10 TOP ILLUSIONS OF THE YEAR page 58

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January/February 2013
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Wisdom from Psychopaths?
page 36

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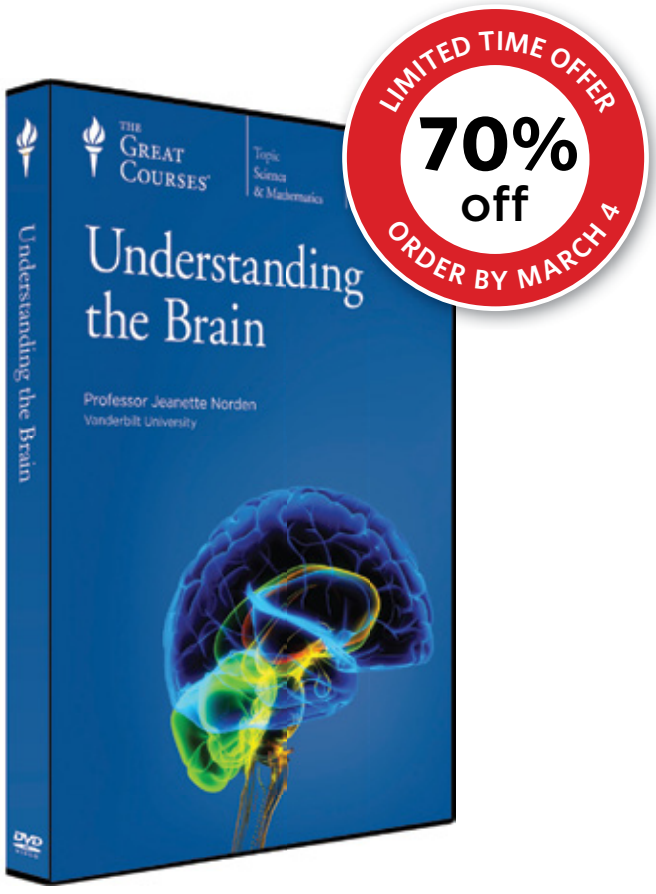

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Cultivating Optimism

This fall Hurricane Sandy famously knocked out power in lower Manhattan. A friend, I'll call her Natalie, was stranded in her cold, dark apartment for days. Most New Yorkers hunkered down with gritty reserve. Yet when I finally reached Natalie, she was bright and cheery. She spoke not about the lack of water or frigid nights but about the romance of living by candlelight and the kindness of neighbors.

This issue's lead article on subconscious mental habits reminded me of Natalie. Our brain's biases can predispose us to view the world through either a positive filter—as with Natalie—or a negative one, as psychologist Elaine Fox explains in "The Essence of Optimism," on page 22. An emerging therapy promises to help tune depressive or anxious minds to a happier channel.

Our brain's unreliable interpretations can sometimes lead to grave consequences, especially in the courtroom. Time can distort eyewitness testimony, for example, and a leading interrogation can extract a false confession. Psychologist Scott O. Lilienfeld and attorney Robert Byron explore the sources of error that can push the gavel toward an unsound ruling in "Your Brain on Trial." Turn to page 44.

The behavioral sciences can also learn lessons from criminals snared by the law. In "Wisdom from Psychopaths?" on page 36, psychologist Kevin Dutton interviews some of the scariest men in prison to discern how, in moderation, the common characteristics of psychopaths—such as charm, focus and ruthlessness—can spell success in various professions in the outside world.

If garnering insights from convicts seems counterintuitive, wait until you read about the mental benefits of first-person shooter games. Of course, concerns remain about how exposure to simulated violence affects players. But, as you will learn in journalist Lydia Denworth's "Brain-Changing Games," on page 28, recent studies show that these games improve visual acuity, spatial reasoning and decision making. Perhaps the optimists are right after all: every cloud has a silver lining.

Sandra Upson
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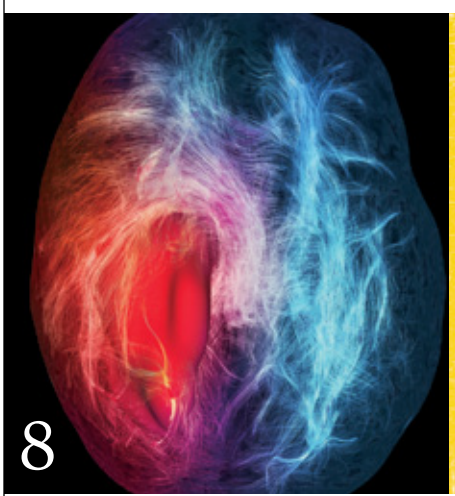
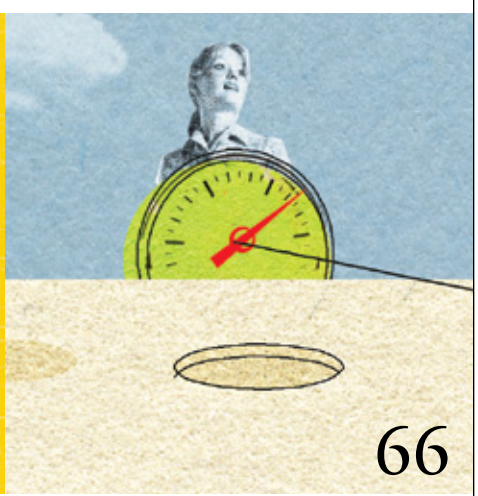
FEATURES

DEPARTMENTS





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SMELL-O-VISION

The cover illustration for the story "Dating in a Digital World," by Eli J. Finkel, Paul W. Eastwick, Benjamin R. Karney, Harry T. Reis and Susan Sprecher, places the two people in perfect position for the function of the vomeronasal organ. This tiny structure hides about one centimeter inside the nose in each nostril along the middle wall, where it can sample each inhalation for pheromones. Mating involves exchanging pheromones, which provide information used by the brain outside of conscious thought.

Until we develop some technique to transfer pheromone information via the computer screen, we will be at a loss to complete the biological process that initiates the mating protocol for our species.

Martin Zane
Hidden Hills, Calif.

Editors' note: For more information on the vomeronasal organ, see "Sex and the Secret Nerve," by R. Douglas Fields; Scientific American Mind, *February/March 2007.*

IS INTELLIGENCE FIXED?

In "Building Better Brains," John Jonides, Susanne M. Jaeggi, Martin Buschkuehl and Priti Shah summarize findings that they interpret to indicate that "fluid" intelligence—the ability to solve novel problems and adapt to new situations—can be increased to a statistically and practically significant degree through working memory training.

The scientific jury is still very much out on whether working memory training truly increases fluid intelligence. With our colleagues, two of us (Hambrick and Redick) recently published a failure to replicate the authors' widely cited 2008 finding, which they describe in "Building Better Brains," that working memory training increases fluid intelligence in young adults. A report of our study appeared online in June in the *Journal of Experimental Psychology: General.*

In a study in *Developmental Psychology* in May, a meta-analysis of the quantitative findings of 23 studies on working memory training—including studies by Jonides et al.—researchers Monica Melby-Lervåg and Charles Hulme found no convincing evidence that working memory training improves either adults' or children's fluid intelligence or scholastic outcomes.

It may turn out that working memory training has generalizable benefits for only some people, under only some circumstances, but it is far too soon to tell even that much. In the meantime, scientists should avoid portraying evidence for the efficacy of working memory training as more definitive than it is.

David Z. Hambrick
Michigan State University
Frederick L. Oswald
Rice University
Thomas S. Redick
Indiana University–Purdue University Columbus

THE AUTHORS RESPOND: *Hambrick and his colleagues' failure to replicate our findings must be taken in the context of research from at least three other independent laboratories that have successfully replicated our original work. As we pointed out in our article, inconsistent results across studies do not necessarily mean that the original finding is false but instead can provide a valuable opportu-*

nity to learn more about the underlying phenomenon.

The study procedure used by Hambrick et al. has several notable weaknesses. For instance, the time to administer each of the 17 tests was so short that measurement quality was probably somewhat questionable. Participants got the best score possible on some of the pretests, thereby giving them no opportunity to improve as a function of cognitive training. Finally, the training curves

Does brain training really result in higher intelligence and better performance in school?

of their participants were notably shallower than those of ours, and we have shown in published research that transfer is related to how well people train. Although we value failures to replicate that are scientifically sound, we have reason to doubt that the cited paper is one of these.

The current body of scientific literature that focuses on training of working memory is still rather small, as is shown quite impressively by the recent meta-analysis, which included only 23 studies with small sample sizes. The studies vary in procedures and subject populations, including children with ADHD and stroke patients. With that in mind, we think it is simply too early to conclude that working memory interventions are not effective. In "Building Better Brains," we acknowledge that there are many questions regarding the breadth and durability of training effects, but we argue that the prevailing evidence supports optimism that intelligence is not entirely fixed.

Editors' note: For more information about this topic, including a new study from the journal Intelligence *that found working memory training did not result in lasting improvements, see "Best Evidence for Brain Training Falls Short," a blog by* Scientific American *editor Gary Stix, at http://tinyurl.com/8r4pn9d*

SCIENCE BIAS

Regarding "Hard to Swallow," by Dwayne Godwin and Jorge Cham, the assumption of such a condescendingly dismissive attitude toward nonmainstream health care modalities reflects badly on a publication founded in scientific principles. One narrative caption makes the blanket statement that "alternative medicine practices, which have no scientific basis, may just be relying on this placebo mechanism." Although this is surely true of some practices, it is irresponsible to imply that such a description applies across the board.

The cartoon betrays a profound ignorance of the perspective being mocked ("I can feel my karmic energy flowing!" cries the acupuncture patient. Seriously?), not to mention the amassed evidence regarding Chinese medicine and various other modalities that at the very least merit more credit and intellectual curiosity than this comic gives them. What I see here demonstrates no scientific effort toward objectivity but rather the dogmatically barred and narrow outlook that so often poses on the pedestal of science.

Karli Nabours-Palermo, R.N.
Lake Charles, La.

GIVING TV TOO MUCH CREDIT

I wouldn't hasten to thank television's increasing portrayal of mental health issues for any apparent drop in associated stigmas, as Daisy Yuhas does in her article "Psychology: As Seen on TV!" Many of the TV shows cited in Yuhas's article depict mental illness in an extreme fashion, with no attempt to represent the humanity of mental illness sufferers let alone the complexity of their conditions. For this I doubt the creators of such shows are motivated by little else than ratings, which would explain their preference for the psychotic disorders and cases of OCD. I recently watched my first episode of *Criminal Minds*. Never have I been so quick to grab the remote control as when a character on the show pronounced: "Listen, doctor, my mother is a paranoid schizophrenic who's been institutionalized, so I know very well what mental illness looks like."

As long as there is no genuine exploration of mental health issues, with attempts to challenge rather than confirm the assumptions we uphold, it could hardly be considered progress if each and every TV show this century were to suddenly feature a shrink.

Chini Ogundare
Sydney, Australia

HELP END CAT ADDICTION

Tori Rodriguez's article about personality changes linked to cats and toxoplasmosis hardly seems to qualify as news. As the writer notes, the connection with schizophrenia and the advice that pregnant women not clean cat litter boxes have been around for a long time, so more common personality changes linked to *Toxoplasma* infections can't really be unexpected.

The big question is why can we not somehow end our culture's addiction to keeping cats as pets? Or at least find a way to ensure they and their owners (servants, staff?) are not infected. Isn't there a hue and a cry whenever any other popular part of our culture (for example, tobacco, trans fats) poses a significant health risk? How is it that cats are somehow immune to criticism but *Toxoplasma gondii* is not?

Joseph R. Sullivan
via e-mail

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>> MEDITATION

Focus on Yourself to Alleviate Social Pain

A training program in mindfulness reduces loneliness and social anxiety

Many people who suffer the pain, depression and negative health effects associated with social anxiety or loneliness do not respond to common therapy tactics or drugs. Two new studies offer hope from an unlikely source: rather than focusing on your relationships with others, turn inward for relief.

Mindfulness meditation—which has been around for well over 2,000 years—has many forms, but an extensive body of research supports the effectiveness of one training program in particular. Mindfulness-Based Stress Reduction (MBSR) is an eight-week program developed in 1979 by a U.S. physician. Initially created to help patients suffering from chronic pain, the program has been found to reduce symptoms of stress, depression and anxiety, even among people with cancer and HIV.

In one of the new studies, published in the October 2012 *Brain, Behavior, and Immunity,* 55- to 85-year-old adults were randomized to either receive MBSR or be put on a waiting list for the program. The loneliness of the participants who received MBSR decreased after training, whereas the loneliness of the wait-listed control subjects increased slightly. MBSR also reduced inflammation—the cause of loneliness-related health risks such as heart attack or stroke—as measured by levels of stress proteins and proinflammatory gene expression.

The other study, published online in August 2012 in *Social Cognitive and Affective Neuroscience,* found that MBSR reduced negative emotions in people with social anxiety disorder.

Mindfulness training teaches people to be fully attentive to their present experience in a nonjudgmental way, which is believed to help reduce the rumination common to mood disorders. "A mindful perspective teaches people how to apply a brake between a single lonely thought and what could be a resulting chain of distressing thoughts and feelings," says psychologist J. David Creswell of Carnegie Mellon University, co-author of the study on loneliness. To find an MBSR program in your area, go to http://tinyurl.com/findMBSR. *—Tori Rodriguez*

EVA TATCHEVA

>> AGING

Brains of "Super Agers" Look Decades Younger

A key attention region may underlie some octogenarians' unusual abilities

As people age, their brain tends to shrink and their memory gets worse. But what if this deterioration weren't inevitable? New research suggests not only that some elderly individuals retain sharp memory skills but also that their brain remains unscathed. Although scientists do not yet know what is responsible for this special resiliency—or how to help people acquire it—a brain region involved in attention may offer an important clue.

Researchers at the Northwestern University Feinberg School of Medicine identified 12 individuals older than 80 years—whom they called "Super Agers"—who performed as well on memory tests as a group of 14 volunteers between the ages of 50 and 65. The scientists performed structural MRI scans on both groups as well as a third group of normal subjects over the age of 80. Although the researchers expected the Super Agers' brains to show some evidence of age-related decline, their average brain thickness matched that of the younger group, and both groups' brains were significantly thicker than those of normal octogenarians.

One brain region important for attention, called the anterior cingulate, was actually thicker in the Super Agers than in their younger counterparts. This finding suggests that "Super Agers may have a particularly keen sense of attention that helps to support their memory," explains lead author Emily Rogalski, a neuroscientist at Northwestern's Cognitive Neurology and Alzheimer's Disease Center, who published the work in the *Journal of the International Neuropsychological Society.* In particular, compared with normal octogenarians, Super Agers have four times as many von Economo neurons, which are large cingulate brain cells implicated in higher-order thinking. In ongoing research, Rogalski hopes to tease out the genetic and lifestyle factors significant for preventing age-related decline, noting that according to her preliminary analyses, "there may be more than one way to becoming a Super Ager."

—Melinda Wenner Moyer

>> PERSONALITY

Death of a Salesman Stereotype

The most gregarious salespeople are not the most successful

Store managers and psychologists have long believed that outgoing individuals make the best salespeople. Yet research now suggests that extroverts are actually less successful at making sales than people with more moderate social temperaments. Adam Grant, associate professor of management at the Wharton School of the University of Pennsylvania, gave personality tests to 340 salespeople and compared their extroversion scores to their yearly revenue. Those who scored exactly halfway between the poles of extreme extroversion and extreme introversion—whom Grant calls "ambiverts"—earned 24 percent more than the introverts and, surprisingly, 32 percent more than the extroverts.

Grant—who is a self-described ambivert and a former salesman himself—says he is not sure why such individuals perform better, but it may be that "they're less likely to get distracted and to talk too much—they find the right balance between talking and listening." In addition, extroverted salespeople may sometimes be too pushy and turn potential buyers off.

Next, Grant plans to investigate whether successful ambiverts are always socially even-keeled or whether they tend to fluctuate between extroversion and introversion depending on factors such as mood or the temperament of their customers.

—Melinda Wenner Moyer

GETTY IMAGES (*left*); JOSH GOSFIELD *Corbis (right)*

We Solemnly Swear ...

1896

Year in which the first psychologist testified in court. Albert Von Schrenk-Notzing addressed witnesses' inaccurate memory recall during a murder trial.

412

Number of people exonerated in the U.S. after being implicated by mistaken witness testimony as of September 2012.

137

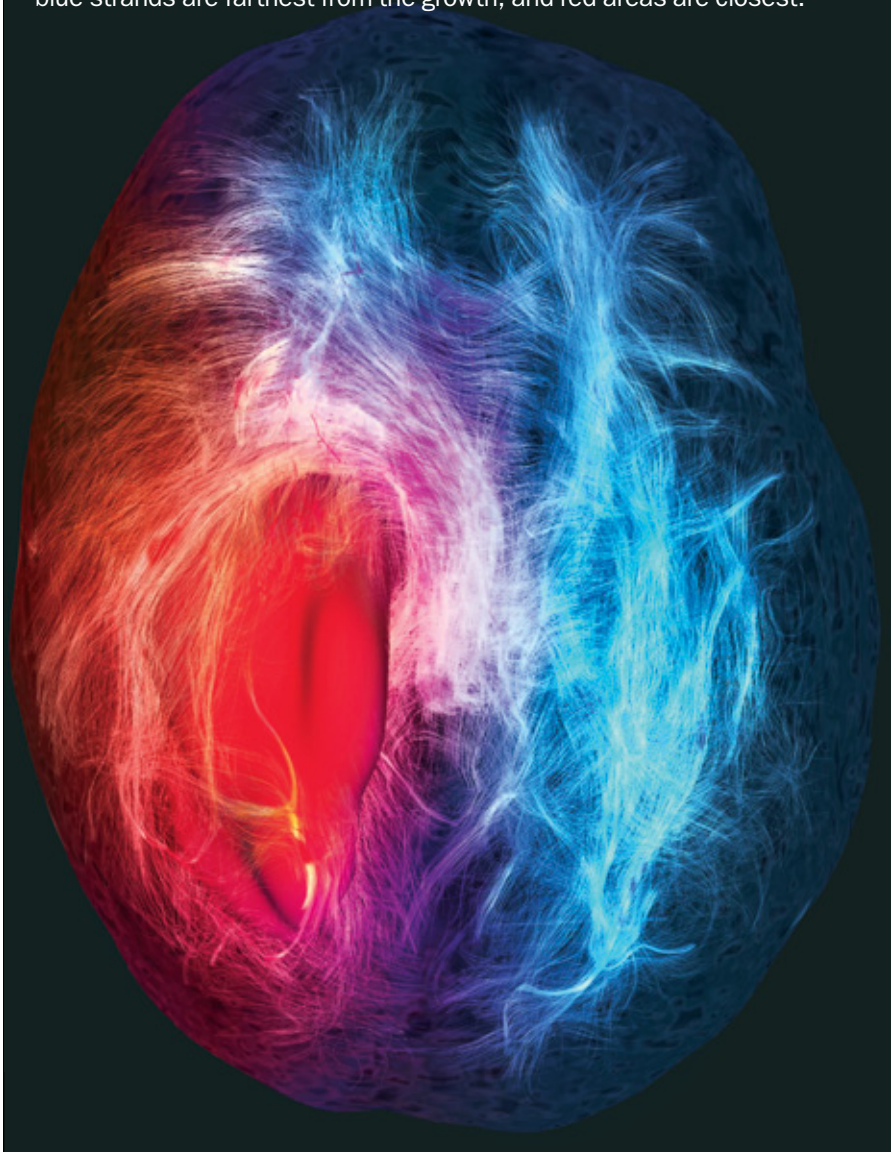
Number of people exonerated in the U.S. after being implicated by false confessions as of September 2012.

See page 44 for more.

Red Alert

>> VISIONS

A magnetic resonance image reveals a glioblastoma tumor (*red*) that has displaced the brain's white matter connections (*colored strands*). The color spectrum in this image gives surgeons vital pre-op information: blue strands are farthest from the growth, and red areas are closest.



435

Percent of Facebook users in New York City who stopped displaying their "friends" list publicly between March 2010 and June 2011, a new study shows. The shift suggests growing concerns about privacy.

>> PARENTING

How Co-Sleeping with an Infant Might Make You a Better Dad

Fathers who sleep next to children have lower testosterone levels

Co-sleeping, the practice of sharing a bed with your baby, has a controversial place in modern society. Proponents argue that it increases the parent-child bond, whereas detractors worry about safety. Now an anthropological study adds a new finding to the debate: fathers who sleep next to their babies tend to have significantly lower levels of testosterone than those who sleep in a different room.

Lee Gettler, an anthropologist at the University of Notre Dame, compared Filipino men's testosterone levels before having a child and again four years later. Men who reported sleeping on the same surface as their child experienced a steep decline in nighttime testosterone levels not seen in men who slept in another room, according to the paper published in September 2012 in *PLOS One*. Studies on women have shown that mothers who sleep with their children pass in and out of sleep. The same disruptions in men could possibly decrease testosterone production, Gettler and his co-authors write.

Previous work in the same population showed that fathers who fully throw themselves into caring for their children are more likely to have low testosterone, suggesting that hormonal fluctuations may support men in being good fathers. "Lower testosterone might orient men more toward the needs of the partner and children and away from risky behavior and competition with other males—which could conflict with investments in parenting," Gettler says. —*Morgen Peck*

COURTESY OF MAXIME CHAMBERLAND, DAVID FORTIN AND MAXIME DESCOTEAUX *Sherbrooke Connectivity Imaging Lab (left)*; GETTY IMAGES *(right)*

264 **Longest verified number of hours a person has gone without sleep.**

>> THERAPY

Can Eye Movements Treat Trauma?

Recent research supports the effectiveness of EMDR

Imagine you are trying to put a traumatic event behind you. Your therapist asks you to recall the memory in detail while rapidly moving your eyes back and forth, as if you are watching a high-speed Ping-Pong match. The sensation is strange, but many therapists and patients swear by the technique, called eye movement desensitization and reprocessing (EMDR). Although skeptics continue to question EMDR's usefulness, recent research supports the idea that the eye movements indeed help to reduce symptoms of post-traumatic stress disorder (PTSD).

Much of the EMDR debate hinges on the issue of whether the eye movements have any benefit or whether other aspects of the therapeutic process account for patients' improvement. The first phase of EMDR resembles the start of most psychotherapeutic relationships: a therapist inquires about the patient's issues, early life events, and desired goals to achieve rapport and a level of comfort. The second phase is preparing the client to mentally revisit the traumatic event, which might involve helping the person learn ways to self-soothe, for example. Finally, the memory processing itself is similar to other exposure-based therapies, minus the eye movements. Some experts argue that these other components of EMDR have been shown to be beneficial as part of other therapy regimens, so the eye movements may not deserve any of the credit. New studies suggest, however, that they do.

In a January 2011 study in the *Journal of Anxiety Disorders*, for example, some patients with PTSD went through a session of EMDR while others completed all the components of a typical EMDR session but kept their eyes closed rather than moving them. The patients whose session included eye movements reported a more significant reduction in distress than did patients in the control group. Their level of physiological arousal, another common symptom of PTSD, also decreased during the eye movements, as measured by the amount of sweat on their skin.

KARIN DREYER *Corbis*

One of the ways EMDR's eye movements are thought to reduce PTSD symptoms is by stripping troubling memories of their vividness and the distress they cause. A study in the May 2012 *Behaviour Research and Therapy* examined the effectiveness of using beep tones instead of eye movements during EMDR. The researchers found that eye movements outperformed tones in reducing the vividness and emotional intensity of memories.

Those studies relied on self-reports of symptom severity, however, so researchers at Utrecht University in the Netherlands sought more objective confirmation of a change in vividness by also measuring participants' reaction times to fragments of a previously viewed picture. The work, published online in July 2012 in *Cognition and Emotion*, compared two groups of participants who had committed one detailed picture to memory. When asked to recall the picture and focus on it mentally, one group was instructed to perform eye movements. That group had slower reaction times to the familiar picture fragments in a subsequent memory test, and subjects reported that the vividness of the recalled pictures had decreased.

These studies and others from the past several years have helped validate EMDR—so much so that the American Psychiatric Association, the International Society for Traumatic Stress Studies, and the Departments of Defense and of Veterans Affairs have deemed it an effective therapy.

Yet how it works remains unclear. Chris Lee, a psychologist at Murdoch University in Australia and co-author of the January 2011 study, says a common theory is that EMDR takes advantage of memory reconsolidation: every time we recall a memory, it is changed subtly when we file it away again. For instance, parts of the memory may be left out, or new ideas and feelings are stored alongside of it. Making eye movements during recall, Lee explains, may compete with the recollection for space in our working memory, which causes the trauma memory to be less intense when recalled again.

"Our experiments clearly show that negative autobiographical memories are very rich in sensory detail, and by pairing them with eye movements, they lose this sensory richness," Lee says. "People describe that the memories become less vivid and more distant, that they seem further in the past and harder to focus on. What follows after this distancing is a reduction in the associated emotional levels." In other words, the traumatic memory stays, but its power has been diminished.

