remaining letters organized into equal-size groups. Reconstruct the quotation.

THFLT DRBRT SSNTN RSTRS
BTNRS LVSTH TWRND RLNGS

3 CONFOUNDING COMPOUNDING

What single five-letter word can be placed in front of each of the following words to make a new word?

__ __ __ __ __ **SHOE**
__ __ __ __ __ **RACE**
__ __ __ __ __ **HAIR**
__ __ __ __ __ **HIDE**

4 WAIT FOR IT

Find the eight-letter word in the square below.

O	M	Y
N	N	
O	T	O

5 HAVE THEY TRIED E-MAIL?

There are 10 teachers in the correspondence school. Each of them must call and talk once a day with all the others, to keep the lesson plans up-to-date. How many calls, in total, are made every day by the staff?

6 FAMILY PLANNING

Jane is older than Susie. Susie is older than William. Lily is older than William but younger than Jane. Betsy is older than Susie but younger than Lily. Is Betsy older than William?

a. Yes

b. No

c. Can't tell from the information given

7 HE DOESN'T TEACH MATH

The absentminded professor bought some new house numbers at the hardware store. Unfortunately, he set the first and last of the three numbers upside down. Naturally, this confused the mail carrier, and one day the owner of the house with a number 297 less than the professor's real address turned up to complain. What is the professor's address?

8 THE PRICE IS RIGHT

If a marigold is worth $6, a daisy is worth $4, and a chrysanthemum is worth $8, what is a rose worth?

9 MYSTERY NUMBER

What is the five-digit number in which the first digit is three times the third digit, the second digit and the third digit added together will give you the fourth digit, and the fourth digit subtracted from the fifth digit will give you the third digit. The fourth digit is one more than the third digit, and the last digit is three more than the fourth digit. The first digit is two more than the last digit. There no zeros in the number.

10 MEET YOUR MATCH

The following matchstick puzzle states incorrectly that eight equals three (in Roman numerals). Can you change only one matchstick to make the equation correct? The spacing between matches may be different in the solution.

11 SCRAMBLER

What's the opposite of the scrambled word below?

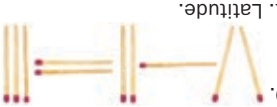
D L N E G U O T I

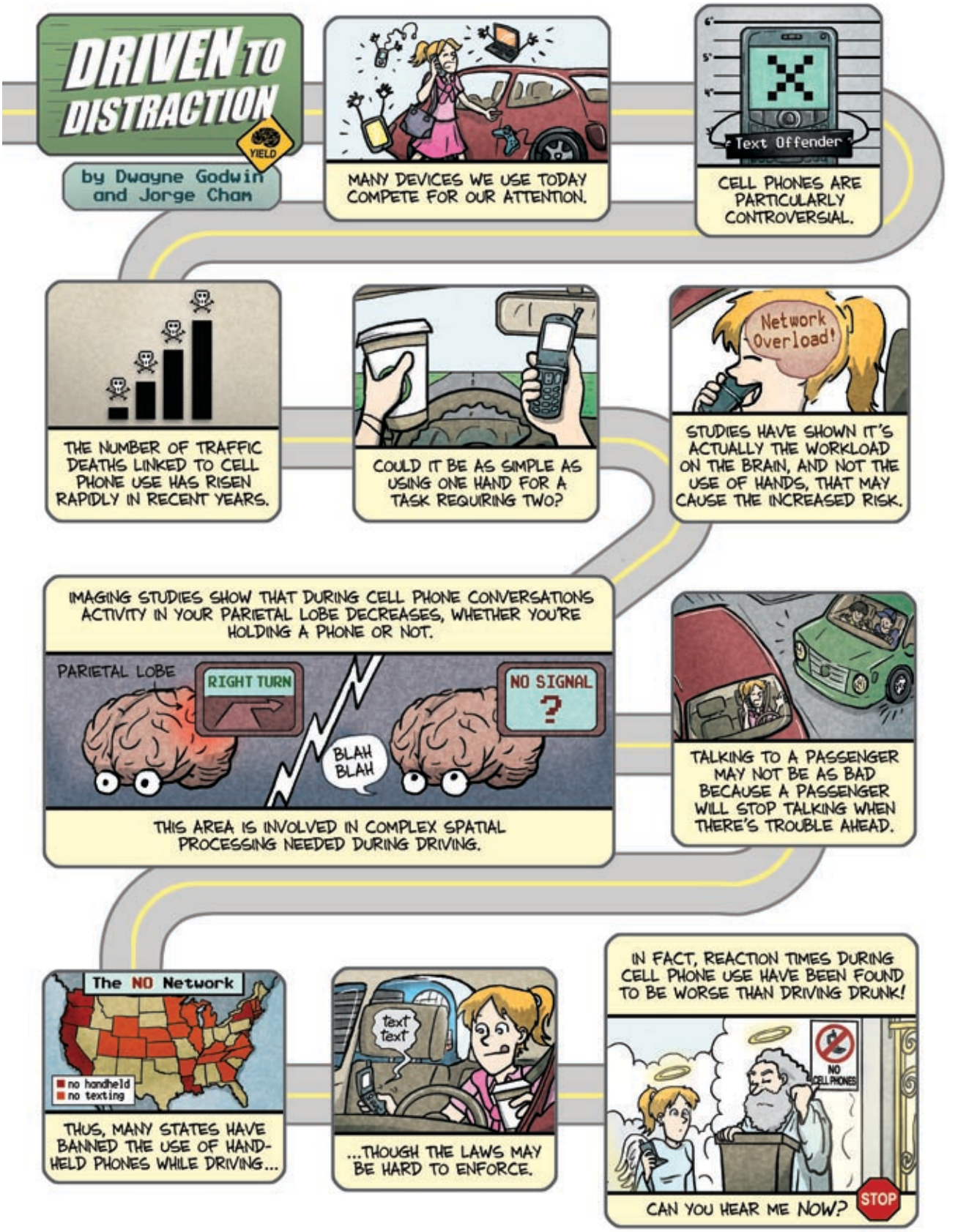
12 BUILDING UP

Fill in the sentence below with three words, each containing the letters of the previous word and one letter more.

__ young girl, with __ interest in cooking, bought a special __ to make crepes.

Answers

1. E. (The letters spell "CAN YOU SOLVE THE PUZZLE" when read counterclockwise around each square followed by its center.)
2. THE FAULT, DEAR BRUTUS, IS NOT IN OUR STARS, BUT IN OURSELVES, THAT WE ARE UNDERLINGS.
3. Horse.
4. Monotony.
5. 45.
6. a. Yes.
7. 906. (The professor put up "609.")
8. $2 (at $2 per syllable).
9. 91,347.
10. 
11. Latitude.
12. A, an, pan.



Dwayne Godwin is a neuroscientist at the Wake Forest University School of Medicine. Jorge Cham draws the comic strip Piled Higher and Deeper *at www.phdcomics.com.*

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