—Tori Rodriguez

EMOTIONS

Ameliorate Anger and Anxiety

Mentally reframing a situation can ease negative feelings

LISA KIMBERLY Getty Images

We can't always avoid events that upset us, but we may be able to change how we feel about them. Psychologists have long been interested in framing, the mental angle we take when we process our experiences, as a method of moving past unwanted negative feelings. Two recent studies yield real-world tips for feeling better quickly:

Distance Yourself from Immediate Frustration

If you are cut off in traffic, you are likely to respond by blowing your horn. Chances are, you will spend the rest of your commute thinking about the actions of the jerk in front of you. Mentally taking a step back from the situation and your emotions, however—a process known as self-distancing—can diffuse your anger and reduce your aggression, researchers say.

Ohio State University psychology graduate student Dominik Mischkowski and his colleagues set out to annoy a group of student volunteers by leading them to believe they were waiting for a study to start. The researchers avoided answering questions and were generally curt. After confirming that the volunteers were indeed upset, Mischkowski asked them to reimagine the experience: half the group by reliving it through their own eyes and the other half by mentally moving away from the situation and watching it at a distance, as if it had happened to someone else. The self-distancing students had less anger and were less likely to respond aggressively to others in a subsequent task, according to results published in the September 2012 *Journal of Experimental Social Psychology*. This technique is useful, Mischkowski says, because prolonged anger can lead to stress, relationship difficulties and high blood pressure.

So the next time a car zips in front of you in traffic, don't focus on your anger from the driver's seat. Instead imagine yourself in a traffic helicopter, observing the entire scene. Take in the bigger picture, keep your emotions at arm's length and let the anger dissipate. —*Carrie Arnold*

Avoid Abstract Thinking about Bad Memories

It's hard not to dwell on a bad experience, but the way you think about it could mean the difference between healthy and unhealthy coping. A study in the September 2012 *Journal of Behavior Therapy and Experimental Psychiatry* focused on people who had recently experienced a highly distressing event—such as a crime, the death of a loved one or a relationship breakup. Subjects in one group wrote about their experiences in a concrete, objective way, by concentrating on questions such as "How do I feel right now? How did I feel at the time of the event and what did I see, hear and think? How might I deal with a similar situation in the future?" The other group wrote in a more abstract, evaluative way, prompted by questions such as "Why did the event happen? Why do I feel this way about it? Why didn't I handle it differently?" After the writing exercise, the concrete-thinking group reported fewer intrusive memories of the event than the abstract-thinking group.

Researchers think the concrete focus helps to facilitate emotional processing and problem solving, whereas an abstract perspective hinders these undertakings. "The processing can take place either 'in your head' or when writing about it," says study author Thomas Ehring, now at the University of Münster in Germany. Past studies indicate that putting words on paper might be better than just thinking [see "The Power of the Pen," by Katja Gaschler; SCIENTIFIC AMERICAN MIND, August/September 2007]. Just be sure to focus on the facts and keep your ideas concrete. —*Tori Rodriguez*

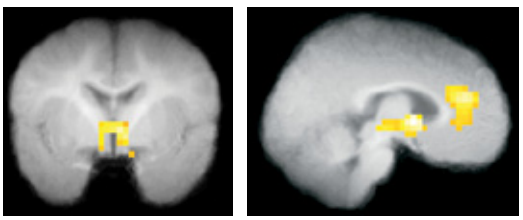
BRAIN IMAGING

Troubled Family Life Changes Kids' Brains

Conflict and neglect affect health through adulthood

Stress and neglect at home take an obvious toll on kids as they grow up. Many decades of research have documented the psychological consequences in adulthood, including struggles with depression and difficulties maintaining relationships. Now studies are finding that a troubled home life has profound effects on neural development.

Kids' brains are exquisitely sensitive. Even sleeping infants are affected by family arguments, a new study concludes. Researchers at the University of Oregon showed with functional MRI scans that infants from families who reported more than the usual levels of conflict in the home were more sensitive to aggressive or angry voices. While asleep, these babies had an uptick in brain activity in response to sentences read in an angry tone of voice, with most of the activity clustered in the parts of the brain responsible for regulating emotions and stress.



Some sleeping infants' hypothalamus and cingulate cortex regions (*yellow*) responded to angry voices.

"Infants are constantly absorbing and learning things, not just when we think we're teaching them," says Alice Graham, a doctoral student who led the study, forthcoming in the journal *Psychological Science*. "We should expect that what's going on in the environment is literally shaping the physical connections in their brains."

As with family fighting, neglect leaves no external marks but powerfully affects the architecture of the brain. A Yale University study of teenagers found evidence using MRI scans that neglect and emotional abuse during childhood reduces the density of cells in emotion-regulating regions of the brain later on. The teens in the study did not meet the criteria for full-blown psychiatric disorders, according to the paper published in 2011 in the *Journal of the American Medical Association*, yet many experienced emotional problems such as impulsive behavior and risk taking.

Even well into adulthood, the effects of neglect are dire. A survey of adult patients at Chicago's Rush University Medical Center found that emotional neglect in childhood seems to increase a person's risk of stroke as they get older. The mechanism behind that increased risk is unknown, according to the paper published online in September 2012 in *Neurology*.

Although young brains may seem easily damaged by neglect or stress at home, that damage is unlikely to be permanent if it can be treated in time, explains physician Hilary Blumberg, who led the Yale teen study. Recognizing that a teen's lack of impulse control might be a symptom of neglect-induced brain changes, for instance, could help social workers or medical professionals offer the right treatments. In the future some of those treatments might directly target the neurological changes. For example, regular exercise is shown to slow the loss of gray matter in the brain caused by aging; perhaps it could protect against neglect-related losses, too. Researchers hope that continuing to investigate the brain changes brought about by a troubled home life will ultimately provide ways to undo the damage at any point in life.

—Ian Chant

FROM "WHAT SLEEPING BABIES HEAR: AN FMRI STUDY OF INTERPARENTAL CONFLICT AND INFANTS' EMOTION PROCESSING," BY A. M. GRAHAM, P. A. FISHER AND J. H. PFEIFER, IN *PSYCHOLOGICAL SCIENCE* (IN PRESS) *(left)*; JOERG STEFFENS *Corbis (right)*

HUMAN QUIRKS

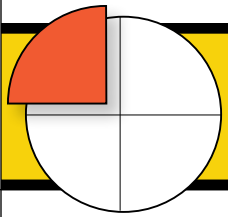
Keep the Teddy Bear

Owning stuffed animals as an adult says nothing about your mental health

An adult who happens to own a robust collection of plush pals might make you uneasy. Past studies of adult psychiatric patients, after all, had found that owners of toy animals were more likely than others to have a personality disorder. Now you can relax, however: a study in the September 2012 *Journal of Adult Development* found no such link in a nonclinical sample of typical adults. The researchers used physiological and self-reported measures of emotion regulation, including tests of psychological immaturity.

Although "some people might automatically assume that an adult owning a toy animal is an indicator of the owner's immaturity," explains lead author Stuart Brody, professor of psychology at the University of the West of Scotland, "there was no association of adult toy animal ownership with emotion regulation and maturity."

So go ahead and leave the toy animals on your bed the next time you have guests—but you may want to keep a copy of this article nearby. ***—Tori Rodriguez***



1 in 4 Approximate proportion of prison inmates who are psychopaths.

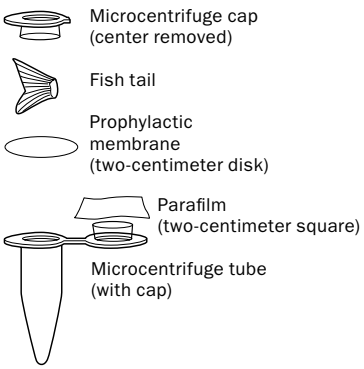
See page 36 for more.

>> BIOPHARMA

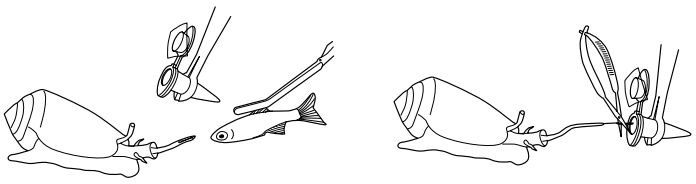
Healing the Brain with Snail Venom

By Daisy Yuhas

Conotoxins—the chains of amino acids found in the venom of a cone snail—are medical marvels. In 2003 psychiatrist and environmentalist Eric Chivian of Harvard University described these sea creatures as having "the largest and most clinically important pharmacopoeia of any genus in nature." Scientists believe conotoxins could help treat epilepsy, depression and other disorders by interacting with the nervous system.



How do you milk a cone snail?



Neuroscientist Baldomero Olivera of the University of Utah was faced with this puzzle in the 1980s. One enterprising undergraduate tried inflating a condom and rubbing it against a goldfish. He then set the fish-scented latex into the cone snail's tank. Almost immediately the snail struck, lodging its tooth into the faux fish.

"The sight of an inflated condom floating at the [water's] surface, with a tethered snail swinging like a pendulum below it, was one of those moments that should have been recorded with a camera," Olivera wrote in the journal *Toxicon* in 2000.

Today researchers use real fish bait with a latex-topped tube to collect venom. Some scientists now clone genetic material to produce a specific toxin.

Why do neuroscientists care about cone snails?

Cone snail venom contains neurotoxins that can target specific locations in the brain and spinal cord. For example, some species of cone snail possess a compound that can act on the same receptors as nicotine. These receptors, located on the surface of neurons, help to govern signaling in the brain. Neuroscientist J. Michael McIntosh of the University of Utah has found that selectively blocking some of these receptors with a cone snail compound can decrease the use of addictive drugs (so far, just in laboratory animals). Blocking a different subset of those receptors can trigger more consumption of a drug instead. Other compounds have been found to interact with receptors that influence feelings of pain or the growth of tumors.

How dangerous is a cone snail's venom?

The cone snail uses a toxin-filled tooth to harpoon its prey, injecting chemicals that can paralyze, stun or kill an unfortunate fish. Attracted by their colorful shells, divers occasionally collect the snails and make the mistake of stowing them in their swim trunks. The results range from a nasty sting to painful lesions and, in a few cases, death.

Tales of the calamitous cone snail have crept into fiction: the toxin was featured as a murder weapon in the 1970s television show *Hawaii 5-0,* and in the more recent film *Jurassic Park 2* only cone snail venom was powerful enough to fell a *Tyrannosaurus rex.* Most of the more than 700 species of cone snail, however, are not toxic to humans.

How do people collect these poisonous sea creatures?

The mollusks are typically found in warm and tropical waters, such as in the Caribbean and near the Philippines. "We can collect snails using a deepwater submersible, scuba diving, deepwater dredging, or simply bending over in the water and picking them up," says Frank Mari, a biochemist at Florida Atlantic University, one researcher who collects and studies the venom of cone snails.

But the loss of coral reefs and overzealousness of shell collectors have made finding certain species increasingly difficult, which could curtail our access to and understanding of this natural pharmacy. Once researchers have a cone snail, however, they can keep milking it for years in a lab.

What do you do with the venom?

Every cone snail species has easily 1,000 peptides of medical interest, which means cone snails offer millions of research possibilities. Some cone snail toxins show promise as muscle relaxants during surgery and as fast-acting interventions after a stroke or heart attack.

In 2004 the pain reliever Prialt became the first FDA-approved, commercially available product derived from cone snail toxin. Based on a peptide from a magician cone snail in Olivera's lab, this pain reliever is estimated to be 1,000 times stronger than morphine, without addictive side effects.

Researchers in Mari's lab have identified a cone snail compound that blocks sodium channels, which could help treat multiple sclerosis. But this is just the beginning.

COURTESY OF STEW ELLINGTON (*photograph*); JASON LEE (*drawings*)

84

Percent of genes that are active in the human brain, according to the first in-depth analysis of data in the Allen Human Brain Atlas.

>> EPIGENETICS

Inheriting Stress

How your grandpa's rough life might make you more anxious

Stressful events early in a person's life, such as neglect or abuse, can have psychological impacts into adulthood. New research shows that these effects may persist in their children and even their grandchildren.

Larry Feig and Lorena Saavedra-Rodríguez, biochemists at the Tufts University School of Medicine, caused chronic social stress in adolescent mice by regularly relocating them to new cages over the course of seven weeks. The researchers then tested these stressed mice in adulthood using a series of standard laboratory measures for rodent anxiety, such as how long the mice spent in open areas of a maze and how frequently they approached mice they had never met before.

Female mice showed more anxious behaviors compared with control animals, whereas the males did not. Both sexes' offspring displayed more anxious behaviors, however, and the males who had been stressed as adolescents even transmitted these behavior patterns to their female

grandchildren and great-grandchildren.

These results, they say, confirm previous studies that females seem to be at higher risk for anxiety, which could be the result of a variety of social or biochemical factors. "Males and females might have the same abnormality at the molecular level," Feig notes, "[but] as males, it doesn't really affect their behavior."

Although Feig does not yet know how the males transmit vulnerability to anxiety—he suspects biochemical changes in sperm—he believes that the effects will most likely be more muted in humans. The mice were raised in simple cages with a limited number of environmental influences. Humans, of course, have a much richer environment, along with the ability to learn new coping skills.

—Carrie Arnold

>> SLEEP

Bright Screens Could Delay Bedtime

Using a tablet or computer in the late evening disrupts the body's melatonin production

If you have trouble sleeping, laptop or tablet use at bedtime might be to blame, new research suggests. Mariana Figueiro of the Lighting Research Center at Rensselaer Polytechnic Institute and her team showed that two hours of iPad use at maximum brightness was enough to suppress people's normal nighttime release of melatonin, a key hormone in the body's clock, or circadian system. Melatonin tells your body that it is night, helping to make you sleepy. If you delay that signal, Figueiro says, you could delay sleep. Other research indicates that "if you do that chronically, for many years, it can lead to disruption of the circadian system," sometimes with serious health consequences, she explains.

The dose of light is important, Figueiro says; the brightness and exposure time, as well as the wavelength, determine whether it affects melatonin. Light in the blue-and-white range emitted by today's tablets can do the trick—as can laptops and desktop computers, which emit even more of the disrupting light but are usually positioned farther from the eyes, which ameliorates the light's effects. The team designed light-detector goggles and had subjects wear them during late-evening tablet use. The light dose measurements from the goggles correlated with hampered melatonin production.

On the bright side, a morning shot of screen time could be used as light therapy for seasonal affective disorder and other light-based problems. Figueiro hopes manufacturers will "get creative" with tomorrow's tablets, making them more "circadian friendly," perhaps even switching to white text on a black screen at night to minimize the light dose. Until then, do your sleep schedule a favor and turn down the brightness of your glowing screens before bed—or switch back to good old-fashioned books.

—Stephani Sutherland

SIGRID OLSSON *Getty Images (top)*; STEVEN PUETZER *Getty Images (bottom)*

$7.9 BILLION

SPENDING IN THE U.S. IN 2011 ON ADHD MEDICATIONS, UP 17 PERCENT FROM 2010.

>> MENTAL HACKS

"I Don't" Beats "I Can't" for Self-Control

Casting willpower as a choice makes sticking to resolutions easier

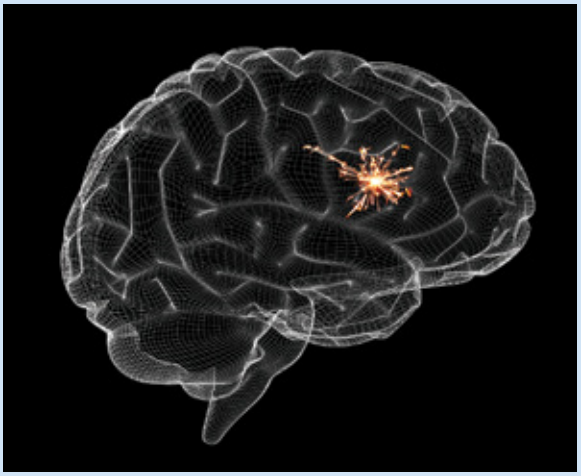
Meet your goals more easily by changing the way you think about your vices. In four related studies published in the August 2012 *Journal of Consumer Research,* researchers examined the effect of different wording when using self-talk to resist temptation. When participants framed a refusal as "I don't" (for instance, "I don't eat sugar") instead of "I can't," they were more successful at resisting the desire to eat unhealthy foods or skip the gym. Study author Vanessa Patrick, professor of marketing at the University of Houston C. T. Bauer College of Business, says, "I believe that an effective route to self-regulation is by managing one's desire for the temptation, instead of relying solely on willpower." She also believes that deprivation is

an ineffective route to self-control. "Saying 'I can't' connotes deprivation, while saying 'I don't' makes us feel empowered and better able to resist temptation." —*Tori Rodriguez*

>> TECHNOLOGY

Stimulating the Brain with Microscopic Magnets

An attractive new method of deep-brain stimulation could solve that therapy's trickiest problems



Imagine if your biggest health problem could be solved with the flip of a switch. Deep-brain stimulation (DBS) offers such a dramatic recovery for a range of neurological illnesses, including Parkinson's disease, epilepsy and major depression. Yet the metal electrodes implanted in the brain are too bulky to tap into intricate neural circuitry with precision and corrode in contact with tissue, so their performance degrades over time. Now neurophysiologists have developed a method of DBS that avoids these problems by using microscopic magnets to stimulate neurons.

In experiments published in June 2012 in *Nature Communications,* neurophysiologist John T. Gale of the Cleveland Clinic and his colleague Giorgio Bonmassar, a physicist at Harvard Medical School and an expert on brain imaging, tested whether micromagnets (which are half a millimeter in diameter) could induce neurons from rabbit retinas to fire. They found that when they electrically energized a micromagnet positioned next to a neuron, it fired.

In contrast to the electric currents induced by DBS, which excite neurons in all directions, magnetic fields follow organized pathways from pole to pole, like the magnetic field that surrounds the earth. The researchers found that they could direct the stimulus precisely to individual neurons, and even to particular areas of a neuron, by orienting the magnetic coil appropriately. "That may help us avoid the side effects we see in DBS," Gale says, referring to, for instance, the intense negative emotions that are sometimes accidentally triggered when DBS is used to relieve motor problems in Parkinson's.

The micromagnets also solve other problems associated with metal electrodes. The magnetic field easily penetrates the magnets' plastic coating, which prevents corrosion and the ensuing inflammation of brain tissue. "I've been doing DBS research for 14 years now, and this is a totally different way of thinking about activating the brain for me, which is very exciting," Gale says.

Although the study focused on stimulating neurons, micromagnets could be used to activate other excitable tissues, such as in the heart, inner ear or muscles in our extremities, as part of a pacemaker or prosthetic device. In humans, the micromagnets would be turned on and off by an external control pack, either wirelessly or by connecting to a wire implanted under the skin. A medical company has acquired the rights to manufacture the micromagnets, and if animal research continues to show them to be safe and effective, these devices could be tested in humans within five years, according to Gale. —*R. Douglas Fields*

Your Twisted Little Mind

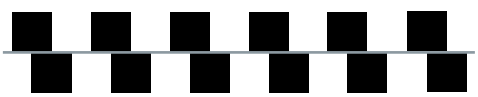
Illusions that distort your perception

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

PETER BENNETTS

VISUAL PERCEPTION begins with our retinas locating the edges of objects in the world. Downstream neural mechanisms analyze those borders and use that information to fill in the insides of objects, constructing our perception of surfaces. What happens when those borders—the fundamental fabric of our visual reality—are tweaked? Our internal representation of objects fails, and our brain's ability to accurately represent reality no longer functions. Seemingly small mistakes lead to the very distorted perceptions of an illusory world. M

STEPHEN L. MACKNIK and SUSANA MARTINEZ-CONDE are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra Blakeslee, now in paperback (http://sleightsofmind.com). Their forthcoming book, *Champions of Illusion,* will be published by Scientific American/Farrar, Straus and Giroux.



PLUMB CRAZY

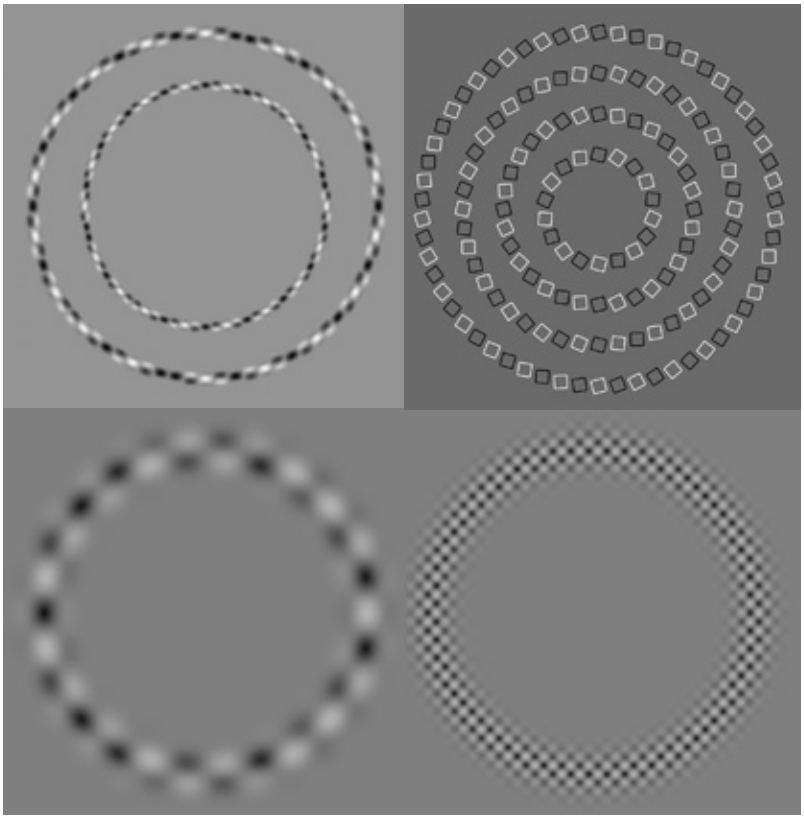
No, the architects of this building were not drunk at the drawing board. In fact, the structure is perfectly rectilinear in every way. No slants, no tilts and no curves: just good old traditional 90-degree angles at work here. The Australian architectural firm of Ashton, Raggatt, and McDougall based the façade design at the Port 1010 building in Melbourne on a famous bit of visual trickery known as the café wall illusion, popularized by vision scientist Richard Gregory of the University of Bristol in England. Mark McCourt, a vision scientist at North Dakota State University, has shown that the positions of the black-and-white bricks invoke a reverse contrast effect called brightness induction, which results in the mortar having the appearance of a twisted cord. Vision scientist and illusion creator Akiyoshi Kitaoka of Ritsumeikan University in Japan has further demonstrated this effect in minimalist fashion by isolating it to a single row of mortar with blocks. The alternation of black-and-white brick positions results in an alternating direction in the twisted cords of the mortar. The brain interprets these cords as being slightly tilted depending on the direction of the twist.

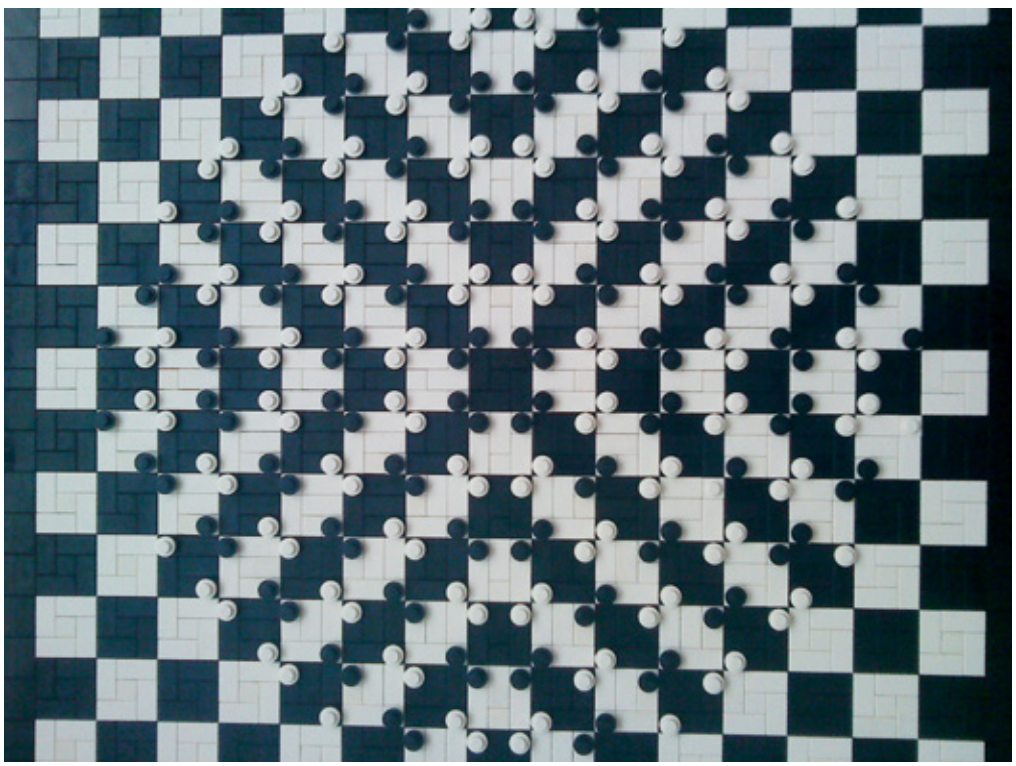
CIRCULAR REASONING

Just as twisted cords power the café wall illusion, so, too, do they distort our perception of simple circles. The upper left pair of nested circular twisted cords shows how this subtle local effect can have major global consequences on our perception of shapes, even one as deceivingly simple as a circle. (To convince yourself that these circles do not actually have corners, see the video at www.youtube.com/watch?v=aXndBs0dvdg&feature=plcp.)

The twist in the cords even works when the twisted elements are not touching, as in the spectacular *Intertwining Illusion* by vision scientist Baingio Pinna of the University of Sassari in Italy. Because the interacting visual elements are no longer in contact with one another, Pinna's version is strongest when you see it with your peripheral vision—out of the corner of your eye. Visual neurons processing peripheral information have low spatial resolution, allowing them to "see" the gross details of objects only, so even distant tilted squares produce the perception of a twisted cord. The low resolution of peripheral visual neurons also plays a role in the bizarre *It's a Circle, Honest!* illusion by vision scientist David Whitaker of the University of Bradford in England and a top-10 finalist in the 2007 Best Illusion of the Year Contest (http://illusionoftheyear.com).

On the lower left, the circle looks round only if you look directly at it; if you position it in the corner of your eye, it has corners! The circle on the lower right, which is made of smaller elements, looks more rounded no matter where you position it on your retina because the smaller elements are smeared out to gray in the visual periphery.





BUILDING THE IMPOSSIBLE, ONE LEGO AT A TIME

Don't believe any of this so far? Think it's all a bunch of camera tricks? Well, you don't have to take our word for it. Go to a Lego store and buy a baseplate that is at least 43 × 43 studs in size, 946 one-by-two tiles (554 black and 392 white), 196 one-by-one tiles (half black, half white), and 240 individual studs (half black, half white). You can then make your own Lego version of *A Bulge,* by Kitaoka.

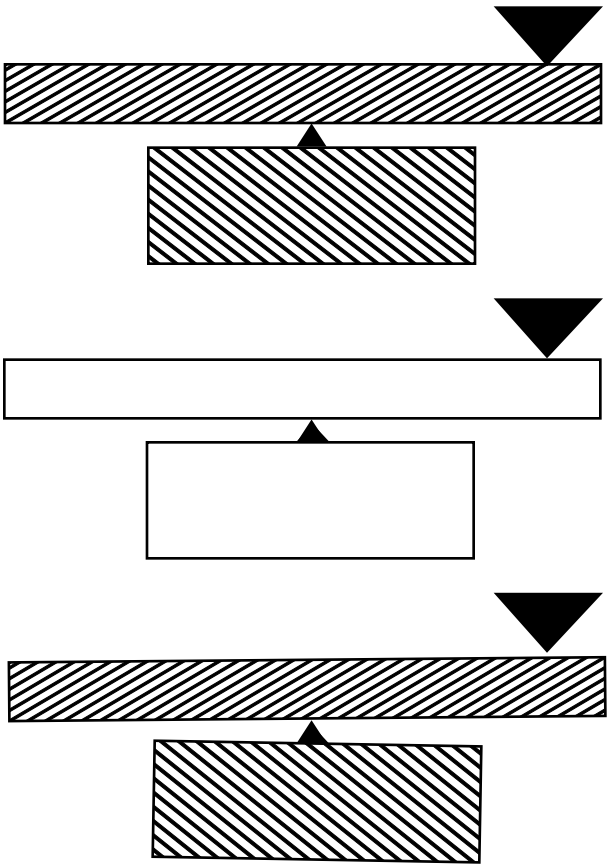
To see the illusion disappear with a single breath, watch this video at www.youtube.com/watch?v=QKCSBkdEUXQ.

COURTESY OF AKIYOSHI KITAOKA *Ritsumeikan University (top row, left);* BAINGIO PINNA *University of Sassari (top row, right);* COURTESY OF DAVID WHITAKER *University of Bradford (bottom row, right);* COURTESY OF ANDREW TYMM *(bottom)*

PASCAL LE SEGRETAIN *Getty Images (Winslet)*; SCIENTIFIC AMERICAN MIND (*seesaws*)

TWISTED SISTER

Women's makeup enhances the attractive facial features while hiding the undesirable. Now there is an outfit to accomplish the same illusory feat for your body. Actor Kate Winslet's dress, created by British fashion designer Stella McCartney, uses contrasting shapes to accentuate hips, shoulders and otherwise highlight the female form. For maximum effectiveness, be sure to wear it only in front of a black background.



THE TEETER-TOTTER SEESAW

Spatial distortions can be measured for their power to alter perception. The seesaw at the top seems to tilt to the right, although, in fact, it is not tilting at all. If we remove the twisting candy-cane stripes from within, we now see the veridical planks and their untilted truth. A clever variant of this illusion, with a physically tilted plank that appears level through illusory means, reveals that the illusion is equivalent, perceptually, to as much as a four-degree actual tilt.

A nice animated version of the effect is at www.moillusions.com/2009/02/slanted-seesaw-optical-illusion.html

(Further Reading)

- **Brightness Induction and the Café Wall Illusion.** M. E. McCourt in *Perception,* Vol. 12, No. 2, pages 131–142; 1983.
- **Shifts of Edges and Deformations of Patterns.** B. Pinna and R. L. Gregory in *Perception,* Vol. 31, No. 12, pages 1503–1508; 2002.

Yet Another Stage of Life?

With millions of young adults failing to launch, the claim that "emerging adulthood" is a new stage of life is gaining traction. This idea could do more harm than good

BY ROBERT EPSTEIN

HOW MANY stages of life are there? According to Hindu teachings, human life unfolds in four stages: childhood, apprenticeship, adulthood and old age. William Shakespeare in *As You Like It* insisted on seven, beginning with infancy, when we are "mewling and puking," and ending with old age, when we are "sans teeth, sans eyes, sans taste, sans everything."

It will come as no surprise that social scientists have expressed their own opinions on the matter, often arguing over the details and sometimes specifying different sets of stages for different abilities, such as cognitive development (Jean Piaget), moral reasoning (Lawrence Kohlberg) and psychosexual development (Sigmund Freud). What is more, when cultures change sufficiently to alter behavior during certain age spans, social scientists sometimes add *new* stages as they notice them.

One dramatic case in point: in 1904, with industrialization rapidly displacing the apprentice system that had tied young and old people together for millennia and with hundreds of thousands of young people wreaking havoc on the streets of mushrooming U.S. cities, psychologist G. Stanley Hall put the term "adolescence" on the social map. Hall mistakenly claimed that this tumultuous stage of life existed in all cultures and eras, but we know now that adolescence is actually a product of industrialization and is by no means a necessary stage of life.

Anthropological studies show that adolescence as Hall defined it is absent in more than 100 cultures around the world—cultures in which young people work side by side with adults at early ages. My own research suggests that it is only when we hold people back from adulthood that we see the depression, defiance and anger so typical of American teens, nearly 50 percent of whom are now diagnosable with at least one emotional, behavioral or substance abuse disorder, according to the 2010 National Comorbidity Survey.

In 1950 psychoanalyst Erik Erikson proposed the existence of yet another new stage of life—"young adulthood"—*in between* adolescence and adulthood proper, characterized by "a deep sense of isolation and self-absorption" and the search for "intimacy," "identity" and "moral values." It lasted, Erikson said, from age 18 to about age 35. Unlike adolescence, however, this stage lit no fires. His idea was still little more than an academic footnote when Erikson died in 1994 at age 91.

But that same year, prompted by a growing body of data suggesting that entry into adulthood in the U.S. was being increasingly delayed, developmental psychologist Jeffrey Jansen Arnett of Clark University gave the idea another shot, this time calling the stage "emerging adulthood." His proposal was also largely ignored until 2000, when, with even more data about delayed adulthood in hand, he presented his case in greater depth in the journal *American Psychologist*.

Between 1970 and 1996, Arnett said, the median age of first marriage had increased from 21 to 25 for women and from 23 to 27 for men, and far more young people were getting college or graduate degrees. With entry into marriage and the workforce delayed, he observed, we need to recognize that before adulthood a new stage of life exists characterized by "identity explorations," "instability" and "self-focus."

This time neither the general public

MÁGOZ

> The label "adolescent" is so powerful that it leads us to view and treat ***all* young people** as if they are equally impaired.

nor scientists (who are also members of the general public, after all) could ignore the idea for the simple reason that many of their offspring were still sitting on their doorsteps. According to a 2012 study by the Pew Research Center, the likelihood that young adults would move to another state dropped by 40 percent between 1980 and 2008. The proportion of young people getting driver's licenses also dropped substantially over that period—and that was even before the Great Recession hit. Since 2008 a whopping 29 percent of adults between the ages of 25 and 34 have lived with their parents at some point.

Interest in Arnett's idea has paralleled the changing U.S. demographics. According to Google Scholar, before 2000 only 140 articles mentioned emerging adulthood, but between 2000 and 2007 the number jumped by another 1,980, and the recession has added, at this writing, another 8,180 scholarly articles to the pile. The trend in Google pages, which mirrors interest by the general public, has been similar. Google now lists 224,000 pages mentioning the exact phrase "emerging adulthood."

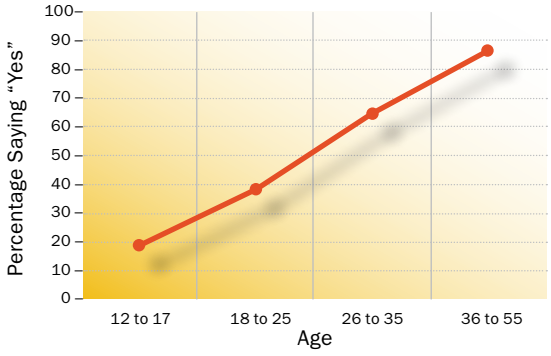
Timing is indeed everything. Hundreds of thousands of teens were on the streets when Hall wrote about adolescence, and millions of young adults are now living in their old bedrooms with Nirvana posters still on the walls. With so many young adults now conspicuously off track, the idea that emerging adulthood exists as a new stage of life has taken hold.

But do scientific data justify its naming, and is there any benefit to the acceptance of such a stage? Having been a researcher for more than 30 years, I cannot help but be skeptical on both fronts. For one thing, if emerging adulthood were truly a new stage, we should see meaningful discontinuities in data that mark both its beginning and end. Instead we generally see a continuation of the century-old trend that is delaying entry into adulthood—a gradual increase in the median age of first marriage, for example. Also, much of the data that Arnett himself cites shows continuity in data across a life span, rather than a discontinuity suggesting that something distinct is happening to young adults [*see illustration below*].

My main concern with Arnett's proposal has to do with the power of labels—especially when we are putting a label on a negative stereotype. There is enormous variability among teens; many are troubled or incompetent, it is true, but my own data suggest that 30 percent of them are actually more competent than half of adults across a wide range of adult abilities. The label "adolescent" is so powerful, however, that it leads us both to view and to treat *all* young people as if they are equally impaired—even to blame that impairment on the so-called teen brain. In my opinion as a research psychologist, this popular idea confirms our negative biases about teens but has a dubious scientific basis [see "The Myth of the Teen Brain," by Robert Epstein; Scientific American Mind, April/May 2007].

According to the new Pew study, most people in their 20s have jobs and do not live with parents, and many are in stable, fulfilling relationships. It is imprudent, I believe—especially based on short-term social trends—to suggest that most or all individuals that age are inherently unstable and unfocused. Over time the label could quite easily come to function as a self-fulfilling prophecy, creating expectations that push more young adults toward dysfunction.

As with new "temporary" taxes, once new psychological labels make it into textbooks, they never disappear. Emerging adulthood is probably here to stay, and that could be bad news for young adults. M



The proportion of people identifying themselves as "adults" increases fairly smoothly as a function of age. The proportion is not especially high or low among so-called emerging adults.

SOURCE: "EMERGING ADULTHOOD: A THEORY OF DEVELOPMENT FROM THE LATE TEENS THROUGH THE TWENTIES," BY JEFFREY JENSEN ARNETT, IN *AMERICAN PSYCHOLOGIST*, VOL. 55, NO. 5; MAY 2000

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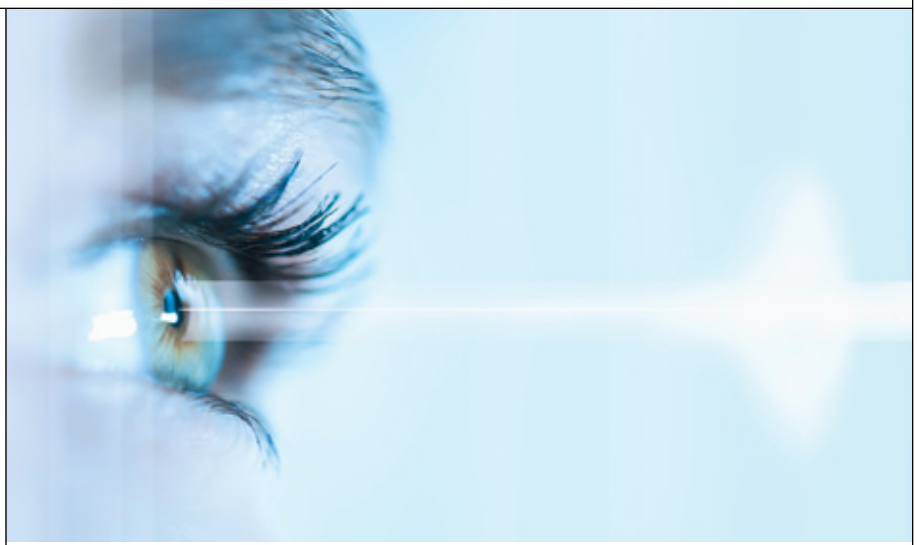
Cracking the Retinal Code

Silicon "eyes" to help people with deteriorating vision are around the corner

BY CHRISTOF KOCH



CHRISTOF KOCH (*Koch*); GETTY IMAGES (*eye*)

Blindness is a private matter between a person and the eyes with which he or she was born.

THE SENTIMENT expressed by the late Portuguese writer José Saramago in his famous novel *Blindness* may be appropriate for a person born unable to see. But what about the tens of millions of people worldwide who suffer from a variety of degenerative diseases that progressively rob them of their eyesight? The problem arises in the nerve cells that line the back of their eyes, their retinas. Fortunately, help is on the way to restore some of the lost vision using advanced neuroengineering.

The hallmark of the two most common forms of adult-onset blindness in the West, age-related macular degeneration and retinitis pigmentosa, is that the photoreceptors responsible for converting the incoming rays of light into nervous energy gradually die off. Yet the roughly one million ganglion cells, whose output wires bundle up and leave the eyeball in the form of the optic nerve, remain intact. So visionary (pun intended) clinical ophthalmologists have paired up with technologists to bypass the defective parts of the retina by directly stimulating ganglion cells via advanced electronics. One of the most successful of such prosthetic devices, manufactured by a California company called Second Sight, uses a camera integrated into eyeglasses to convert images into electronic patterns. These patterns are sent to a small, 10- by six-pixel microelectrode array surgically positioned onto the retina. It stimulates neural processes that relay their information in the form of binary electrical pulses, so-called action potentials or spikes, to the brain proper.

Spikes are the universal idiom in which neurons communicate with one another. Once we understand their whispering language, the neural code, we will be much closer to deciphering the ancient mind-body riddle. The sparse information relayed by this prosthetic—using 60 rather than the millions of photoreceptor channels—nonetheless helps. A recent interim report on a clinical trial with 30 patients who have end-stage retinal degeneration and who carry a Second Sight visual prosthetic concluded that the devices were safe and efficient. That is, they unambiguously improved visual acuity. Whereas untreated subjects could only tell light from dark, those with the prosthetic could detect hand movements and some could even count fingers. Although their measured acuity (20/1,260 compared with 20/20 for perfect vision) still leaves them legally blind, they do see something.

It is widely assumed that these residual visual abilities will improve as finer electrode arrays with a larger number of stimulation sites become available. Given the relentless progress in integrated circuit technology, this enhancement will undoubtedly happen. Yet others argue that what is really needed are more sophisticated encoding strategies. Think about it: What would happen to your computer if you were to suddenly turn all the transistors in its central processing unit simultaneously on and off? Clearly, the more you know about how software instructions are turned into patterns of electrical charge on transistor gates, the more productively you could manipulate the computer, hacking its transistors.

Exploiting the Neural Code

Sheila Nirenberg, a neuroscience professor at the Weill Medical College of Cornell University in New York City, and her Ph.D. student Chethan Pandarinath have just demonstrated this enhanced understanding of neural code by using the latest techno craze, optogenetics [see "Playing the Body Electric," by Christof Koch; Scientific American Mind, March/April 2010]. This method targets specific groups of nerve cells in mice that have been infected with genetically modified viruses that express a protein called channelrhodopsin-2 (ChR2). The viruses cause the neurons to express ChR2 in their surface membrane; ChR2 is a light-sensitive protein that responds to blue light. Shoot a pulse of blue light at a cell that expresses it, and it will respond with an electric signal that, if large enough, leads to an action potential. Any group of neurons can be made to fire on command

provided that they carry the molecular signature targeted by the virus. Nerve cells that do not have the appropriate molecular signature will not express ChR2. Optogenetics is hot because it allows researchers to deliberately intercede at any point within the tightly woven networks of the brain, moving from observation to manipulation, from correlation to causation.

To appreciate the beauty and specificity of Nirenberg's approach, it is important to realize that there is not just a single homogeneous group of retinal ganglion cells leaving the eye. Rather about 20 distinct types of cells exist, each one specialized for a different task. Some ganglion cells respond only to the onset of light but not when it ceases ("on" cells), whereas a second set signals the reverse—they respond with spikes when light is turned off ("off" cells) but are silent when they see a bright region. If a microelectrode array simultaneously stimulated both "on" and "off" cells—as would happen with an all-electronic strategy—it would confuse the visual brain because it would appear that light had just been turned both on and off simultaneously!

Other populations of ganglion cells carry information relating to a specific wavelength (involved in color vision), whereas still others convey information about things moving downward or sideways, and so on. In a sense, all of us have 20 different views of the world, emphasizing varying aspects of the visual environment. How these fractionated and disparate views are unified to yield the coherent picture of the world that we perceive consciously remains deeply puzzling.

Fortuitously, it looks as if each of these cell types has its own distinct molecular bar code. This knowledge can be used to restrict the expression of the optogenetic molecules to just those cells and then to target the artificial stimulation appropriately. That is, if we knew the retinal code of "on" cells—the way they convert visual information into electrical pulses—as well as their molecular signature, these cells (or any other group) could be selectively targeted.

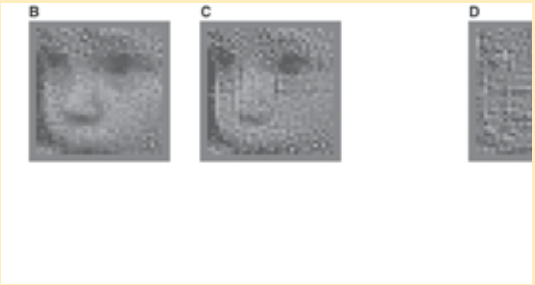
Nirenberg and Pandarinath accomplished this targeted approach in blind mice by making them carry a mutated version of a gene needed for photoreceptors whose ganglion cells also express ChR2. An encoder takes an image captured by a digital camera and converts it into a train of spikes appropriate to a particular group of ganglion neurons, for instance, "on" cells. It does this conversion from images into the retinal code by training and comparing its response with those actually recorded from "on" retinal ganglion cells. Thus, as a simple example, if a bright light had just moved into the field of view, the encoder should generate a burst of pulses. These signals are turned into pulses of blue light that drive the "on" retinal ganglion cells to fire a similar sequence of pulses. To the neurons in the brain proper that are the recipients of these "on" retinal ganglion cells, these pulses convey the datum that something luminous has just made its appearance [*see upper illustration in box at left*]. Exploiting the same code as used by a healthy retina should help these blind mice see.

How well this device reconstructs pictures is shown in the images at the lower left. If the baby picture at the far left is sent through the device, the brain could, in principle, reconstruct the image at the near left. Far from perfect, but clearly the image of a toddler.

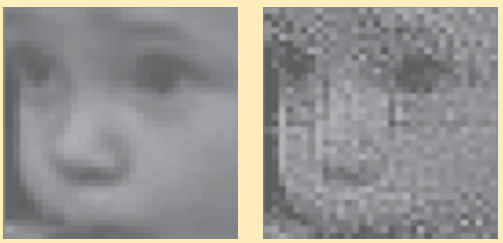
In a field test, actual mice outfitted with this retinal prosthetic could reliably detect motion to the left or to the right.

The true measure of performance, injecting a blind person's eye with viruses that express ChR2 in retinal ganglion cells and giving the patient a set of glasses that carries the encoder and light stimulator, is within reach. The fantastic marriage of molecular biology, optics and electronics that is optogenetics will soon bear fruit and help people regain their eyesight. Stay tuned. M

Vision Prosthetic



Signals from five ganglion cells (*top row*) are recorded from the retina of a normally sighted mouse looking at a movie of people walking, landscapes, and so on. The bottom row illustrates the response of five matched ganglion cells in a blind mouse fitted with an optoelectronic prosthetic device that stimulates the ganglion cells via light beams. The blind rodent's responses are similar to those of a normal mouse.



The image of a baby's face (*left*) is shown reconstructed from the spike trains, or signals, of a blind retina using a prosthetic (*right*). The reconstruction provides a measure of how well a blind mouse with its vision restored in this way would see the original 35- by 32-pixel photograph.

CHRISTOF KOCH is chief scientific officer at the Allen Institute for Brain Science in Seattle and 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.

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FROM "RETINAL PROSTHETIC STRATEGY WITH THE CAPACITY TO RESTORE NORMAL VISION," BY SHEILA NIRENBERG AND CHETHAN PANDARINATH, IN *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA*, VOL. 109, NO. 37; SEPTEMBER 11, 2012

The *Essence* of [Optimism]

We can tune our mind to notice the bright side of ambiguous events, bolstering our resilience to stress and anxiety

By Elaine Fox

When I was a 14-year-old in a suburb of Dublin, we were at the height of "the Troubles." During this period of civil unrest, our school regularly took in girls from Northern Ireland to get them away from the bomb blasts and shootings in Belfast, some two hours' drive across the border. One of these girls was named Sandra, and she had been at our school for a couple of weeks when one day the two of us decided to walk home for lunch. As I was walking and chatting, I suddenly became aware that Sandra was no longer beside me.

Looking around, I saw her about 10 meters back, lying flat on the pavement. A car had backfired, and she had instantly thrown herself on the ground. Deep in her brain, an alarm signal had gone off. That same signal had slipped past me unnoticed.

How we interpret the events in our lives determines their significance to us. Often these incidents are ambiguous: they may represent a threat, as in gunfire, or they may be neutral, as in a car backfiring. Our responses reveal something deeper about the way our brain analyzes what is happening around us. To a mind sculpted by a violent and dangerous environment, a loud bang is highly salient.

Ambiguous situations crop up all the time, particularly in the social world. Perhaps your boss rushes past you one morning at the office. Her brusque demeanor could signal that she is annoyed with you, or it could mean she is running late to a meeting. New research tells us that subtle, subliminal biases in interpreting such events can affect our life trajectory. Through some combination of genetics and personal experiences, we can develop a habit of seeing the proverbial glass as either half full or half empty. That

PHOTOILLUSTRATION BY AARON GOODMAN

A socially anxious person might focus on the single bored face in the crowd without taking into account the many more engaged listeners.

JOHN LUND AND PAULA ZACHARIAS *Getty Images*

frame of mind in turn alters our resilience to adversity, for better or worse.

Cognitive psychologists have long known that people who rate higher on measures of anxiety and depression—my colleagues and I call it emotional vulnerability—tend to draw overly negative conclusions when faced with ambiguous social situations. We also know that people who react more emotionally to adversity are at a higher risk of acquiring disorders of anxiety and depression the next time they encounter a stressful period.

A growing body of evidence now suggests that cognitive biases are the reason that some of these emotional disorders arise and stay entrenched. A tendency to notice, analyze and mull over threatening events can lead us to believe in a more menacing world than when we routinely see the sunny side of life. An emerging field known as cognitive-bias modification (CBM) aims to turn these negative predilections around, to instill more positive assessments and to bolster our defenses against stress.

FAST FACTS

Put on a Happy Face

1» **Subliminal negative biases in attention, interpretation and memory are linked with a heightened vulnerability to stress and anxiety.**

2» **A new therapeutic approach, called cognitive-bias modification, aims to overturn these biases and build resilience with a simple computerized task.**

3» **Early results suggest that the therapy could help combat depression, anxiety disorders and even alcohol addiction.**

Toxic Tendencies

Hundreds of psychology experiments support the view that we possess ingrained biases that correlate with a person's ability to weather life's ups and downs. Biases direct our thinking at several levels, including what we pay attention to, how we interpret our experiences and what we end up storing in memory. Psychologists have developed ingenious tools for measuring these mental habits under highly controlled laboratory conditions.

One simple way to assess how we interpret things is to ask people to listen to someone saying numerous homophones, which are words that sound alike but have different spellings, and to write down the word they hear. For example, homophones such as dye and die or pane and pain sound the same but have either a negative or a benign meaning. A program of research started by psychologist Michael Eysenck, now emeritus at the University of London, and his colleagues in the 1980s has shown us that those who rate higher on measures of anxiety are more likely to write down the negative spellings, whereas those who are low in anxiety give equal weight to both negative and benign words.

Other tests can investigate biases in what we pay attention to. One approach is to use software that flashes images of different scenes. Study participants may see, for example, a pair of facial expressions on a computer screen before a single letter replaces them on the display. Half the time the letter appears where a hostile face had been, and half the time it pops up in the space previously occupied by a smiling visage. Participants are asked to push the appropriate button when they see a letter and to ignore the images. Over hundreds of trials researchers have observed that people who

are emotionally vulnerable respond faster when the target appears near a hostile face, whereas resilient people react more quickly when the target lands near a joyful face. This simple gamelike activity, called the attentional probe task, reveals our habit of tuning into the negative or the positive at lightning-fast speed.

In everyday life a pessimistic pattern can work against us. A socially anxious person giving a speech, for instance, might focus on the bored or mildly hostile face in the crowd without noticing the many engaged listeners in the audience. Over time a negative bias in attention can help construct a more hostile view of the world than if a person's focus lands instead on friendly, accepting faces. A simple modification to the attentional probe task, however, can allow us to unseat subliminal biases—for therapeutic effect.

> A negative bias in attention can construct a more hostile worldview than if a person's focus tends to lands on friendly faces.

A Better Bias?

Psychologist Colin MacLeod of the University of Western Australia was one of the first to try to deliberately shift subliminal habits. In 2002 his team found that it could train students to either notice or tune out threatening words such as cancer or rape. The students saw a nasty word and a neutral term displayed simultaneously on a computer screen. A split second later a target letter appeared on the screen to which people had to respond as quickly as they could by pressing a button.

Half the students saw the letter always appear where the nasty word had been. For the others, the letter inevitably replaced the neutral word. After hundreds of these events, participants who were trained to avoid the threatening words responded much faster when the target letter was juxtaposed with the neutral word, and the subjects who had focused on the nasty words were correspondingly much swifter when responding to letters that supplanted the negative word.

The students were then subjected to a mildly stressful test. They were given a limited amount of time to solve a series of difficult anagrams, some of which were impossible. The participants who had been trained to notice threat reported more stress than those who had been trained to steer clear of the unpleasant words. This finding, though limited to subjective report, was the first glimmer that practicing attending to negative versus neutral features can determine how we react in real-life situations.

In subsequent studies, the same team tested young students from Singapore weeks before they were due to travel to Australia to attend university there. Half of the participants underwent the same threat-avoidance training, with letters appearing where neutral words had been. The remaining students were given a placebo training regimen, the goal of which was to instill no bias at all. These participants viewed the same sets of words, but the target letter appeared equally often in the locations of the threatening and benign words.

For three weeks students underwent several sessions of their assigned training condition before catching a flight to Australia. MacLeod's team met the students at Perth's airport and measured how well they adjusted during their first few weeks in the new country. The results showed that those who had practiced avoiding threat before they left home were less stressed and less anxious when they arrived in their new environment as compared with those who had received placebo training.

As with attention, our interpretational style can also be modified. Andrew Mathews and Bundy Mackintosh of the MRC Cognition and Brain Sciences Unit in Cambridge, England, presented people with a series of ambiguous scenarios such as the following:

> "You have decided to go caving even though you feel nervous about being in an enclosed space. Going deep inside the cave, you realize you have completely lost your __"

This description is followed by a word fragment such as w_ y ("way" is a negative outcome), or f_ar ("fear" is a positive outcome). Participants filled in the fragments in about 100 different ambiguous scenarios for about an hour. One day later the subjects watched video clips of accidents. Those who had formulated positive resolutions

(The Author)

ELAINE FOX is director of the Affective Neuroscience Laboratory in the department of psychology at the University of Essex in England and author of *Rainy Brain, Sunny Brain.*

reported less anxiety and demonstrated less stress when compared with those who had repeatedly rehearsed negative resolutions. Other work has confirmed that inducing a more benign style of interpreting potentially scary situations can have direct effects on how well people cope with subsequent stress and adversity. These initial studies laid the groundwork for a slew of recent investigations into CBM in clinical populations.

A Vaccine against Negativity

Most cognitive theories of emotional disorders assume that subconscious biases increase the frequency and intensity of conscious negative thoughts. One influential theory of social anxiety disorder outlined by University of Oxford psychologist David M. Clark, for example, posits that preferentially noticing ominous external social signals, such as frowning faces, and negative internal cues, such as the sensation of blushing, can produce anxious feelings and a bleak self-evaluation—two key features of the disorder. Both anxiety and depression are associated with persistent tendencies to focus on either threatening or unflattering information, to interpret environmental cues pessimistically and to recall more unhappy memories. As a result, an obvious next step is to consider whether CBM could improve these symptoms in clinical populations.

Beginning around 2008, several experiments have done just that. A 2011 meta-analysis—a study of studies—reviewed 12 randomized controlled trials involving people diagnosed with a variety of anxiety disorders. The studies all consisted of about 16 sessions across a number of weeks and used the attentional training method developed by MacLeod and his colleagues. The authors concluded that training in avoiding threats was more effective than the placebo activity in alleviating the symptoms of clinical anxiety disorder in adult patients. A more recent study investigated CBM's effect on childhood anxiety disorders. In 2012 psychologist Yair Bar-Haim of Tel Aviv University reported that ratings of anxiety symptoms by the children, parents and clinicians declined as compared with placebo training after four weekly sessions.

Other researchers have explored attentional training in depression, in particular whether it can serve as a "cognitive vaccine" against relapse. Although both drug and talk therapies can ease depression temporarily, all are highly ineffective a year or more later. Around 60 percent of those who suffer from major depressive disorder relapse within a year regardless of whether they are taking antidepressants or engaged in talk therapy.

Among the strongest predictors of relapse are negative cognitive biases. To investigate whether we can unseat these mental habits, psychiatrist Michael Browning of Oxford and his colleagues selected 61 patients who had experienced at least two serious episodes of major depression but were in remission. Half were placed in a CBM training program designed to orient their attention toward positive rather than neutral faces or words. The others practiced a placebo training activity. The researchers evaluated their subjects' progress using a standard depression questionnaire and samples of their salivary cortisol. Negative responses to the questionnaire items and high amounts of this stress response hormone are also predictors of relapse.

The results were mixed, but in a telling way: CBM training with words was no better than placebo, but CBM using faces was highly effective in reducing depression symptoms when compared with placebo training. Learning to orient toward happy, smiling faces reduced the number of downbeat responses on the questionnaire. It also lowered the levels of salivary cortisol. Because this therapeutic approach is still young, further studies will need to iron out such details as whether faces versus words are more effective in various contexts.

> Learning to orient toward happy, smiling faces reduced the number of downbeat answers on a depression questionnaire.

Plan of Action

We also lack a solid understanding of why CBM might work. Most treatments used to tackle emotional problems, including cognitive-behavior therapy (CBT), mindfulness-based meditation and antidepressants, involve several components. The premise behind CBT, a widely used treatment for disordered thinking, is that learning to adjust or cope with maladaptive thought patterns can lead to emotional and behavioral change. A strong relationship with a therapist is usually important, and recipients of the therapy often complete exercises that challenge overly negative beliefs. CBM techniques might thus be a distillation of one essential aspect of more complex therapeutic interventions.

One promising feature of cognitive-bias modification therapy is that its core exercises can be done on a mobile phone or laptop almost anywhere, not only in a therapist's office.

If CBM matures into a fully accepted therapy, it will almost certainly become incorporated into a more complex regimen, such as CBT, rather than deployed on its own.

Indeed, a procedure intended to help people with drinking problems has already produced promising initial results when used with CBT. This version of CBM, unlike the others described here, involves an active component. In an experiment led by psychologist Reinout Wiers of the University of Amsterdam, 214 patients struggling with alcoholism used a joystick to either push or pull images of beverages on a screen. For example, participants might push away a picture of a bottle of beer, causing it to shrink in size, and pull closer a picture of a soft drink, making it grow larger on the screen. A year later individuals who had pushed back the alcoholic drinks and drawn forward the benign beverages were significantly less likely to have relapsed than subjects who had pushed and pulled equal numbers of both types of drinks.

The strong outcome suggests that incorporating a meaningful action—such as rejecting bad items and embracing positive ones—into CBM training could strengthen this therapy. Yet these are early days. Future research will need to test not only what training stimuli work best but also how enduring the changes are. Should therapies involve recurring top-ups of CBM, and if so, how often?

One particularly appealing angle of this new therapeutic approach is the ease with which it can be delivered on computers, smartphones or tablets. A person could visit his therapist, for instance, and leave with a tailor-made CBM intervention on his mobile device to help him through the tough times ahead. Healthy people, too, might use these techniques to boost a more resilient frame of mind so that they can flourish, rather than simply getting by.

Even simple techniques can shake loose a negative mood. Keeping a diary of the day's events, for example, can remind you later of the good things that may have been forgotten. Changing routines can also interrupt a dark period. Take a different route to the grocery store, for example, or call up a friend out of the blue. Lastly, giving yourself a 15-minute break from your day can help calm a stressed-out brain. A quick jaunt outside with a switched-off mobile phone can give a turbulent mind a chance to settle down. Whether coping with a bad day or a lingering malaise, cultivating healthy mental habits can bring optimism back for good. M

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DAVE AND LES JACOBS *Corbis*

BRAIN-CHANGING GAMES

Playing violent video games can sharpen our focus, reasoning and decision-making skills. But do we really need the weapons?

By Lydia Denworth

ILLUSTRATION BY CHRIS WHETZEL

I am in an overgrown lot leaning against an eight-foot-tall shipping container. I look both ways, weighing my options. A man with an assault rifle is looking for me, just as I am looking for him. Hoping for a better vantage point, I run toward the abandoned car to my right. A metallic bang rings out as my opponent's shot hits the wall I have just left. I dodge around the next container, then circle behind it. Raising my M16, I peer through the scope as I run. There he is! I hit the track pad of my laptop hard and fast, but my aim is wobbly. I miss. He spins, fires, and I'm dead.

Playing games such as Call of Duty: Modern Warfare 2 (*left*) and Halo 4 (*right*) can make you smarter.

So ended my introduction to first-person-shooter video games. Clearly, I was not very good. With practice, I would probably get better. What is less obvious is that a decade of research has shown that if I spent a few more hours playing Call of Duty, I could improve more than my aim and the life expectancy of my avatar. Aspects of my vision, attention, spatial reasoning and decision making would all change for the better.

These striking findings have contributed to a shift in the national conversation about video games. Not long ago a few lone voices contested the conventional wisdom that they were at best frivolous and at worst a dangerous waste of time and brainpower. Yet more than 90 percent of children play them, and adults do, too. In fact, the average gamer's age is 33 years. Along with continuing popularity has come a surge in acknowledging the positive side of gaming. Game designer Jane McGonigal's best-selling 2011 book *Reality Is Broken* even argued that games can change the world. In a 2011 speech to students, President Barack Obama recognized the potential and called for investment in educational technology, though with a caveat: "I want you guys to be stuck on a video game that's teaching you something other than just blowing something up."

Teaching is the critical word. The most consequential conclusion of the research is that video games have a power few other activities can claim. With practice, a violinist can play a Mozart string concerto beautifully, but that will not make her better at much else. Gamers, though, do not just learn to be good at shooting. In neurological terms, action games seem to "retune connectivity across and within different brain areas," according to neuroscientist Daphne Bavelier of the University of Rochester and the University of Geneva. That means that gamers "learn to learn." The ability to apply learning to broader tasks is called transfer, and it is the holy grail of education.

So far the games shown to have the most potent neurological effects are the ones parents hate the most: violent first-person shooters. Scientists are trying to figure out how and why these games affect players so as to create products that emphasize benefits but have fewer drawbacks. "I'm really interested in how the brain learns and how we can promote brain plasticity for learning," Bavelier says. "The issue is trying to understand how technology can be leveraged for the better."

New Vision

Bavelier stumbled on the subject of video games by accident. Until a decade ago, her laboratory focused on the effects of congenital deafness on vision. In the fall of 2000 she assigned an undergraduate, C. Shawn Green, to program his own version of a standard test of visual attention in which individuals first identify a central white square and then indicate on a touch screen the location of a shape that briefly flashes some distance away. The task, known as the "useful field of view," measures spa-

FAST FACTS

Today's Lesson: Call of Duty

1» **A body of recent research shows that playing certain video games improves vision, attention, spatial reasoning and decision making.**

2» **More than 90 percent of children play video games, and adults do, too: the average gamer's age is 33 years.**

3» **The games that have the most powerful neurological effects are the ones parents hate the most: violent first-person shooters.**

ACTIVISION *AP Photo (left)*; DAMIAN DOVARGANES *AP Photo (right)*

Gamers are better at attention tasks such as visually tracking a friend as he or she weaves through a crowd of people.

MICHEL TCHEREVKOFF *Getty Images*

tial attention—that is, the ability to keep track of multiple locations and shift attention across space. You employ this skill while driving, for example, to transfer your focus from the road to a sudden movement on the right. When Green tested it on himself, he did about twice as well as the norm. He faulted his programming but brought in some friends to test it further. They scored as high as Green did.

So Bavelier took the test. She fell within the normal range, meaning she did rather poorly. "We looked at each other and said, 'What's common between you and your friends?' " Bavelier remembers. The answer: they all regularly played action-packed, first-person-shooter video games.

Bavelier reassigned Green to a new study that compared various aspects of visual attention in eight action gamers and eight nongamers. In one task, subjects reported how many squares flashed on a screen at one time. The more items a person can register immediately, without counting them one by one, the greater his or her attentional capacity. Gamers averaged 4.9 items versus 3.3 for nongamers. In a test of attention to locations in space, gamers were roughly twice as accurate as nongamers at indicating where targets appeared. Gamers also significantly outperformed nongamers when they had to identify, and thus pay attention to, whether certain letters appeared in a string of letters flashed in rapid succession.

The action-game players were not more attentive from the start, the researchers determined. Instead it appears that experience with these games is what improves attention. Bavelier and Green had nine nongamers play Medal of Honor, a first-person shooter set on the battlefield, for an hour a day for 10 days while eight nongamers played Tetris. Before and after training, both groups took three tests of visual attention. Those who played Medal of Honor improved on all three tasks; those who played Tetris showed no improvements. Bavelier did not yet know what accounted for the benefits, but she guessed that the simultaneous demands of action games might be a critical ingredient. Tetris, after all, requires attending to only one falling tile at a time.

With such striking results in hand, Bavelier decided to approach action video games more methodically. First, she backtracked to examine the games' effect on vision. "We were trying to understand whether very early sensory processes, which typically are not very plastic, might be changed for the better," she says. To study visual acuity—a person's ability to see detail—she and Green asked 10 gamers and 10 nongamers to say whether a T was right side up or upside down as other T shapes crowded in. They measured how close together the letters could be before interfering with performance. This skill—actually the ability to see detail in cluttered visual environments—is critical for reading. Gamers could tolerate more crowding and still pick out the T, suggesting their detail detection was better. In addition, nongamers who trained on an action game, this time Unreal Tournament 2004, improved on this same test of visual acuity.

PEOPLE WHO PLAY LIVE-ACTION VIDEO GAMES "LEARN TO LEARN." THE ABILITY TO APPLY LEARNING TO BROADER TASKS IS CALLED TRANSFER, AND IT IS THE HOLY GRAIL OF EDUCATION.

In other findings, Bavelier and her team demonstrated that gamers also have better contrast sensitivity, or the capacity to distinguish different degrees of gray, which is useful for driving a car in fog (and a necessary skill for radiologists).

Playing video games might even ameliorate certain visual disorders. In amblyopia, or "lazy eye," blurred or otherwise poor vision in one eye disrupts neuronal circuits in the visual cortex during development, leaving one eye underdeveloped. In children, doctors patch the dominant eye to strengthen the weaker eye. Yet the treatment does not work in adults. In 2011 research optometrists Roger Li and Dennis Levi and their colleagues at the University of California, Berkeley, published a pilot study in which 10 adults with amblyopia played Medal of Honor for 40 hours with one eye patched. Three other patients played a nonaction video game, and seven had their eyes patched before play began. Tested before and after training, patients who played one-eyed saw their acuity improve more than 30 percent, a fivefold greater recovery than would be expected from patching in children. In addition, the adults' spatial attention skills got a 40 percent boost, and their depth perception was enhanced by 50 percent. Li and Levi are now conducting a randomized trial with another 20 patients. They expect results within two years.

Big Thinkers

If games improve eyesight and visual attention, researchers considered what other brain processes they might be able to tweak. Cognitive psychologist Ian Spence of the University of Toronto wondered why males tend to perform better than females on tasks such as field of view, which measures spatial attention, and mental rotation, which tests a higher-level capacity called spatial reasoning that enables us to visualize how objects behave in three-dimensional space. Both types of spatial skills correlate with success in science and math. Spence and his colleague Jing Feng, a psychologist, theorized that video games could partially account for the gender gap because more males play them and because Green

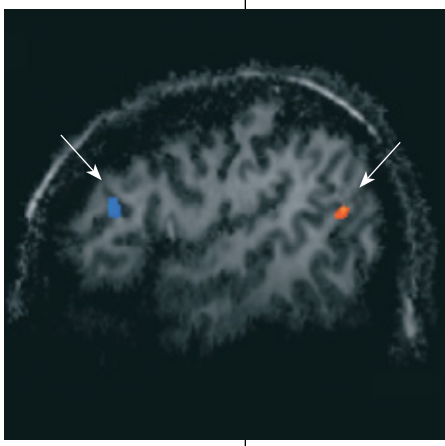
THOSE WHO PLAYED HALO, AN INTERSTELLAR FIRST-PERSON SHOOTER, SCORED BETTER ON THE ESSAY AS MEASURED BY THEIR KNOWLEDGE OF FIVE FACTS ABOUT PLATE TECTONICS.

GETTY IMAGES

Video-game players excel at making quick decisions. When they drive, this skill helps them rapidly assess and react to flashes of light or movement near the vehicle. Is that a child about to run into the intersection?

and Bavelier's work suggested that playing these games had benefits for spatial attention.

First, they established a disparity in spatial attention along gender lines in a group of 48 university students. They then divided six male and 14 female students, none of them gamers, into matched pairs of the same sex. One member of each pair of students trained for 10 hours on Medal of Honor: Pacific Assault, and the other played Ballance, a three-dimensional puzzle game involving steering a ball through an obstacle-laden maze. After training, action-game players improved by 10 to 15 percent on both the field-of-view task *and* a mental rotation challenge, whereas the puzzle-game players saw no change. In both instances, the females improved the most, virtually erasing the gender disparity in field of view and significantly reducing it in mental rotation. The results indicate that the theory was right: a difference in gaming experience between males and females could account for some of the gender inequality in spatial skills. Also, notably, playing these games can sharpen both types of spatial acuity and therefore, perhaps, even scientific aptitude.



Video-game players use their brains more efficiently than nongamers to execute complex movements. When gamers prepared to move their hand opposite their eyes, they relied on their prefrontal cortex (*blue spot*), an area charged with planning, showing they had a rule for the action. Nongamers depended on their parietal cortex (*red spot*), indicating that they were thinking more about the details of the movement.

Indeed, in a study published last year cognitive psychologist Christopher A. Sanchez, now at Oregon State University, connected game-induced improvements in spatial reasoning with the ability to learn certain types of scientific material. Participants played just 25 minutes of either Halo, an interstellar first-person shooter, or Word Whomp, a timed spelling game. Next, they read a brief nonscientific text as a diversionary task followed by an explanation of plate tectonics. Finally, they wrote an essay on the causes of the eruption of Mount St. Helens. Those who played Halo scored better on the essay than those who played Word Whomp as measured by their knowledge of five facts about plate tectonics. Spatial reasoning also improved after playing Halo (but not after the word game), as determined by two standard tests of this skill taken before and after the session. "In first-person-shooter games, you are rotating constantly and locating yourself in space," says Sanchez, who believes this skill is linked to grasping some types of concepts. "When you're trying to learn [plate tectonics], you're extrapolating a spatial mental representation, a three-dimensional model that is running and changing all the time inside your head."

Action gamers are also better at making decisions when a rapid response is important, according to a 2010 study by Green and Bavelier, probably because they are faster at assessing new visual information. They asked 12 nongamers and 11 gamers to look at a display of moving dots and indicate the net direction of motion—whether more dots were moving to the right or left. Both groups were equally accurate, but gamers were substantially faster at deciding. A second experiment in which participants were asked to distinguish pure tones from white noise showed that gamers were also faster at making decisions about auditory input. This type of decision making can be critical behind the wheel. For example, it enables a driver to recognize more rapidly whether the flash of movement to the right of the vehicle is relevant: Is it a child about to run in front of the car or an inconsequential flashing light?

Video games also train hand-eye coordination, although the primary improvement in this domain appears to be cognitive. In a 2010 study neuroscientist Lauren E. Sergio of York University in Toronto and her colleagues scanned the brains of gamers and nongamers (13 of each) using functional MRI while they performed increasingly difficult hand-eye tasks while looking at a screen. The easiest tasks were those in which a person could watch a target, such as pressing a tab on the screen, followed by those that required a user to look away from their hands, akin to using a mouse to operate

(The Author)

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FROM "EXTENSIVE VIDEO-GAME EXPERIENCE ALTERS CORTICAL NETWORKS FOR COMPLEX VISUOMOTOR TRANSFORMATIONS," BY JOSHUA A. GRANEK ET AL., IN *CORTEX*, VOL. 46, NO. 9; OCTOBER 2010

A study of laparoscopic surgeons showed that the number-one predictor of surgical skill was how well a doctor played video games.

In a Harris poll, 8.5 percent of children in the U.S. showed signs of addiction to video games. Among casino gamblers, the addiction rate is 4 to 6 percent.

a computer. In the most difficult tests, participants could not look at their hands and had to move a joystick in the opposite direction of the stimulus—if it moved right, they moved left—meaning they had to inhibit the natural tendency to follow what the eye sees. The harder the task, the more it recruited a part of the brain behind the forehead called the prefrontal cortex, which is involved in planning complex actions and, when necessary, can act as an inhibitor of gut responses, forcing us to stop and reconsider.

"Everybody used the same basic network of brain parts, and the performance was the same, but the network was reweighted," Sergio says. "The gamers were using much less of the basic motor control parts, and other areas were more active, mainly in the front part of the brain." The difference was greatest on the most difficult skills, such as those that involved acting in a manner discordant with that of a cue. We need to employ such cognitive control, for example, to steer a sailboat, which turns left when the tiller is moved right, and vice versa. These results, Sergio believes, suggest that gamers use their prefrontal cortex to perform visuomotor skills more than nongamers do. This pattern, which is also seen in concert musicians, is considered a sign of expertise and may lead to better performance during extremely complex motor feats, such as piano playing or surgery.

A striking application of this skill surfaced in a 2007 study of 33 laparoscopic surgeons, who operate while looking through a camera rather than directly at the patient. Developmental psychologist Douglas A. Gentile of Iowa State University tested the doctors on a set of standardized suturing skills. "The number-one predictor of surgical skill was how good they were at video games," he says. "The number-two predictor was how much they had played video games in the past. Only after that did we get to things like how many years of training they had or how many surgeries they had performed." Other researchers have found similar results with airplane and drone pilots.

Just a Game?

Despite such positive findings, heavy use of video games can also have serious drawbacks. Game addiction has not yet been officially recognized as a disorder, but studies by Gentile and others found between 5 and 11 percent of children worldwide say such games are disrupting their lives, suggesting they could be considered addicted. In the U.S., where Gentile worked with Harris Polls, the figure was 8.5 percent. In contrast, 4 to 6 percent of casino gamblers are considered addicted. Thus, even if playing violent video games can be beneficial, as Gentile recognizes it can be, people need to be alert to the dangers of too high a dose.

Gentile has also been taking a closer look at the content of these violent games, the blowing things up that the president decried. Researchers agree that such games lead to a short-lived increase in aggression. "Even though you know it's just a game, your body dumps stress hormones into your bloodstream that get you prepared to fight," Gentile says. "Once you stop playing, it wears off after half an hour."

Of more concern are studies across thousands of gamers indicating that regular exposure to violent video games (meaning several hours a week) accounts for 1 to 4 percent of the many possible triggers for aggression. (Other predictors range from provocation to poverty and child abuse.) Most consider this percentage to represent a small effect. Gentile also emphasizes that protective factors such as involved parents and good social skills can minimize the problem. Put another way, play-

LESTER LEFKOWITZ *Getty Images (top)*; JAMES LEE *iStockphoto (bottom left)*; KATHY KONKLE *iStockphoto (bottom right)*

IDEALLY, THEN, RESEARCHERS WOULD BE ABLE TO TEASE OUT THE BENEFICIAL INGREDIENTS OF THESE GAMES TO CREATE NONVIOLENT VERSIONS THAT TRAIN BRAINS JUST AS EFFECTIVELY.

ers for whom games can spawn violence usually have other troubles. If you are looking at violent crime, Gentile agrees video games have almost nothing to do with it. Still, he adds, gaming could have an impact on milder forms of aggressiveness. "If what you care about is the everyday aggression you see in seventh grade—people ostracizing one another, saying unkind things, bullying," Gentile explains. "I say there's a huge effect. Games change the way kids see the world."

Making Peace

Ideally, then, researchers would be able to tease out the beneficial ingredients of these games to create nonviolent versions that train brains just as effectively. So far these factors seem to include operating from a first-person point of view, managing multiple streams of information and goals, and making rapid decisions. Bavelier imagines a game in which you are on a planet where animals are suffering from a deadly disease. You are the veterinarian who must find them and inject them with lifesaving medicine. To add to the challenge, the disease is deadly to humans, so you cannot let them touch you. "It's all the same dynamics of an action game," Bavelier says, "but suddenly you're doing good."

What makes games fun and absorbing are rich graphics and sufficiently complex storylines. All of it stimulates the brain's reward system—releasing a jolt of dopamine, a neurotransmitter associated with pleasure that both encourages continued play and sparks learning. "The very mechanics that seem to make commercially successful games superfun are also the ones that are seeming to have the positive effects in terms of brain plasticity," says Alan Gershenfeld, president of E-Line Media, a company he co-founded to create games for learning, health and social impact.

Success in building a new suite of brain-changing games, however, will require not only good science but also partnerships between neuroscientists and expert game designers. Bavelier has joined forces with Gershenfeld, and the two are raising funds to develop what they say will be the first game "designed from the ground up" to take advantage of the new research: a nonviolent action game targeted at developing number sense in eight- to 14-year-olds.

GETTY IMAGES

Playing violent video games can briefly boost aggressiveness, and regular exposure could cause kids to be meaner to one other.

Meanwhile some existing nonviolent video games may lead to other benefits. In a 2009 study Gentile found that prosocial games, those that require cooperation, make children more helpful and sociable. "I don't believe action games are going to be the solution to everything—quite the contrary," Bavelier says. Given that games are here to stay, getting the best out of them could be an epic win for everyone. M

(Further Reading)

- **Action Video Game Modifies Visual Selective Attention.** C. Shawn Green and Daphne Bavelier in *Nature,* Vol. 423, pages 534–537; May 29, 2003.
- **Video Games and Spatial Cognition.** Ian Spence and Jing Feng in *Review of General Psychology,* Vol. 14. No. 2, pages 92–104; June 2010.
- **Children, Wired: For Better and for Worse.** Daphne Bavelier, C. Shawn Green and Matthew W. G. Dye in *Neuron,* Vol. 67, No. 5; September 9, 2010.
- **Improved Probabilistic Inference as a General Learning Mechanism with Action Video Games.** C. Shawn Green, Alexandre Pouget and Daphne Bavelier in *Current Biology,* Vol. 20, No. 17, pages 1573–1579; September 14, 2010.
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WISDOM FROM PSYCHOPATHS?

A scientist enters a high-security psychiatric hospital to extract tips and advice from a crowd without a conscience

By Kevin Dutton *Illustrations by Niklas Asker*

"Got anything sharp?" the woman at reception barks, as I deposit the entire contents of my briefcase—laptop, phone, pens—into a clear, shatter-resistant locker in the entrance hall. "Now place the index finger of your right hand here and look up at the camera."

Once you pass through border control at Broadmoor, the best-known high-security psychiatric hospital in England, you are immediately ushered into a tiny air lock, a glass-walled temporary holding cell between reception and the hospital building proper, while the person you are visiting—in my case, a psychologist assigned to escort me to my destination—gets buzzed by reception and makes his way over to meet you.

Adapted from *The Wisdom of Psychopaths: What Saints, Spies, and Serial Killers Can Teach Us about Success,* by Kevin Dutton, by arrangement with Scientific American/Farrar, Straus and Giroux, LLC (US), Doubleday Canada (Canada), Heinemann (UK), Record (Brazil), DTV (Germany), De Bezige Bij (Netherlands), NHK (Japan), Miraebook (Korea) and Lua de Papel (Portugal).

"Psychopathy is like a medicine for modern times. In moderation, it can prove extremely beneficial. But if you overdose, then, as is the case with all medicines, there can be some rather unpleasant side effects."

It's a nervy, claustrophobic wait. As I sit flicking through magazines, I remind myself why I'm here—an e-mail I had received a couple of weeks after launching the Great British Psychopath Survey, in which I tested people in different professions for psychopathic traits [*see box on page 42*]. One of the survey's respondents, a barrister by trade, had written to me. He had posted a score that certainly got my attention.

"I realized from quite early on in my childhood that I saw things differently than other people," he wrote. "But more often than not, it's helped me in my life. Psychopathy (if that's what you want to call it) is like a medicine for modern times. If you take it in moderation, it can prove extremely beneficial. It can alleviate a lot of existential ailments that we would otherwise fall victim to because our fragile psychological immune systems just aren't up to the job of protecting us. But if you take too much of it, if you overdose on it, then there can, as is the case with all medicines, be some rather unpleasant side effects."

The e-mail had got me thinking. Might this eminent criminal defense lawyer have a point? Was psychopathy a "medicine for modern times"? The typical traits of a psychopath are ruthlessness, charm, focus, mental toughness, fearlessness, mindfulness and action. Who wouldn't at certain points in their lives benefit from kicking one or two of these up a notch?

I decided to put the theory to the test. As well as meeting the doctors in Broadmoor, I would talk with some of the patients. I would present them with problems from normal, everyday life, the usual stuff we moan about at happy hour, and see what their take on it was. Up until now it had seemed like a good idea.

"Professor Dutton?" I look up to see a blond guy in his mid-30s peering around the door at me. "Hi, I'm one of the clinical leads at the Paddock Center. Welcome to Broadmoor! Shall I take you over?"

The Paddock Center is an enclosed, highly specialized personality disorder directorate comprising six 12-bedded wards. Around 20 percent of the patients housed there at any one time are what you might call "pure" psychopaths. These are confined to the two Dangerous and Severe Personality Disorder (DSPD) wards. The rest present with so-called cluster disorders: clinically significant psychopathic traits, accompanied by traits typically associated with other personality disorders—borderline, paranoid and narcissistic, for example. Or they may have symptoms such as delusions and hallucinations indicative of psychosis.

Suddenly, reality dawns. This is no drop-in center for the mocha-sipping worried well. This is the conscienceless inner sanctum of the Chianti-swilling unworried unwell—the preserve of some of the most sinister neurochemistry in the business. The Yorkshire Ripper is in here. So is the Stockwell Strangler. It's one of the most dangerous buildings on earth.

We emerge from the mazy, medicinal bowels of the hospital to the right of a large, open-air enclosure, topped off with some distinctly uncooperative razor wire. "Er … I am going to be all right, aren't I?" I squeak.

My guide grins. "You'll be fine," he says. "Actually trouble on the DSPD wards is relatively rare. Psychopathic violence is predominantly instrumental, a direct means to a specific end. Which means, in an environment like this, that it's largely preventable. And in the event that something does kick off, easily contained.

"Besides," he adds, "it's a bit late to turn back now, isn't it?"

Getting to Know the Locals

We enter one of Broadmoor's ultra-sequestered DSPD wards. My first impression is of an extremely well appointed student residence hall. All blond, clean-shaven

FAST FACTS

Life Lessons from the Inside

1» **Psychopaths have personality traits that, in moderation, can offer significant benefits. These typically terrible individuals may thus have a lot to teach the rest of us.**

2» **The triumvirate of charm, focus and ruthlessness that psychopaths possess can predispose a person for long-term life success.**

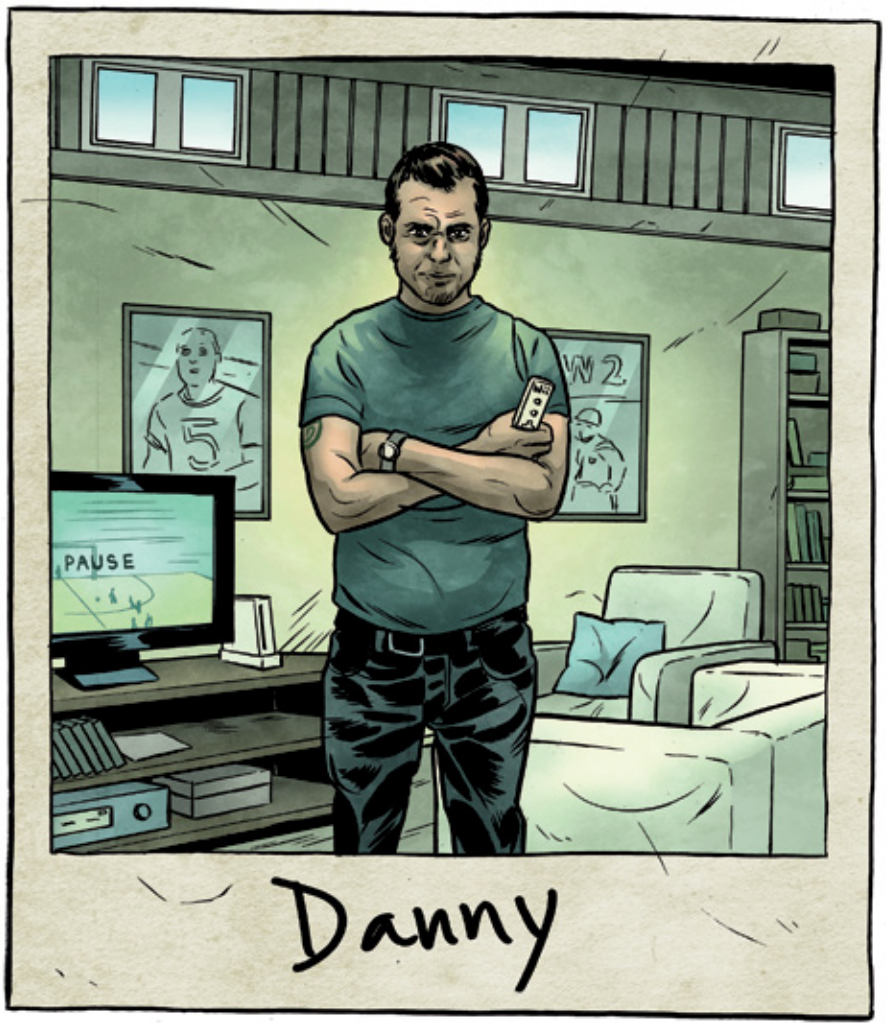
3» **A psychopath's proclivity to live in the moment can arm against anxiety and bring joy.**

wood. Voluminous, freshly squeezed light. There's even a pool table, I notice. A man named Danny shoots me a glance from behind his Nintendo Wii. Chelsea are 2–0 up against Manchester United. "We are the evil elite," Danny says. "Don't glamorize us. But at the same time, don't go the other way and start dehumanizing us, either."

Larry, a gray, bewhiskered, roly-poly kind of guy, takes a shine to me. Dressed in a Fair Isle sweater and beige, elasticized slacks, he looks like everyone's favorite uncle. "You know," he says, as he shakes my hand, "they say I'm one of the most dangerous men in Broadmoor. Can you believe that? But I promise you, I won't kill you. Here, let me show you around."

Larry escorts me to the far end of the ward, where we stop to take a peek inside his room. It looks like a typical single-occupancy hospital room, though with a few more creature comforts such as a computer, desk space, and a raft of books and papers on the bed. Next is the garden: a sunken, gray-bricked patio affair, about the size of a tennis court, interspersed with benches and conifers. We then drop in on Jamie.

"You know," says Larry, a gray, bewhiskered, roly-poly kind of guy. "They say I'm one of the most dangerous men in Broadmoor. Can you believe that? But I promise you, I won't kill you. Here, let me show you around."



Danny and his fellow imprisoned psychopaths are endowed with a laserlike focus. They are better than most people at keeping their goal in mind and not getting caught up in the heat of the moment.

"This guy's from Cambridge University," announces Larry, "and he's in the middle of writing a book on us."

Jamie stands up and heads us off at the door. A monster of a man at around 6'2", with char-grilled stubble and a piercing cobalt stare, he has the brooding, subsatanic presence of the lone, ultraviolent killer. The lumberjack shirt and shaven, wrecking-ball head don't exactly help matters.

"So what's this book about, then?" he growls, in a gangsterish Cockney whisper, arms folded in front of him, left fist jammed under his chin. "Same old bollocks, I suppose? Lock 'em up and throw away the key? You know, you've got no idea how vindictive that can sound at times. And, might I add, downright hurtful. Has he, Larry?"

Larry guffaws theatrically and clasps his hands to his heart in a Shakespearean display of angst. Jamie, meanwhile, dabs at imaginary tears.

"I happen to think that you guys have got something to teach us," I say. "A certain personality style that the rest of us can learn from. In moderation, of course. That's important. Like the way, just now, you shrugged off what people

Jamie, another "pure" psychopath in residence, exemplifies ruthlessness. He suggests devising clever, nonviolent ways to take down adversaries when necessary to get what you want.

might think of you. In everyday life, there's a level on which that's actually quite healthy."

Jamie seems quite amused by the idea that I might be soliciting his advice. "Are you saying that me and Larry here have just got too much of a good thing?"

Back at other end of the ward, Danny has just been named Man of the Match. "I see he hasn't killed you, then," he says casually. "You going soft in your old age, Larry?"

I laugh. More than a little nervously, I realize. But Larry is deadly serious.

"Hey," he says insistently. "You don't get it, do you, boy?" He looks at me. "I said I wouldn't kill you. And I didn't, right?"

And it hits me that Larry may not have been bluffing. The curtain comes down on the football game. Danny zaps it off. He leans back in his chair.

"So a book, eh?" he says.

"Yes," I say. "I'm interested in the way you guys solve problems."

Danny eyes me quizzically. "What kind of problems?" he asks.

"Everyday problems," I say, and I tell him about some friends of mine who were trying to sell their house.

Ruthless People

How to get rid of an unwanted tenant? That was the question for Don and his wife, Fran, whose elderly mother, Flo, had just moved in with them. Flo had lived in her previous house for 47 years, and now that she no longer needed it, Don and Fran had put it on the market. Being in an up-and-coming area of London, the house had drawn quite a bit of interest. But there was also a problem. The tenant. Who wasn't exactly ecstatic at the prospect of hitting the road.

Don and Fran had already lost out on one potential sale because he couldn't, or wouldn't, pack his bags. But how to get him out?

"I'm presuming we're not talking violence here," inquires Danny. "Right?"

"Right," I say. "We wouldn't want to end up inside now, would we?"

Danny gives me the finger. But the very fact that he asks such a question at all debunks the myth that violence, for psychopaths, is the only club in the bag.

"How about this, then?" rumbles Jamie. "With the old girl up at her in-laws, chances are the geezer's going to be alone in the house, yeah? So you pose as some bloke from the council, turn up at the door

"You talk about 'doing the right thing.' But what's worse? Beating someone up who deserves it? Or beating yourself up who doesn't? If you're a boxer, you put the other guy away as soon as possible."

and ask to speak to the owner. He answers and tells you the old dear ain't in. Okay, you say. Not a problem. But have you got a forwarding contact number for her, cuz you need to speak to her urgently?

"By this stage he's getting kind of curious. What's up? he asks, a bit wary, like. Actually, you say, quite a lot. You've just been out front and taken a routine asbestos reading. And guess what? The level's so high it makes Chernobyl look like a health spa. The owner of the property needs to be contacted immediately. A structural survey has to be carried out. And anyone currently living at the address needs to vacate the premises until the council can give the all clear.

"That should do the trick. With a bit of luck, before you can say 'slow, tortuous death from lung cancer,' the wanker will be straight out the door."

Jamie's elegant, if rather unorthodox, solution to Don and Fran's stay-at-home tenant conundrum certainly had me beat. The idea of getting the guy out so sharpish as to render him homeless and on the streets just simply hadn't occurred to me. And yet, as Jamie quite rightly pointed out, there are times in life when it's a case of the "least worst option." Interestingly, he argues that it's actually the right thing to do.

"Why not turf the bastard out?" he asks. "I mean, think about it. You talk about 'doing the right thing.' But what's worse, from a moral perspective? Beating someone up who deserves it? Or beating yourself up who doesn't? If you're a boxer, you do everything in your power to put the other guy away as soon as possible, right? So why are people prepared to tolerate ruthlessness in sport but not in everyday life? What's the difference?"

Winning Smiles

Jamie's solution to Don and Fran's tenant problem carries undertones of ruthlessness. Yet as Danny's initial qualification of the dilemma quite clearly demonstrates—"I'm presuming we're not talking violence here, right?"—such ruthlessness need not be conspicuous. The dagger of hard-nosed self-interest may be concealed, rather deftly, under a benevolent cloak of opaque, obfuscatory charm.

Psychopaths' capacity for charm is, needless to say, well documented. As is their ability to focus and "get the job done." It's a powerful, and smart, combination.

Leslie, another inmate, has a nice take on charm: "The ability to roll out the red carpet for those you cannot stand in order to fast-track them, as efficiently as possible, in the direction you want them to go."

Leslie, another inmate, has joined us and has a rather nice take on charm: "The ability to roll out a red carpet for those you cannot stand in order to fast-track them, as smoothly and efficiently as possible, in the direction you want them to go."

With his coiffured blond locks and his impeccable cut-glass accent, he looks, and sounds, like a dab hand. He also has a good take on focus, especially when it comes to getting what you want. Leslie realized from a rather young age that what went on in his head obeyed a different set of operating principles than most.

"When I was a kid at school, I tended to avoid fisticuffs," he tells me. "You see, I figured out pretty early on that, actually, the reason why people don't get their own way is because they often don't know themselves where that way leads. They get too caught up in the heat of the moment and temporarily go off track.

"Jamie was talking about boxing there a minute ago. Well, I once heard a great quote from one of the top trainers. He said that if you climb into the ring hell-bent on knocking the other chap into the middle of next week, chances are you're going to come unstuck. But if, on the other hand, you concentrate on winning the fight, simply focus on doing your job, well, you might just knock him into the middle of next week anyway."

The triumvirate of charm, focus and ruthlessness can predispose someone for long-term life success. Take Steve Jobs. Jobs, commented journalist John Arlidge shortly after the Apple chief's death in 2011, achieved his cult leader status "not just by being single-minded, driven, focused … perfectionistic, uncompromising, and a total ball-breaker." In addition, Arlidge noted, he had charisma. He would, as technology writer Walt Mossberg revealed, drape a cloth over a product—some pristine creation on a shiny boardroom table—and uncover it with a flourish.

Apple isn't the world's greatest techno innovator. Far from it. It wasn't the first outfit to introduce a personal computer (IBM), nor the first to introduce a smartphone (Nokia). What Jobs brought to the table was style. Sophistication. And timeless, technological charm.

(The Author)

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Apple's setbacks along the road to world domination serve as a cogent reminder of the pitfalls and stumbling blocks that await all of us in life. Everyone, at some point or other, leaves someone on the floor, so to speak, and there's a pretty good chance that that someone, today, tomorrow or at some other auspicious juncture down the line, is going to turn out to be you.

Neural Steel

Psychopaths, lest Jamie and the boys have yet to disabuse you, have no problem whatsoever facilitating others' relationships with the floor. But they're also pretty handy when they find themselves on the receiving end. And such inner neural steel, such inestimable indifference in the face of life's misfortunes, is something that all of us, perhaps, could do with a little bit more of.

Studies of psychopaths have even revealed a brain signature for this relative indifference to setbacks. Anthropologist James Rilling of Emory University and his co-workers scanned the brains of those scoring high in psychopathy after these individuals experienced having their own attempts to cooperate unreciprocated. The scientists discovered that, compared with "nicer," more equitable participants, the psychopaths exhibited significantly reduced activity in the brain's emotion hub, the amygdala. This diminished activity, suggestive of a muted emotional reaction, could be considered a neural trademark of "turning the other cheek," a response that can sometimes manifest itself in rather unusual ways.

A psychopath's rapacious proclivity to live in the moment, to "give tomorrow the slip and take today on a joyride" (as Larry, rather whimsically, puts it), is well documented—and at times can be stupendously beneficial.

"When we were kids," Jamie chimes in, "we'd have a competition. See who could get the most elbows (rejections) on a night out. You know, from girls, like. The bloke who'd got the most by the time the lights came on would get the next night out for free.

"Course, it was in your interest to rack up as many as possible, right? A night on the piss with everything taken care of by your mates? Sorted! But the funny thing was, soon as you started to get a few under your belt, it actually got f— harder. Soon as you realize that it actually means jack, you start getting cocky. You start mouthing off. And some of the birds start to buy it!"

The Feel-Good Emergency

Mental toughness and fearlessness often go hand in hand. Of course, to many of us lesser mortals, fearlessness may seem quite foreign. But Leslie explains the rationale behind this state—and how he maintains it. "The thing about fear, or the way I understand fear, I suppose—because, to be honest, I don't think I've ever really felt it—is that most of the time it's completely unwarranted anyway. What is it they say? Ninety-nine percent of the things people worry about never happen. So what's the point?

Psychopaths at the Office?

The Great British Psychopath Survey is the first of its kind to assess the prevalence of psychopathic traits within an entire national workforce. Participants were directed to my Web site, where they completed the Levenson Self-Report Psychopathy Scale and then received their score. They also entered their employment details. A total of 5,400 people responded. I grouped the respondents by profession and found I had at least 15 individual results for 50 different professions. I then found the average score on the Levenson scale for each occupation and ranked the jobs accordingly. The standings below reveal the U.K.'s 10 most and least psychopathic professions, according to my study. —*K.D.*

Most Psychopathic Professions	Least Psychopathic Professions
1. CEO	1. Care worker
2. Lawyer	2. Nurse
3. Media (TV/radio)	3. Therapist
4. Salesperson	4. Craftsperson
5. Surgeon	5. Beautician/Stylist
6. Journalist	6. Charity worker
7. Police officer	7. Teacher
8. Cleric	8. Creative artist
9. Chef	9. Doctor
10. Civil servant	10. Accountant

Like his comrades in the ward, Larry doles out a hefty helping of charm. Along with focus, ruthlessness and mental toughness, charm is a key ingredient in the recipe for both psychopathy and success.

"I think the problem is that people spend so much time worrying about what might happen, what might go wrong, that they completely lose sight of the present. They completely overlook the fact that, actually, right now, everything's perfectly fine.

"So the trick, whenever possible, I propose, is to stop your brain from running on ahead of you."

Leslie's pragmatic endorsement of the principles and practices of what might otherwise be described as mindfulness is typical of the psychopath. A psychopath's rapacious proclivity to live in the moment, to "give tomorrow the slip and take today on a joyride" (as Larry, rather whimsically, puts it), is well documented—and at times can be stupendously beneficial. In fact, anchoring your thoughts unswervingly in the present is a discipline that psychopathy and spiritual enlightenment have in common. Clinical psychologist Mark Williams of the University of Oxford, for example, incorporates this principle of centering in his mindfulness-based cognitive-behavior therapy program for sufferers of anxiety and depression.

"Feeling good is an emergency for me," Danny had commented as he'd slammed in his fourth goal for Chelsea on the Wii. Living in the moment, for him and many psychopaths, takes on a kind of urgency. "I like to ride the roller coaster of life, spin the roulette wheel of fortune, to terminal possibility."

A desire to feel good in the here and now, shrugging off the future, can be taken to an extreme, of course. But it's a goal we could all perhaps do with taking onboard just a little bit more in our lives.

"Settle in okay?" my guide inquires as we jangle back to clinical psychology suburbia. I smile. M

Editors' note: The names and physical characteristics of the individuals mentioned in this excerpt have been changed to disguise their identities.

(Further Reading)

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- **Psychopathic Personality: Bridging the Gap between Scientific Evidence and Public Policy.** Jennifer L. Skeem, Devon L. L. Polaschek, Christopher Patrick and Scott O. Lilienfeld in *Psychological Science in the Public Interest,* Vol. 12, No. 3, pages 95–162; December 2011.
- Take part in the Great American Psychopath Survey and learn much more about psychopaths at Dutton's Web site: **www.wisdomofpsychopaths.com**

YOUR BRAIN ON TRIAL

Lessons from psychology could greatly improve courtroom decision making, reducing racial bias, eyewitness errors and false confessions

By Scott O. Lilienfeld and Robert Byron

ILLUSTRATION BY DAVID SENIOR

ISTOCKPHOTO

On January 18, 2011, Kevin Benefield was convicted of the rape and murder of Barbara Pelkey in Wallingford, Conn. Benefield was deemed guilty on the basis of DNA evidence, which exonerated Kenneth Ireland, the man initially convicted of the crimes. Ireland's newfound freedom was bittersweet. It arrived only after he had spent more than 20 years in prison, having been arrested at age 18 and convicted wrongfully in 1989.

Ireland is hardly alone. Stories of people cleared of crimes following erroneous convictions have become ubiquitous fixtures of the news cycle. Many of these errors have been exposed with the aid of welcome scientific advances, especially DNA analysis. But wouldn't it be better if a systematic approach were available to help prevent wrongful convictions and other serious miscarriages of justice in the first place?

In fact, there exists such an approach: psychological science. Yet many well-established psychological findings have yet to exert much influence on the legal system, in part because of a resistance to change and in part because of differing traditions. Whereas science tends to question common intuitions regarding human nature, the legal system tends to embrace them. Our thesis is straightforward: psychological research can inform courtroom decision making and help decrease the frequency of flawed verdicts. As a psychologist (Lilienfeld) and an attorney (Byron), we are concerned by the yawning gulf between psychological science and the law, though optimistic that this gulf can ultimately be narrowed.

In this article, we show how and, in so doing, make no pretense at comprehensiveness. Instead, to give readers a flavor of how psychological science can improve legal decision making, we survey five domains in which research in psychology can inform courtroom decisions: judges' instructions to jurors, eyewitness testimony, suspect lineups, false confessions and racial bias in jury decision making.

Please Strike That from the Record

As emeritus Princeton University psychologist and Nobel laureate Daniel Kahneman notes in his 2011 book *Thinking, Fast and Slow,* there are two basic modes of human thinking. System 1 cognition is rapid, automatic and intuitive; System 2 thinking is deliberate, controlled and analytical. At the risk of oversimplifying these two modes of information processing, let us say that System 1 initially believes what it perceives and that System 2 only later subjects it to scrutiny. In 1990 psychologist Daniel Gilbert, now at Harvard University, and his co-authors presented participants with statements based on a word from the Hopi language (such as "a *monischa* is an armadillo"); a few seconds later participants learned whether the assertion was true or false. Subjects were distracted in the intervening seconds by a challenging task—hitting a button as soon as they heard a musical tone—intended to prevent them from processing these statements mentally and, in effect, shutting down System 2. Later, when Gilbert asked distracted subjects whether each statement was true or false, they were more likely to identify the statements as true. Believing is our default state, so it comes to us naturally; disbelieving does not.

The judicial domain typically ignores the System 1–System 2 distinction. Research using simulated jurors, reviewed by psychologist Nancy K. Steblay of Augsburg College and her colleagues in 1999, shows that a judge's admonitions to jurors to disregard a

FAST FACTS

Courting Science

1» **Psychological research can inform courtroom decision making and help decrease the frequency of flawed verdicts.**

2» **As of this writing, the Innocence Project has freed 301 individuals on the basis of DNA evidence. In about 75 percent of these cases, a principal cause of the wrongful conviction was faulty eyewitness testimony.**

3» **To prevent false confessions, a video of the full interrogation should be available to substantiate any self-incriminatory statements.**

4» **Placing blacks on the jury can defuse the biases of white jurors.**

CHRISTOPHE LEHENAFF *Getty Images*

Eyewitness memory can be distorted by "facts" learned later. If a witness is told that two vehicles "smashed" into each other, she may falsely recall having seen broken glass at the scene.

piece of evidence presented during a trial are often fruitless because this information still exerts a significant influence over verdicts. False beliefs often persist long after they have been discredited. Psychologists term this phenomenon belief perseverance. Despite what judges may assume, we do not—arguably cannot—merely wipe our mental slates clean after being instructed to ignore information. The judicial system neglects belief perseverance in another way. Among the first things the judge does at a trial is read the charges to the jury. At that moment, any presumption of innocence that may have lingered in a juror's mind can be dispelled because jurors tend to believe the charges as read.

DESPITE WHAT JUDGES MAY ASSUME, WE DO NOT—ARGUABLY CANNOT—WIPE OUR MENTAL SLATES CLEAN AFTER BEING INSTRUCTED TO IGNORE INFORMATION.

Psychological science points to a few potential fixes to the thorny problem of belief perseverance. First, research reviewed by psychologist Tarika Daftary-Kapur of the John Jay College of Criminal Justice and her co-workers in 2010 suggests that jurors can better ignore stricken evidence once they hear a clear-cut rationale for why the information is unfair to the prosecution or to the defense. So rather than merely instructing jurors to ignore evidence, judges should explain why they should ignore it. Second, judges should avoid reading the charges at the beginning of the trial. Besides obviating the presumption of innocence, which is a cornerstone of our criminal justice system, this practice can generate a template—what psychologists call a schema—by which jurors evaluate the evidence. This schema can fuel confirmation bias, the deeply ingrained propensity to seek out evidence that fits with what we believe, encouraging the jury to accord more weight to evidence that seems to prove the charges than to evidence that does not.

Seeing Is Not Believing

"I'll never forget that face." Few phrases strike more fear into the hearts of eyewitness memory experts—and with good reason. The past several decades of psychological research teach us that

human memory, though a finely honed product of natural selection, is anything but perfect. Pioneering research by University of California, Irvine, psychologist Elizabeth F. Loftus and her colleagues shows that eyewitness reports of an incident can be influenced adversely by a plethora of factors, including information provided *after* the event. In classic work from 1974 by Loftus and John C. Palmer of the University of Washington, witnesses who had viewed a film of a car crash and were told that the vehicles had "smashed" into each other were more likely to recall having seen broken glass at the scene a week later than those told that they had "hit" each other. There was no broken glass at the scene.

Research demonstrates that our memories do not operate like video cameras or tape recorders. Most neuroscientists believe that every time we recall an event, we alter our memory trace of it. Yet in a large survey of the American public in 2011, psychologists Daniel Simons of the University of Illinois and Christopher Chabris of Union College found that 63 percent of respondents believe that "memory works like a video camera."

On occasion, eyewitness errors are merely humorous. In a New York City murder trial in 2011, Dorothy Canady insisted that she would never forget the criminal's face. Yet when asked from the witness stand to locate him, she pointed to one of the jurors, triggering giggles in the courtroom. Other eyewitness mistakes, however, damage people's lives. Take the 1984 case of Jennifer Thompson, then a student at Elon College in North Carolina, who was raped in her off-campus apartment. In her 2009 book *Picking Cotton,* Thompson describes how she pointed to Ronald Cotton as the suspect, saying that she was "100 percent certain" when she spotted him in the courtroom. Cotton spent 11 years behind bars before another man, Bobby Poole, was identified definitively by DNA evidence as the rapist. Thompson, wracked with guilt over her error, reached out to Cotton for forgiveness. They have since become friends and now tour the country giving joint presentations on the hazards of eyewitness errors.

AFTER INSISTING SHE WOULD NEVER FORGET THE CRIMINAL'S FACE, DOROTHY CANADY LOCATED THE MAN IN THE COURTROOM. SHE POINTED TO A JUROR.

As of this writing, the Innocence Project, a national organization focused on correcting wrongful convictions through DNA testing and judicial reform, has freed 301 individuals on the basis of DNA evidence. In about 75 percent of these cases, a principal cause of the erroneous guilty verdict was faulty eyewitness testimony. In about 35 percent of *these* cases, the testimony stemmed from two or more incorrect observers, demonstrating that consistency should not be confused with correctness—or as psychologists are fond of saying, reliability is not validity. Psychological science has homed in on the factors that consistently distort eyewitness memory. A 2001 survey of eyewitness memory experts by psychologist

In 1984 Jennifer Thompson (*left*) misidentified Ronald Cotton (*right*) as her rapist. Cotton spent 11 years in prison before being exonerated on the basis of DNA evidence.

GERRY BROOME *AP Photo (left)*; SCOTT WITTER *(right)*

Police often show witnesses a line of people like this one, from which they are to pick the perpetrator. But data indicate that presenting people one at a time generally leads to fewer mistakes.

JOHN LUND AND SAM DIEPHUIS *Getty Images*

Saul M. Kassin, now at the John Jay College of Criminal Justice, and his colleagues revealed several points of consensus. All else being equal, such testimony is less accurate when witnesses are forced to identify someone who differs from them in race (for example, Thompson was Caucasian, and Cotton and Poole were African-American), when the crime involved a weapon ("the weapon focus" effect), and when interrogators ask suggestive questions ("The guy who did it had a thin moustache, right?"). Eyewitness memory also tends to be more error-prone when the crime unfolded quickly, when a long time has elapsed between the incident and its recollection, or when the witness was intoxicated during the crime.

A procedure called the cognitive interview, developed by psychologists Ronald P. Fisher of Florida International University and R. Edward Geiselman of the University of California, Los Angeles, may circumvent some of the shortcomings of eyewitness memory. The cognitive interview relies on techniques derived from scientifically supported principles of memory, such as asking open-ended rather than suggestive questions, reminding witnesses of the context of the crime, offering them retrieval cues (reminders) of the crime and discouraging them from guessing. Most evidence indicates that this procedure can enhance accurate recall of crimes.

Educating judges and jurors about the science of eyewitness testimony may also help. Triers of fact need to understand that a witness's recollections, though sometimes accurate, can be warped by a host of well-established factors. They also must realize that a witness's confidence is not a foolproof bellwether of correctness. In July 2012, in a pioneering move, the New Jersey Supreme Court instructed judges to make jurors explicitly aware of many of these facts. Two months later the Connecticut Supreme Court followed suit—a pattern we hope will be repeated elsewhere. Or, as Loftus quips, the legal system might modify its oath to witnesses to read, "Do you swear to tell the truth, the whole truth or whatever it is you think you remember?"

The Usual Suspects

We can all picture the scene: the classic Hollywood movie setup of five or six people arrayed in a line as a crime victim inspects them one by one. A police officer, aware of the suspect's identity, stands by as the victim picks out the most likely criminal. Before leaving, the officer communicates with the victim, perhaps giving him or her feedback on the

(The Authors)

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choice ("good job"). In most U.S. police precincts, this "simultaneous" lineup procedure is the customary way of doing business, although most jurisdictions now use photographs rather than live lineups. Yet evidence from the laboratory increasingly suggests that this method is often biased against the innocent and frequently associated with high error rates. In one 2001 study of simultaneous lineups in real cases, witnesses picked the wrong person about a quarter of the time.

In 2006 former schoolteacher John Mark Karr (*right*) confessed to killing six-year-old JonBenét Ramsey (*left*) a decade earlier. But DNA told a different story.

MARK FIX *Corbis (left)*; SUKREE SUKPLANG *Corbis (right)*

ERROR RATES DROP WHEN OFFICERS ARE "BLIND" TO THE IDENTITY OF THE SUSPECT AND TELL THE WITNESS THAT THE SUSPECT MAY NOT BE IN THE LINEUP.

Psychological research points to a better way. Data reviewed by Iowa State University psychologist Gary L. Wells and his collaborators in 2006 demonstrate that "sequential" lineups, which present witnesses with only one person at a time, tend to yield lower error rates than do the traditional procedures. In a simultaneous lineup, witnesses rely on a rule of thumb that is relative rather than absolute: they ask themselves, "Which of these people is most similar to the suspect I remember seeing?" and feel compelled to pick the closest match even if it is far from a perfect one. As a result, they may choose someone who looks a bit like the real criminal but who is innocent. In contrast, in a sequential lineup, witnesses ask themselves, "Are any of these people identical to the suspect I remember seeing?" and feel free to answer "no." This is another domain in which psychological science is slowly finding its way into police practice. As of this writing, two states (New Jersey and North Carolina) mandate sequential lineups.

Work by Wells and others shows that error rates drop when police officers conducting the lineup procedure are "blind" to the identity of the suspect and tell the witness that the suspect may not be in the lineup. This practice minimizes the implicit demand on witnesses to pick someone even if that person is not whom they recall seeing. In addition, witnesses should never receive feedback about whether they selected the "right" suspect because such information can bolster confidence in their pick even when it is wrong.

Constructing the lineup properly is also crucial. Although there is no simple recipe for doing so, the participants should match the suspect on key physical characteristics such as race, approximate height and weight, and presence or absence of facial hair. Psychologists have devised a clever method to ascertain whether a lineup is biased: if observers who did not see the crime and know nothing about it consistently pick out the same person as the probable sus-

pect when asked to guess who did it, the lineup is likely to be biased, almost certainly because that person stands out physically in some way.

Like most things in life, there are trade-offs. In particular, the reforms we and others have proposed may boost the odds of false negatives—that is, overlooking the people who committed the crimes in question, a drawback highlighted by University of California, Riverside, psychologist Steven E. Clark in a 2012 article. Still, because the American judicial system should be safeguarding the innocent, in most cases, these improvements are well worth the cost.

I Confess

In 1932 the American public was transfixed by media coverage of a tragedy, soon to be known as the Crime of the Century: the abduction and murder of the 20-month-old child of famed aviator Charles Lindbergh. Horrific as the crime was, more than 200 people came forward to admit to it. In 2006 former schoolteacher John Mark Karr confessed to the widely publicized 1996 Colorado killing of JonBenét Ramsey, a six-year-old child beauty pageant contestant. Yet DNA evidence later showed that Karr could not have been the murderer.

It probably goes without saying that false confessions matter. Survey data collected by Kassin in 1998 demonstrate that judges and jurors perceive confessions as providing conclusive evidence of guilt. Complicating matters further, other evidence reviewed in 2009 by psychologists Allison D. Redlich of the University at Albany, S.U.N.Y., and Christian A. Meissner of the University of Texas at El Paso indicates that people are poor at distinguishing false from true confessions.

Many of us find the notion that a person would own up to a crime they did not commit difficult to fathom, but evidence suggests that false confessions are not rare. Data from the Innocence Project indicate that up to 27 percent of individuals initially found guilty but later cleared by DNA evidence had confessed in spite of their clean hands. Research points to both personal and situational factors that boost the odds of these admissions. False confessors are especially likely to be young and suggestible and to have histories of crime or substance abuse. Cognitive impairment and serious mental illness are also risk factors. People are particularly prone to admitting to crimes erroneously when isolated from others and confronted with evidence of their guilt even if investigators have fabricated that evidence.

Highly coercive interrogations are also a prime culprit. Many people presumed that Amanda Knox, the University of Washington student tried in Italy for the brutal murder of Meredith Kercher in 2007, must have been guilty because she had confessed. They may, however, have underestimated the impact of a 43-hour coercive interrogation across a five-day period in a foreign country, with the final eight hours conducted overnight without food or water.

The widely used Reid technique, developed by training firm John E. Reid and Associates and taught to many U.S. police officers, is a virtual recipe for spurious confessions. Officers isolate suspects and confront them with evidence that appears to implicate them. They brush aside any denials from the suspect. Interrogators give the suspect the choice between two alternatives that both imply guilt—for example, "Did you plan out this crime for months, or was it just a spur of the moment thing?" Questioners also

KELLY REDINGER *Corbis*

Coercive interrogations that last for days put suspects in a fragile mental state that can lead to a false confession. Young people are particularly apt to admit to a crime they did not commit.

Mixed-race juries are fairer to black defendants. Diversity also appears to improve accuracy and critical thinking among jurors.

use "minimization," mitigating the seriousness of the purported crime with statements such as "Well, it is true that you should not have robbed the bank, but we realize that you needed the money." They also downplay the anticipated punishment, assuring suspects, for example, that "the judge and jury will understand that you were under a lot of financial and emotional strain when you stole the car."

In most cases, these techniques are ill advised. In 2005 psychologist Melissa B. Russano of Roger Williams University and her colleagues gave undergraduates a problem to solve, while another "student" (actually a confederate in league with the experimenters) working on the same problem sat beside them. In one condition, the confederate cheated by requesting help from the subject. Following the session, the experimenter interrogated participants about whether they helped the student cheat using techniques similar to those advocated by Reid and Associates. The questioning doubled the odds of a genuine confession, but it increased the chances of a false confession much more, by a factor of more than seven. [For more on false confessions, see "True Crimes, False Confessions," by Saul M. Kassin and Gisli H. Gudjonsson; Scientific American Mind, June 2005.]

Again, psychological data suggest remedies. So-called self-incriminatory statements uttered under interrogation should be accompanied by a video of the full interrogation to reveal whether coercive or other leading practices were used, and no such statement should be admitted if an attorney for the defendant was absent. In addition, a technique dubbed PEACE, for *p*reparation and planning, *e*ngage and explain, obtain an *a*ccount, *c*losure and *e*valuation, developed by U.K. psychologists in collaboration with attorneys and police officers, is a promising alternative. In contrast to most standard interrogation techniques, the PEACE method has fact finding as its major goal. It emphasizes building rapport, asking open-ended questions and obtaining the suspect's version of events.

Twelve Angry Men and Women

Last but not least is the problem of racial bias. Most problematically, some white jurors appear to be biased against black defendants. Indeed, research shows that whites tend to presume that black defendants are guilty—more so than the reverse. Research by psychologist Joshua Correll of the University of Chicago and his collaborators in 2007 further suggests that racial bias may be rapid and largely automatic. Correll showed student volunteers faces, either black or white, on a computer, followed by either a handgun or hand tool such as a hammer or a wrench, which they needed to identify as quickly as possible. The volunteers were instructed to ignore the face, the ostensible purpose of which was to signal that the image of a gun or tool was about to appear. Participants identified the handguns more

RON CHAPPLE *Getty Images*

rapidly when a black, but not a white, face came right before it. Moreover, when pressured to identify the object quickly, they were more likely to identify it as a gun when they had just seen a black face.

How can we defuse the biases of white jurors? Scientific evidence suggests a relatively simple remedy: placing blacks on the jury. Psychologist Samuel R. Sommers of Tufts University reported actual trial data in 2006 showing that the higher proportion of whites a jury has, the harsher it is toward black defendants. Furthermore, diverse juries—those with at least two blacks on the jury panel—are not only fairer to black defendants but also fairer across the board, perhaps because they are exposed to broader perspectives. They also appear to be superior critical thinkers, possibly because white jurors know that they will need to later justify their decisions to minority jurors. White participants in Sommers's diverse juries brought up more facts about the case during deliberations, committed fewer factual mistakes and were more open to talking about race when on diverse rather than on all-white juries. Prior to the deliberations, just knowing they were about to serve on a racially heterogeneous jury made whites less likely to assume that a black defendant was guilty.

In practice, attorneys can and often will issue objections to excuse a juror without cause; these challenges have often removed black jurors. For a long time these exclusions required no explanation. In the 1986 case of *Batson v. Kentucky,* however, the U.S. Supreme Court ruled that such a challenge cannot be used to discriminate on the basis of race, and if it seems to, the side in question must offer a race-neutral explanation (such as the fact that the juror has an obvious bias). Still, the process is not foolproof, and attorneys can often generate sufficiently plausible reasons to exclude black jurors when they want to.

Bridging the Gap

In our "closing arguments," we acknowledge that we have surveyed only the tip of a huge iceberg. We have not discussed other domains in which the melding of science and the law could prove beneficial. For example, in the field of lie detection, psychologists Aldert Vrij of the University of Portsmouth in England and Bella DePaulo of the University of California, Santa Barbara, have reported that despite popular conception, nonverbal cues such as fidgeting and averting gaze are *not* telltale signs of deception. Standard police training in detecting deception emphasizes these erroneous cues and therefore typically leads to *decreases* in accuracy. Investigators would do better to pay attention to verbal cues, listening for a lack of detail and minor imperfections in suspects' stories, which *are* often indicative of lying.

WHEN THE LEGAL SYSTEM BECOMES MORE ACCEPTING OF PSYCHOLOGICAL FINDINGS, IT WILL NOT BE IMMUNE TO ERROR. BUT IT WILL BE A BETTER AND FAIRER SYSTEM.

As a second example, when police make videos of interrogations, they typically train their cameras directly on the suspect. Yet psychologist G. Daniel Lassiter of Ohio University and his colleagues demonstrated in 1992 that this seemingly innocuous decision engenders bias against the suspect, probably because observers are prone to attributing cause—and blame—to whatever is most visually salient, a phenomenon Lassiter dubbed the "camera-perspective effect." Lassiter's work shows that broadening the camera angle to include both interrogator and suspect diminishes this bias.

The two of us eagerly await a day when our legal system is grounded more firmly in psychological science. Although the developments we have cited in New Jersey, Connecticut and North Carolina suggest an opening of the judicial mind to psychology research, they constitute only a modest step. When the legal system finally becomes more accepting of well-established psychological findings, it will not be immune to error, because fallibility is an inescapable characteristic of the human condition. Moreover, science is itself provisional and subject to correction. But we are persuaded that it will be a better and fairer system, one that strives ruthlessly to root out biases in the interests of protecting the public. M

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THE MYSTERY OF THE MISSED CONNECTION

A common but little understood malformation reveals the brain's incredible plasticity

By Claudia Christine Wolf

Sarah Mellnik was four years old when her doctors discovered the striking anomaly in her brain. She was missing the massive connective bridge that ordinarily unites the brain's two hemispheres. This malformation can delay the development of verbal and motor skills, among other abilities. Today, however, Mellnik is a gregarious and active 29-year-old. She not only walks, she volunteers as an assistant dance teacher.

FAST FACTS

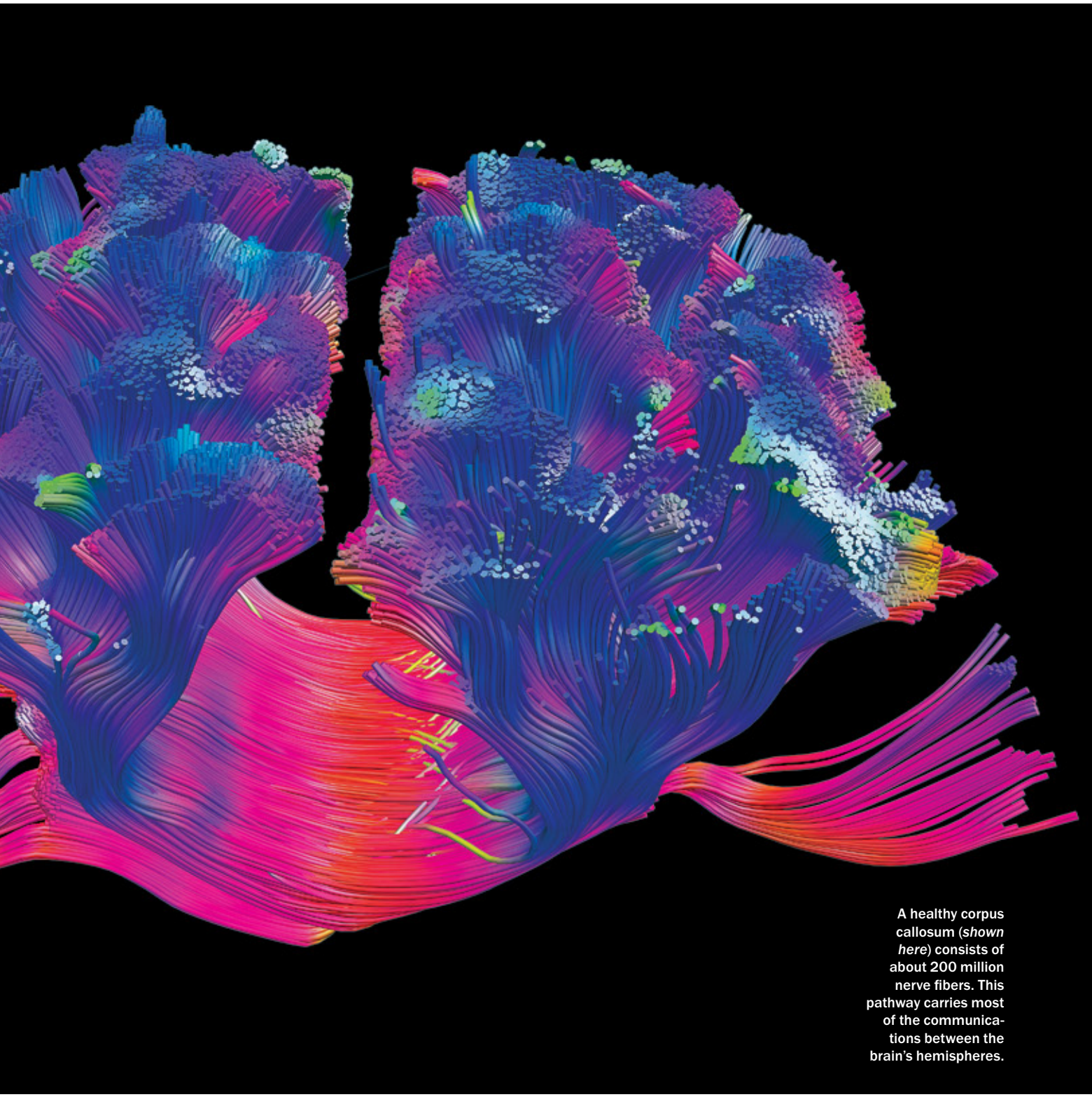
Neural Highways

1» A malformed corpus callosum, the massive connective bridge that carries most messages traveling between the two hemispheres, can lead to a range of cognitive deficits.

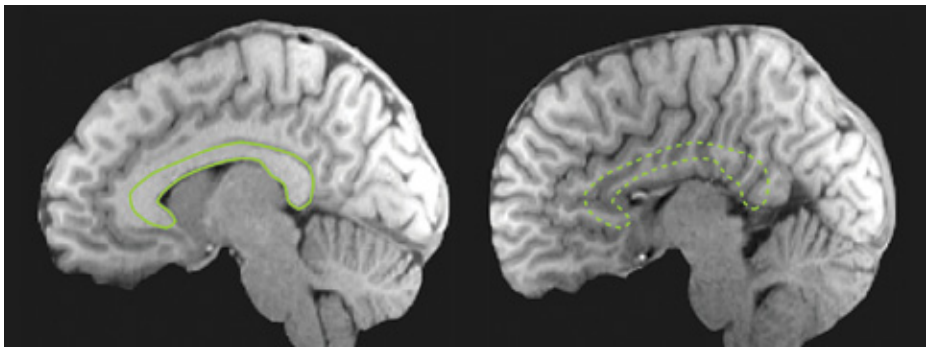
2» Early in life the brain can rewire itself to compensate for the absence of this critical structure, revealing the organ's innate plasticity.

3» In addition to complicating verbal and motor activities, a malformed corpus callosum may also play a role in disorders such as autism and schizophrenia.

COURTESY OF SUDHIR PATHAK *Walter Schneider Lab, LRDC, University of Pittsburgh*



A healthy corpus callosum (*shown here*) consists of about 200 million nerve fibers. This pathway carries most of the communications between the brain's hemispheres.



In the brain shown at the right, the corpus callosum failed to develop. Other tissue filled the allotted space but did not form a central bridge, as seen at the left. The acallosal brain can often reorganize itself to connect the hemispheres through other means.

These milestones did not come easily. In high school she endured other students' taunts, disbelieving teachers and difficulties with class work. In spite of her struggles, Mellnik earned her high school diploma in 2000. Her mantra, which she repeats to herself and others like her, is "Never give up."

When brain development goes awry, as in Mellnik's case, a structure called the corpus callosum can grow in only partially or not at all. In a typical brain the 200 million nerve fibers of the corpus callosum serve as a high-speed data line that shuttles neural messages between hemispheres. Individuals with this disorder, called agenesis of the corpus callosum, often have cognitive deficits, ranging from autismlike symptoms to mild learning difficulties.

The fact that the brain can cope at all without its largest connective pathway reveals its remarkable dynamism. The brain's self-tuning in the absence of the corpus callosum exposes some of the rules that govern neural plasticity and repair. These findings could also help us better understand diverse conditions, including autism and schizophrenia, that may arise in part from a malformed corpus callosum.

Gaps in the Brain's Bridge

This set of nerve fibers is perhaps best known for its role in one of the most famous experiments in neuroscience. In the 1960s Michael S. Gazzaniga and Richard Sperry of the California Institute of Technology studied a group of people with epilepsy whose corpus callosum had been severed to stop the spread of seizures through the brain. The surgery quelled the seizures, but it also brought on cognitive problems.

Sperry and Gazzaniga discovered these disabilities by asking subjects to train their eyes on a dot in the middle of a screen while images appeared to the right or left of the dot. These so-called split-brain patients could identify the pictures without hesitation when they appeared on the right side but not when they showed up on the left.

As scientists now know, information entering each eye travels to the opposite brain hemisphere for processing. In most people, only the left hemisphere is dominant for verbal tasks. When visual input traveled to a patient's right hemisphere, that signal could not then cross the brain to produce the words needed to identify the images. This discovery, which confirmed how the hemispheres specialize in processes, garnered Sperry the 1981 Nobel Prize in medicine. The work also illustrates the vital role of the corpus callosum in a normally functioning brain. [For more on split-brain patients, see "Spheres of Influence," by Michael S. Gazzaniga; Scientific American Mind, June/July 2008.]

Typically this 10-centimeter-long bundle of neural fibers begins to grow during the 11th week of pregnancy and continues to develop through adolescence. Every fiber is a neuron's axon, the long, spindly protrusion that connects brain cells. Chemical messengers guide the first nerve fibers, called pioneer axons, from one hemisphere to a terminus in the opposite hemisphere. Other axons follow the pioneers until many millions of threads of nervous tissue weave the two hemispheres together. These links play a role in multiple essential functions, including attention and memory.

Life experiences can alter the corpus callosum. For example, in 2008 Harvard Medical School neuroscientist Gottfried Schlaug found that musicians who began studying an instrument before age seven have a larger corpus callosum than nonmusicians, as well as bulked-up portions of the auditory and motor areas of the brain. A difficult childhood can have the opposite effect: a 2004 study led by Martin Teicher, also at Harvard, showed that children who were neglected or abused had a corpus callosum that was 17 percent smaller than that of healthy children.

The ability of a brain of the corpus callosum

In roughly one in 4,000 infants, however, the corpus callosum fails to form, leading to speech and motor delays in as many as 80 percent of cases. One prominent example is the savant Kim Peek, whose astonishing feats of memory inspired the 1988 movie *Rain Man*. Often genetics are to blame, but environmental factors can also take a toll: almost 7 percent of babies with fetal alcohol syndrome develop an abnormal corpus callosum.

Individuals lacking this structure also tend to be born with other brain malformations. As a result, some people exhibit severe handicaps, such as seizures and mental retardation, whereas others possess ordinary IQs. Roughly a

COURTESY OF MIKE TYSZKA *California Institute of Technology*

(The Author)

CLAUDIA CHRISTINE WOLF is a biologist and an editor at *Gehirn & Geist*.

third of individuals without a corpus callosum meet the criteria for an autism spectrum disorder.

Because the outcomes vary so widely, those with a malformed corpus callosum may go undiagnosed for years. For instance, Joseph Galbraith learned only at age 45 that he had the disorder. "All of my life I knew that I was not connecting the dots like other people," he says. "It seemed like 40 years of shame and guilt started melting away."

The Plastic Brain

The cognitive deficits that accompany agenesis of the corpus callosum differ from those seen in Sperry and Gazzaniga's experiments in telling ways. In 1991 neuropsychologist Maryse Lassonde and her colleagues at the University of Montreal recruited three groups of people: those who had their corpus callosum fully severed as an adult, individuals who underwent the procedure in childhood and subjects who never developed one at all. Lassonde asked her blindfolded participants to identify objects in either their left or right hand by touch. As with visual input from the eyes traveling across hemispheres, information from the right hand is processed in the left hemisphere, and vice versa.

What they discovered was startling. Only split-brain patients who had had these central fibers severed as adults could not name the objects in their left hand. Subjects who had lived most of their life without a complete structure had no trouble with the task. Somehow the young brain could compensate.

Scientists are only now learning how extensive that compensation is. In 2011 neuroimaging specialist J. Mike Tyszka and his colleagues at Caltech observed the neural activity patterns of eight people who had never grown a corpus callosum. These individuals had normal IQs and no other brain abnormalities. When the subjects lay idle in a brain scanner, Tyszka expected to see the two hemispheres operating independently of each other. To his surprise, the two halves' activation patterns were both synchronized and symmetric. In all, the patterns looked very much like those of normal brains.

In my own research my colleagues and I have learned that people with a malformed corpus callosum but no other brain defects can relay complex information between hemispheres, further evidence that the brain must depend on alternative pathways. This work dovetails with the idea that during critical growth periods the young brain can respond to congenital defects, injuries and surgical procedures by forming new connections. The ability of a brain during childhood to find different wiring patterns reveals its extraordinary malleability and plasticity. The question now is how exactly messages can traverse the brain when the backbone of its communication network is shut down.

during childhood to find different wiring patterns in the absence reveals its extraordinary malleability and plasticity early in life.

Rebuilding Connections

One hypothesis is that the brain builds up much smaller bridges between hemispheres. In my study, for example, four of our five subjects had an unusually large anterior commissure, a bundle of fibers that is normally about a tenth the size of the corpus callosum. Another possibility is that neurons rely on stunted structures known as Probst bundles, which develop out of axons that fail to cross to the other hemisphere. A team under neuroscientist Jerry Silver of Case Western Reserve University found evidence that these bundles might have conduction properties similar to those of intact nerve cells.

A more recent hypothesis comes from Tyszka and his colleagues. They derived insight from songbirds, whose acallosal brains also have synchronized hemispheres. A neural pathway based in the thalamus, near the center of the brain, relays information throughout the songbirds' cortex. The researchers hypothesize that the two halves of the human brain may also synchronize through the thalamus or through another midbrain structure.

Discovering how brains reorganize and resynchronize may lead to therapies for many different kinds of brain repair. Scientists have observed, for example, that individuals with autism and schizophrenia may have a smaller corpus callosum. This finding is in line with theories that these disorders involve low or aberrant connectivity in the brain.

Easing the challenges of people with a malformed corpus callosum is the immediate goal, however. Mellnik has come to accept the time it takes her to learn. When she graduated from high school, she swore she was done taking classes, but now she is a part-time college student. Mellnik sounds confident of her success. "I'm doing it at Sarah's pace," she says and is not shy about adding: "I just made the dean's list." M

(Further Reading)

- **How Does the Corpus Callosum Mediate Interhemispheric Transfer? A Review.** L. J. Van der Knaap and I. J. van der Ham in *Behavior and Brain Research,* Vol. 223, No. 1, pages 211–221; September 30, 2011.
- **Visuotactile Interactions in the Congenitally Acallosal Brain: Evidence for Early Cerebral Plasticity.** Claudia C. Wolf et al. in *Neuropsychologia,* Vol. 49, No. 14, pages 3908–3916; December 2011.
- **Neurodevelopment after Prenatal Diagnosis of Isolated Agenesis of the Corpus Callosum: An Integrative Review.** Alexandros Sotiriadis and George Makrydimas in *American Journal of Obstetrics and Gynecology,* Vol. 206, No. 4, pages 337.e1–337.e5; April 2012.

MIRAGES AND MIND BENDERS

THE 10 BEST ILLUSIONS OF THE YEAR

By Susana Martinez-Conde and Stephen L. Macknik

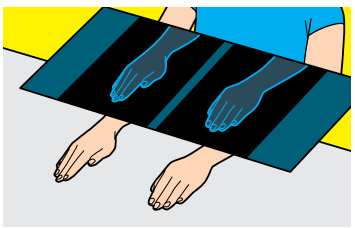
A trusting young woman puts her hands in a box with a transparent top. She is participating in an experiment, but this one has the aura of a magic show. The investigators ask her to hold her hands steady between vertical blue lines. She does so, watching her hands carefully. They do not appear to move, nor does she feel as if they are moving.

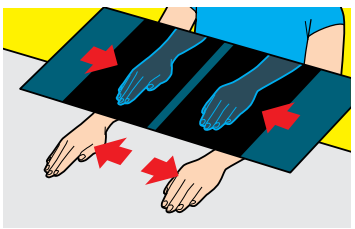
The investigators flick a switch, and the box darkens on one side, obscuring her right hand. They ask her to reach across with her left hand to touch her now invisible right. She complies, but her eyes suddenly widen with alarm. All she feels with her left hand is empty space.

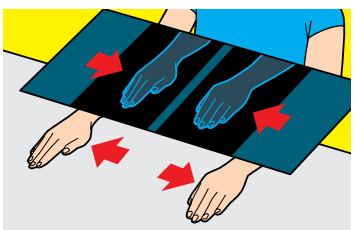
"Where's my hand gone?" she asks with growing anxiety, then suddenly she explodes with laughter as she realizes that these scientists are of the mad variety. Still, just to be sure, she pulls both her hands from the box to check that they are still there. They are. This time.

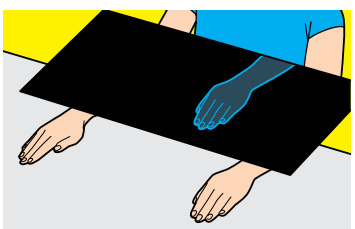
This scene, captured on video, helped the inventors of the mirage multisensory illusion box win first prize at the 2012 Best Illusion of the Year Contest. As with many well-known illusions, this one came about by accident. Three psychologists at the University of Nottingham in England created the box to study how the brain integrates visual input, bodily sensations and tactile information. One day one of them, Roger Newport, was trying to fix a misalignment in the box. He discovered "that my right hand was in the wrong place and my left was out of sight. I tried to touch my left hand with my right and missed it. I was so surprised I decided to see whether I could re-create the feeling experimentally."

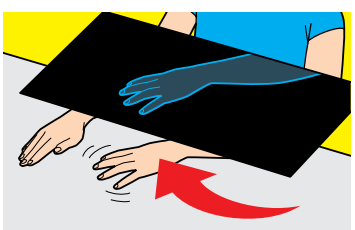
Equipped with a camera, a mirror and a monitor, the box created the illusion that the woman was looking at her own hands when in fact she was seeing a video re-creation of them. The hand images, manipulated by computer software, moved slowly inward. To compensate, the woman moved her hands outward—although it all happened so gradually that she did not notice. In less than a minute, the space between











Illustrations by Jason Lee

her hands became much greater than she realized.

The disappearing hand trick was one of 59 illusions submitted to the contest this year by psychologists, neuroscientists, artists, mathematicians and tinkerers from around the world. A panel of six judges winnowed the entries to a top-10 short list, and last May in Naples, Fla., an audience of 1,000 illusion lovers selected three winners.

The contest, which began in 2005, honors the best new illusions created or published within the preceding year, from all sensory modalities. It is hosted by the Neural Correlate Society, a nonprofit organization that brings together researchers from fields as diverse as art, mathematics, psychology and neuroscience to promote scientific understanding of perception and cognition. One of us (Martinez-Conde) is president of the society and the other (Macknik) vice president, and we both help orchestrate the event. *Scientific American* is a longtime sponsor.

The contest is playful, but for scientists it serves a deeper purpose. By definition, we experience illusions when the physical reality of the world fails to match our perception. All these little hiccups are an opportunity to peer behind the curtain, to learn more about how the brain works.

NOW, WHERE DID I PUT MY HAND?

In everyday experience, sensations such as sight, touch and proprioception (the awareness of one's body in space) work together to inform us about the location of our various body parts. Separate these inputs, as the creators of the mirage illusion box did, and the brain is easily confused. The woman in these images is surprised after trying to touch her hand and discovering that it is not where she thought it was.

To understand this illusion, think of how jerky a baby's early movements are and how unsteady she is as she learns to walk. She dynamically adjusts and readjusts virtually every muscle in her body as she struggles to remain upright. You do the same, even when sitting still, just more smoothly and without conscious oversight. The mirage box, created by University of Nottingham psychologists Roger Newport, Helen R. Gilpin and Catherine Preston, reveals what happens when these bodily sensations are dissociated from visual input.

For a demonstration, visit http://illusionoftheyear.com/2012/the-disappearing-hand-trick/, and for an amusing collage of reactions from study participants, see www.youtube.com watch?v=-4r1ANw0X3I

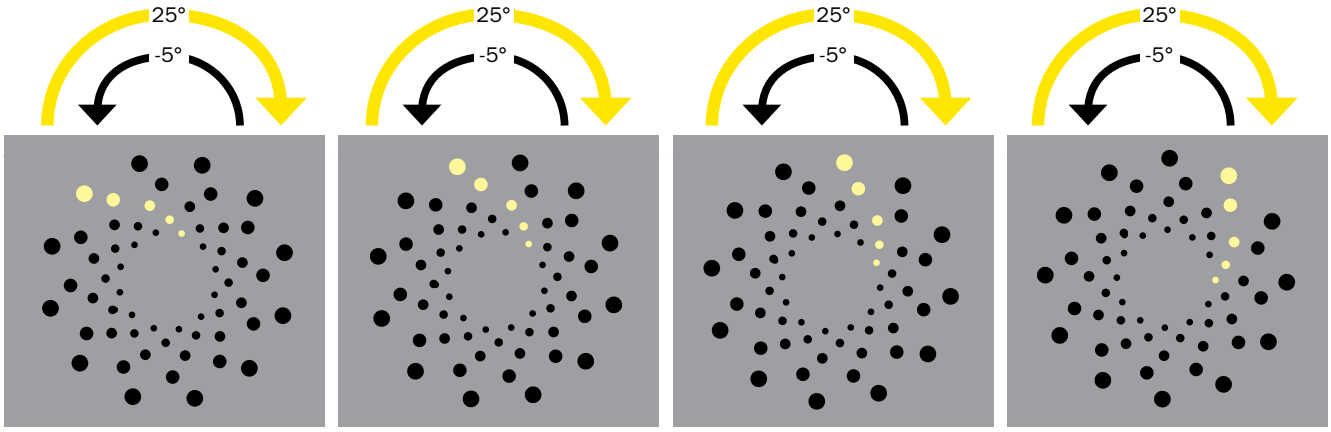
COURTESY OF ROGER NEWPORT, HELEN R. GILPIN AND CATHERINE PRESTON *University of Nottingham (screenshot)*

COLOR WAGON WHEEL

Vision scientist Arthur Shapiro, an illusion contest veteran with four previous trophies, bagged third prize in collaboration with his colleagues William Kistler and Alex Rose-Henig of American University. The team was inspired by a classic phenomenon known as the wagon wheel illusion.

In the standard wagon wheel, nested circular rows of black disks rotate clockwise but appear to rotate counterclockwise. The effect relies on the specific geometry. The disks in each row are spaced 30 degrees apart, and when they jump clockwise by intervals of 25 degrees, you have the option to interpret the jump as either a large clockwise turn of 25 degrees or a small counterclockwise turn of five degrees. Your brain chooses the less dramatic movement as the most probable one, and so the wheel appears to turn counterclockwise.

Shapiro and his colleagues had the idea to color some of the disks yellow. The result is a novel and striking illusion: a wheel that spins simultaneously in both directions (http://illusionoftheyear.com/2012/color-wagon-wheel). When you look at the yellow disks, you can tell that they are moving clockwise because their 25-degree jump is unambiguous—there are no other nearby yellow disks to confuse the matter. Yet you still have a strong sensation that the wheel, as a whole, moves in the opposite direction because the remaining black disks continue to drive the wagon wheel illusion.



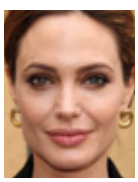
FAST FACTS

Gray Matters

1» The brain evolved not to interpret reality perfectly but to make quick and useful judgments about our surroundings. Illusions reveal some of these quirky neural shortcuts.

2» One groundbreaking new illusion exploits the fact that a shift in attention (with no change of gaze) changes what we see. Two others trade on the characteristics of peripheral vision, which registers motion but misses key details such as an object's true position.

3» The Best Illusion of the Year Contest brings scientific and popular attention to these delightful perceptual oddities. Anyone can submit an illusion to next year's contest: see http://illusionoftheyear.com/submission-instructions for the rules.



WHEN CELEBRITIES TURN UGLY

The prize for second place also resulted from a chance discovery. An undergraduate working with cognitive scientist Matthew Thompson of the University of Queensland in Australia was up late, preparing a set of photographs for an experiment on face perception. The student, Sean Murphy, aligned the faces at the eyes and skimmed through them in his computer. After a few seconds, he began to see highly deformed and grotesque faces staring back at him (our interpretation is the retouched photographs at the right). Surprised, he looked one by one at the faces that had struck him as the ugliest. "Each of them appeared normal or even attractive," Thompson says. "Sean had discovered the flashed-face distortion effect." The illusion works because our visual system processes each face not as an isolated entity but in comparison with the faces that precede and follow it, Thompson says. "Aligning the faces and presenting them quickly makes it easy for us to compare them, so their differences get more extreme," he adds. You may be thinking, okay, the illusion may work with the faces of most of us mere mortals, but surely the scientists couldn't make Brangelina look hideous, right?

Check out the two videos at http://illusionoftheyear.com/2012/when-pretty-girls-turn-ugly-the-flashed-face-distortion-effect

COURTESY OF ARTHUR SHAPIRO, WILLIAM KISTLER AND ALEX ROSE-HENIG *American University (top)*; S. BUKLEY *Shutterstock (Angelina Jolie)*; SHUTTERSTOCK *(Matt Damon)*; COURTESY OF JASON TANGEN, SEAN MURPHY AND MATTHEW THOMPSON *University of Queensland (screenshot)*

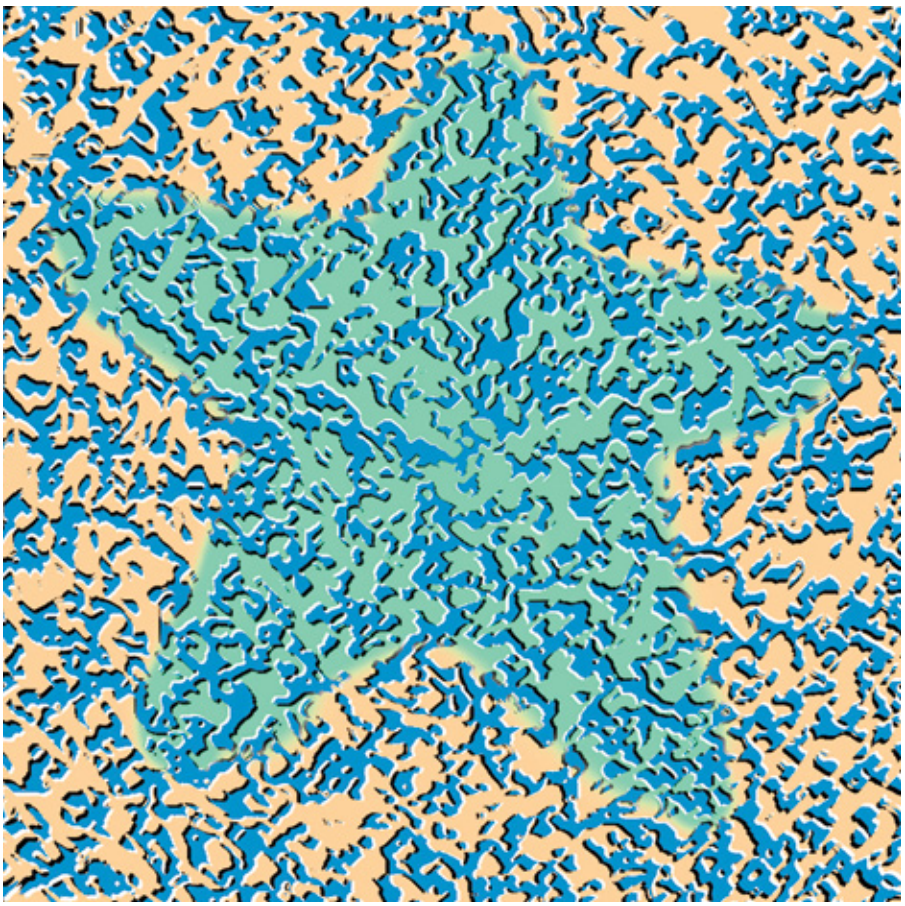
FLOATING STAR

This five-pointed star is static, yet observers experience the powerful illusion that it is rotating clockwise. Created by artist Joseph Hautman, who moonlights as a graphic designer under the pseudonym "Kaia Nao," it is a variation on the famous rotating snakes illusion created by vision scientist Akiyoshi Kitaoka of Ritsumeikan University in Kyoto.

Hautman determined that an irregular pattern, unlike the geometric one Kitaoka used, was particularly effective. Recent research we have done with our Barrow Neurological Institute colleague Jorge Otero-Millan reveals that among the key elements that make this type of illusion work are the small, jerky eye motions that people unconsciously make when looking at an image (known as microsaccades).

In Hautman's illusion, each of the blue jigsaw pieces has a white or black border against a lightly colored background. As you look around the image, your eye movements stimulate motion-sensitive neurons. These neurons perceive direction by virtue of the shifting lightness and darkness boundaries that indicate an object's contour as it moves through space. In the floating star image, carefully arranged transitions between white, light-colored, black and dark-colored borders fool the neurons into responding as if they were seeing continual motion in the same direction, rather than stationary edges.

The online link to the illusion is at http://illusionoftheyear.com/2012/floating-star



SWELLED HEADS

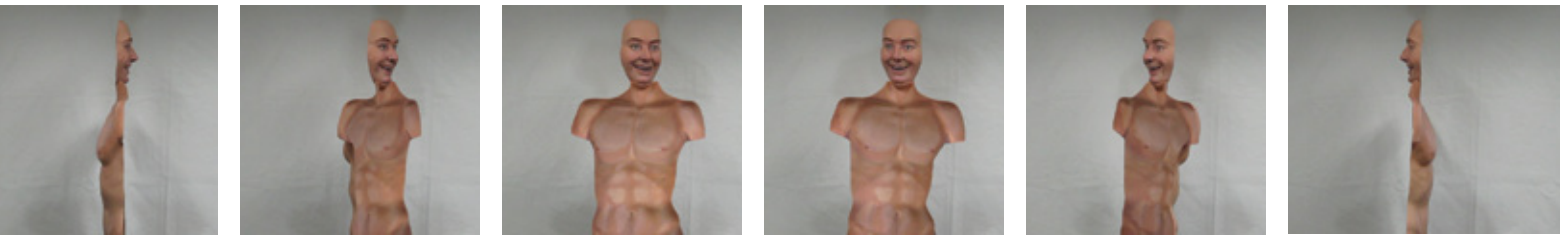
Turns out that compliments don't make people's heads expand; chipmunk cheeks do. Cognitive scientists Kazunori Morikawa and Eri Ishii of Osaka University recently discovered a phenomenon they call the head size illusion. The two faces shown here are identical except that in one image the man has a wider jaw and fuller face. The fatter head appears larger, but it is not.

The head size illusion demonstrates that the brain does not determine the size of visual stimuli in isolation; it compares objects and features with those nearby in the visual scene. The illusion occurs in everyday life, Morikawa says, and offers an opportunity. "If one part of your face or body appears wider or thinner than average, other parts appear wider or thinner, too. You can take advantage of such illusions to make yourself look better, using effective makeup and clothing," he explains.

(The Authors)

SUSANA MARTINEZ-CONDE and STEPHEN L. MACKNIK are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors, with Sandra Blakeslee, of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* now in paperback (http://sleightsofmind.com). Their forthcoming book, *Champions of Illusion,* will be published by Scientific American/Farrar, Straus and Giroux.

COURTESY OF KAIA NAO (*top*); COURTESY OF KAZUNORI MORIKAWA AND ERI ISHII *Osaka University (bottom)*

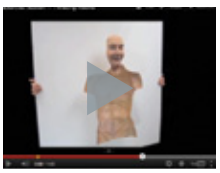


BEND IT LIKE LINDA BLAIR

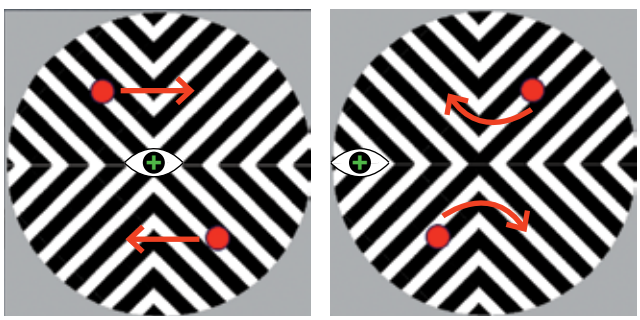
During the 1974 screening of the classic horror flick *The Exorcist,* starring Linda Blair as a demon-possessed girl, a spectator fainted in shock and broke his jaw on the seat in front of him. He sued Warner Brothers and settled out of court for an undisclosed sum. The exorcist illusion, presented by vision scientist Thomas Papathomas of Rutgers University, also made jaws drop, though with less severe consequences.

Papathomas produced this three-dimensional illusion with the help of three Rutgers colleagues: technician Tom Grace, Sr., artist Robert Bunkin and computer graphics expert Marcel de Heer. The team had earlier created hollow face illusions (where the inside of a hollow mask is cleverly painted to make it appear to protrude). Now they have created a "hollow body" illusion, with a critical twist: they paired a hollow mask with a nonhollow torso, and vice versa. The sculptures have no moving parts, but when the head-torso composites are rotated, "the effect is a flexible, twisting neck out of a 3-D rigid [body], like in *The Exorcist,*" Papathomas says.

This illusion reveals some of the biases the brain uses to interpret the orientation of faces and bodies. For example, your brain assumes that people's faces and bodies are lit from above—namely, by the sun. So when you view a hollow mask or body and the lighting orientation appears reversed, so does the rotational direction.



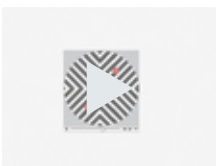
Visit http://illusionoftheyear.com/2012/exorcist-illusion-twisting-necks to watch the head of the devil's spawn do an illusory 360 around its torso.



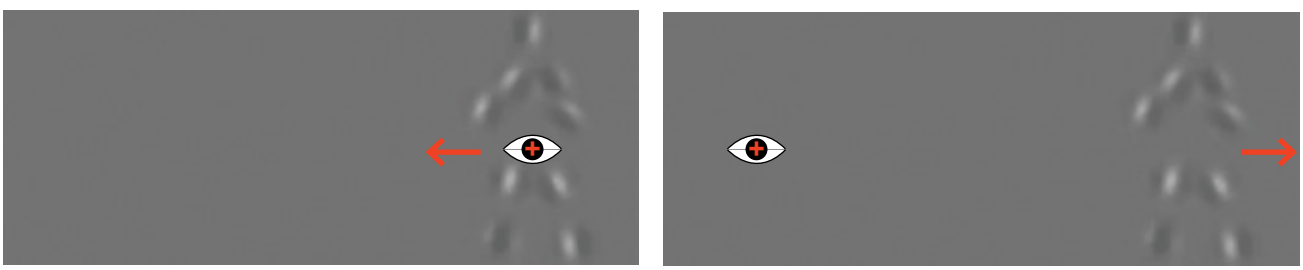
QUIRKS OF PERIPHERAL VISION, PART 1

A colored dot moves horizontally over a patterned black-and-white background. When you look straight at it, you see it accurately. But if you glance at it from the corner of your eye, the dot suddenly appears to glide diagonally. This animated illusion by vision scientist Stuart Anstis of the University of California, San Diego, demonstrates the different roles of central and peripheral vision. "In central vision, we see the positions of objects very precisely, whether they are stationary or moving," Anstis says. "Peripheral vision is very good at picking up movement. That's why we wave to attract a friend's attention in a crowded airport." But the outskirts of our gaze are not well suited to detecting positions. In this illusion, position and motion distort each other.

Anstis's striking creation has implications for everyday life. "When we drive, our wide-angle vision detects targets lying way out in our periphery. It's important to turn our gaze toward moving peripheral targets, to avoid the weird perceptual distortions demonstrated in my illusion," he says.



See two versions of it at http://illusionoftheyear.com/2012/the-colored-dot-peripheral-vs-central-vision

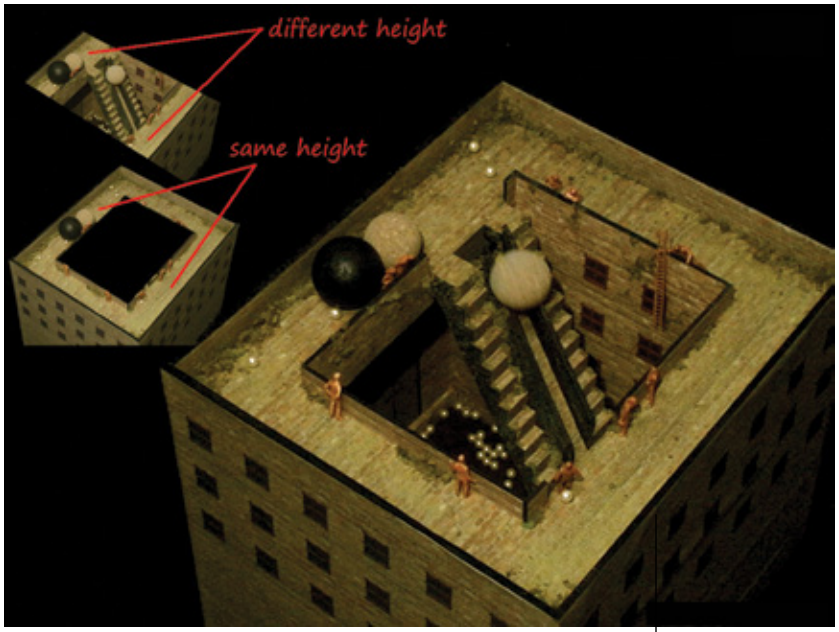


QUIRKS OF PERIPHERAL VISION, PART 2

Vision scientists Steven Thurman and Hongjing Lu of U.C.L.A. created a human figure out of disks known as Gabor patches, which are striped circular or oval patterns with blurry edges. The figure appears to walk to the left when you view it directly. But wait! If you look away the figure suddenly seems to change direction and walk to the right. The direction reversal is created by a disconnect. Thurman and Lu positioned the disks to represent a person walking to the right, despite the overall leftward shift created by the motion within the disks. Our central vision does not pick up the subtle rightward-moving walking cues, but super-motion-sensitive peripheral vision grasps them at once and integrates them into our perception of the object's trajectory.

Take a gander at the ambiguous walker at http://illusionoftheyear.com/2012/peripheral-action-phantom-illusion and go to http://illusionoftheyear.com/finalists_2012/thurman/dancing.mov to see it dancing out of the corner of your eye.

COURTESY OF THOMAS PAPATHOMAS, TOM GRACE, SR., MARCEL DE HEER AND ROBERT BUNKIN *Rutgers University (top);* COURTESY OF STUART ANSTIS *University of California, San Diego (middle);* COURTESY OF STEVEN THURMAN AND HONGJING LU *U.C.L.A. (bottom)*



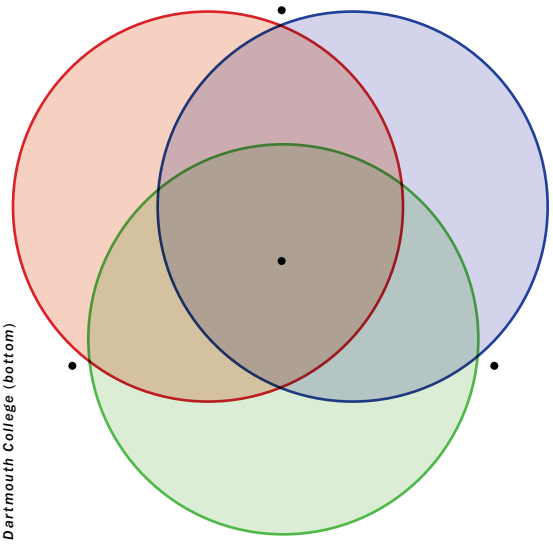
CHANNELING ESCHER

M. C. Escher, the iconic Dutch graphic artist, created etchings of water rolling uphill from his remarkable intuition that human perception assembles the whole of an image out of a multitude of little parts. Neuroscience research has proved Escher right: we now know that the visual system puts together the global perception of a scene from many local relations among object features. As a result, tiny mistakes that are too small to detect locally (and that occur in the real world rarely, if ever) can add up across space to become major mistakes at the global level, and voilà!—you have an impossible image.

Artist Sachiko Tsuruno of Kinki University in Japan has taken that concept to the next level. She built an architectural model that resembles the interior of a fortress and filmed balls rolling along inclines inside it. But because of the perspective she shot it from, you cannot shake the perception that the balls are rolling uphill between two level surfaces, as ridiculous and impossible as that may seem to your rational mind.

The clues to her deception are all there, but because they are virtually invisible at the local level the image is devastatingly convincing at the global level. Balls never do roll uphill unaided, so it must be that the uphill roll is actually downhill. The only possibility, then, is that the construct is not a tower at all but a clever representation of surfaces that look like a tower when seen from one specific perspective. Among the telltale signs: If you black out the staircase (a local clue), the top of the tower looks flat, whereas if you black out the sides (another local clue), it looks as if the top is on two levels connected by a staircase (*inset*). The brain is wired to interpret flat surfaces as three-dimensional, she says, adding, "My illusion occurs because most viewers misinterpret the 3-D structures."

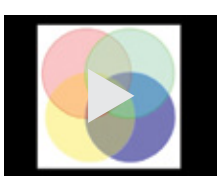
Marvel at it at http://illusionoftheyear.com/2012/illusion-of-height-contradiction



FILLING IN THE BLANKS

One new illusion is so significant that we think it should be included in the next generation of cognitive neuroscience textbooks. Vision scientist Peter U. Tse of Dartmouth College, winner of two previous trophies, grouped three colored disks so that they overlap in the center like a Venn diagram. If you fix your gaze on the central intersection and attend to one disk only, that entire disk will appear to take on the uniform color that it has in its outer region, where it does not overlap with the other disks. The attended disk will also look as if it is floating transparently above the other disks, despite the fact that the colors are mixed in some regions—and that the center is actually gray! No matter which disk you focus on, it will seem to fill in with a single homogeneous color.

The illusion demonstrates the brain's remarkable ability to see different things in the same scene, depending on its focus. For example, when you look at a pond, you may see clouds reflected on the surface, but with a subtle shift of attention you can instead find yourself looking at the stones at the bottom. In the same way, as you shift your attention to a specific disk in Tse's drawing, your brain suppresses the other disks and enhances the one you are looking at.



For an animated version, go to http://illusionoftheyear.com/2012/attentional-modulation-of-perceived-color

COURTESY OF SACHIKO TSURUNO *Kinki University (top)*; COURTESY OF PETER U. TSE *Dartmouth College (bottom)*

(Further Reading)

- **169 Best Illusions.** *Scientific American Mind* special issue, Vol. 20, No. 1; Summer 2010.
- **Multisensory Disintegration and the Disappearing Hand Trick.** Roger Newport and Helen R. Gilpin in *Current Biology,* Vol. 21, No. 19, pages R804–R805; October 11, 2011.
- **Microsaccades and Blinks Trigger Illusory Rotation in the "Rotating Snakes" Illusion.** Jorge Otero-Millan, Stephen L. Macknik and Susana Martinez-Conde in *Journal of Neuroscience,* Vol. 32, No. 17, pages 6043–6051; April 25, 2012.

All about Me

The sharp sword of narcissism can cut both ways

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

NARCISSISM has long gotten a bad rap. Its unseemly reputation dates back at least to ancient Greek mythology, in which the handsome hunter Narcissus (who undoubtedly would be gloating over his present-day fame) discovered his own reflection in a pool of water and fell in love with it. Narcissus was so transfixed by his image that he died staring at it. In 1914 Sigmund Freud likened narcissism to a sexual perversion in which romantic attraction is directed exclusively to the self. Contemporary views are hardly more flattering. Enter the words "narcissists are" into Google, and the four most popular words completing the phrase are "stupid, "evil," "bullies" and "selfish."

In 2008 psychologist Jean M. Twenge of San Diego State University and her colleagues found that narcissism scores have been climbing among American college students in the U.S. for the past few decades. Although the data are controversial, these scholars argue that we are living in an increasingly narcissistic culture.

Some of the opprobrium heaped on narcissists is surely deserved. Yet research paints a more nuanced picture. Although narcissists can be difficult and at times insufferable, they can also make effective leaders and performers. Moreover, because virtually all of us share at least a few narcissistic traits, we may be able to learn something about ourselves from understanding them.

Calling All Narcissists

Psychologists conceptualize narcissism as extreme self-centeredness. Of course, we can all be a bit self-focused at times, but for narcissists the self is an overriding concern. In the laboratory, psychologists often measure narcissism using the Narcissistic Personality Inventory. On this questionnaire, individuals pick one statement from pairs such as "I prefer to blend in with the crowd; I like to be the center of attention" and "I am no better or worse than most people; I think I am a special person." Their score reflects how narcissistic they are.

Some items on the test reflect a truth dating back to the Greeks: narcissists are obsessed with their looks. In 2008 Washington University psychologist Simine Vazire and her colleagues found that such individuals tend to wear expensive clothing and spend a lot of time preening. Data also confirm that narcissistic people like to talk about themselves. In 1988 psychologists Robert Raskin of the University of California, Berkeley, and Robert Shaw of Yale University found that in taped monologues, narcissistic undergraduates were significantly more likely than other students to use the word "I" and less likely to use the word "we."

In extreme forms, narcissism can become pathological. In the latest edition of psychiatry's bible, the *Diagnostic and Statistical Manual of Mental Disorders*, narcissistic personality disorder (NPD) is marked by an excessive sense of self-importance, unrealistic fantasies of success, and intense envy of others' accom-

COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); COURTESY OF HAL ARKOWITZ (*Arkowitz*); DAVID POHL (*illustration*)

plishments. People with NPD are also convinced they deserve special treatment. For example, they may be enraged that they need to wait on line at a restaurant behind other "lesser" people.

Increasing evidence suggests that the NPD diagnosis is actually a mix of two flavors. Grandiose narcissism is the flamboyant, boastful form that probably characterizes both malignant leaders such as Benito Mussolini and Saddam Hussein and highly venerated figures such as General George S. Patton. The lesser-known "vulnerable" variety of self-devotion afflicts more reserved, fragile individuals who may resemble the self-effacing and thin-skinned characters portrayed by Woody Allen in his films.

No one really knows what causes the intense concern with the self that narcissists display. In one theory, they are compensating for low self-esteem by becoming egotistic. Yet this intriguing conjecture has weak scientific support, and another theory suggests that only vulnerable narcissists lack a sense of self-worth.

The Mirror Has Two Faces

Narcissists routinely wreak havoc in everyday life. In a study published in 2004 psychologist W. Keith Campbell of the University of Georgia and his colleagues showed that narcissism is linked to overconfident but rash decision making, such as making unwise bets, and earlier work by Campbell's team tied narcissism to infidelity. Narcissists are also prone to aggression, especially following insults, as a 1998 study revealed. Brad J. Bushman, now at Ohio State University, and Roy F. Baumeister, now at Florida State University, reported that narcissistic college students were more likely than others to retaliate with a loud blast of noise against another "subject" (a confederate of the experimenters) who had derogated an essay they had written. The negative feedback, the authors reasoned, was a threat to their egos.

Even greater damage can stem from the clinical disorder. In 2002 psychologist Paul Nestor of the University of Massachusetts Boston found that individuals with marked features of NPD are at risk for violence and for antisocial personality disorder, a condition that is tied to crime and other irresponsible acts. Self-destructive behaviors may also result from the despair highly narcissistic people feel when others stop noticing them. In a 2009 study a team led by psychologist Aaron L. Pincus of Pennsylvania State University associated features of pathological narcissism with suicide attempts. Vulnerable narcissists may be in particular danger of hurting themselves. Data from 2011 suggest that vulnerable, but not grandiose, narcissism is linked to suicidal thinking, self-harm and emotional distress.

Yet narcissism may be a double-edged sword. A 2009 investigation led by psychologist Amy B. Brunell of Ohio State University at Newark found that narcissistic individuals readily emerged as leaders in group discussions, and among students enrolled in a graduate business program, narcissists were likely to rise to top positions. These outcomes agreed with an earlier study in which psychologist Ronald J. Deluga of Bryant University asked presidential experts to rate U.S. chief executives on a scale of narcissism. Presidents judged to be more narcissistic were rated by an independent group of historians as particularly effective, charismatic and creative. (Narcissism in a leader may sometimes turn off potential followers, however. Psychologist Timothy A. Judge of the University of Florida and his collaborators found that narcissistic students in management programs tend to perceive themselves as better leaders, but others judged them as worse.)

Narcissists' advantages extend beyond leadership, however. In a study published in 2011 psychologist Peter D. Harms of the University of Nebraska–Lincoln and his colleagues showed that narcissistic individuals excelled in simulated job interviews, in part because they were skilled at self-promotion. These findings may dovetail with 2006 results from researchers at the University of Southern California who found that celebrities' narcissism scores exceeded those of the general population.

There is no known effective remedy for narcissism in any of its forms. Yet recognizing that these highly self-centered people probably differ from us in degree rather than kind may give us more empathy for them. If a narcissist is mistreating you, here is a strategy for handling the situation: find a way to be assertive while assuaging his or her sensitive ego.

Although the extreme self-promotion of grandiose narcissists can be dangerous, such self-focus in moderate doses may be advantageous when it comes to professional success and leadership. In this respect, we may have a thing or two to learn from those who see themselves at the center of the universe. M

A group of historians judged narcissistic U.S. presidents to be particularly effective, **charismatic and creative**.

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

Send suggestions for column topics to editors@SciAmMind.com

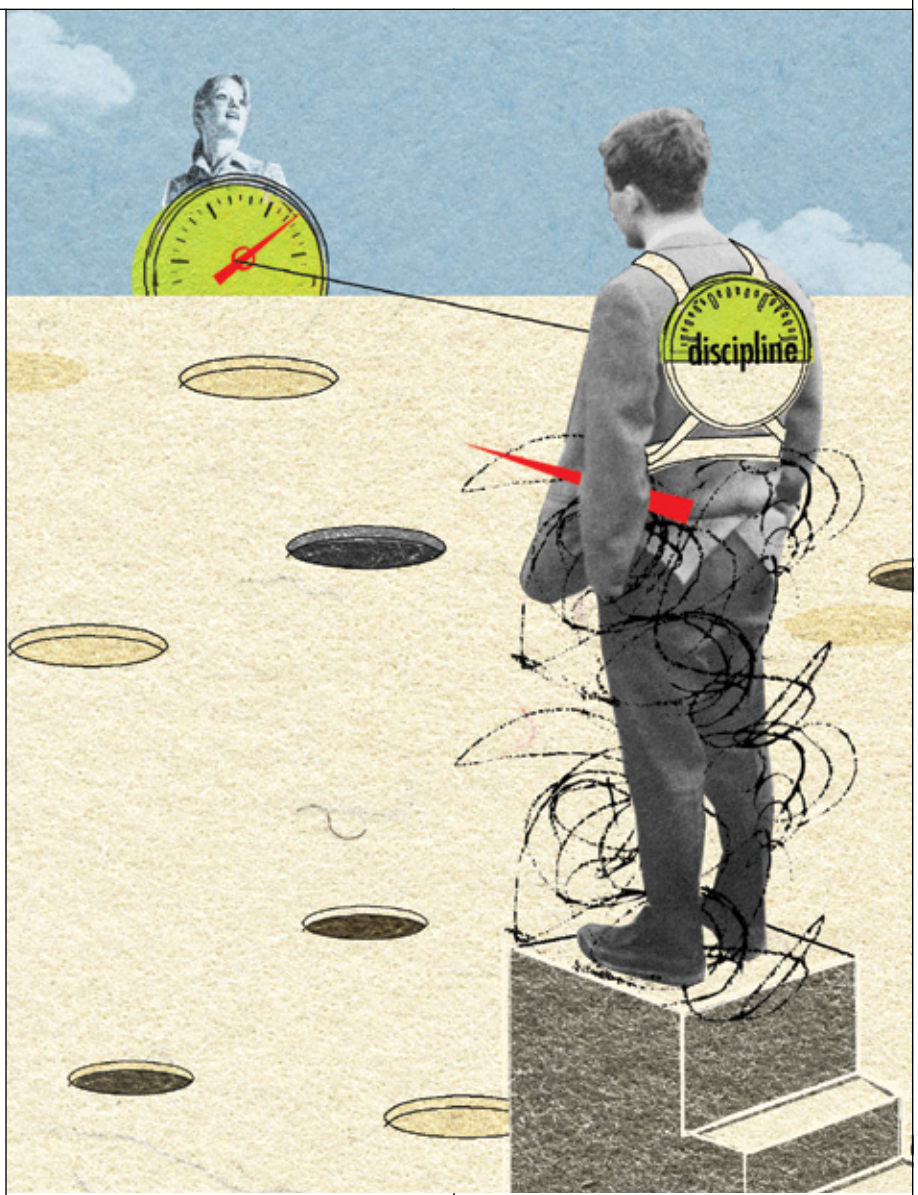
(Further Reading)

◆ **The Handbook of Narcissism and Narcissistic Personality Disorder: Theoretical Approaches, Empirical Findings, and Treatments.** Edited by W. Keith Campbell and Joshua D. Miller. John Wiley & Sons, 2011.

Finding Self-Discipline in Others

People who lack restraint seek out colleagues and friends who are not impulsive

BY WRAY HERBERT



MATT MENDELSON (*Herbert*); KATE LEMAY (*illustration*)

MY HIGH SCHOOL classmate Tom Gordon was everyone's choice for "least likely to succeed." He drank too much and drove too fast, and he got busted for petty theft again and again. He skipped school as often as he showed up, and he was too undisciplined for sports or other organized activities. When he did get hired for part-time jobs, he would either quit or get himself fired soon after. He was a loser.

So imagine my bewilderment when I ran into Tom (whose name I have changed to protect his identity) some years later. He was sitting in a local diner, drinking coffee and reading several newspapers, including the *Wall Street Journal*. It turns out that a few years out of school, he had married one of our quieter and more studious classmates. He had started surrounding himself with her solid and conscientious friends, leaving the bad boys of high school behind. He no longer ran with a fast crowd, and he rarely even had a drink. He was an engaged father and had a small business. He lived a life of moderation.

Many people know a Tom Gordon or did at one time, and most of their stories do not have such a happy outcome. Indeed, most kids with poor self-control grow up to be adults with poor self-control. So what turned Tom around? Why didn't his undisciplined nature lead him inevitably into a life of trouble and failure, as we all had predicted?

New research may offer some insights into Tom's mysterious turnaround. A team of Duke University psychological scientists, headed by Gráinne Fitzsimons, has been studying people with poor self-discipline, in particular the idea that the Tom Gordons of the world may be aware of their shortcomings—and compensate for them. Perhaps, they suggest, Tom deliberately chose a new social circle—both wife and friends—as a self-regulatory strategy, riding the disciplinary coattails of the more fortunate.

Wanting for Willpower

Fitzsimons and her colleagues ran a couple of laboratory experiments, plus a study of actual couples, to see how lack of self-control shapes our views of other, more disciplined people. In one study, for

Volunteers who had been **sapped of self-control** viewed highly disciplined managers more positively.

example, the researchers used a standard lab manipulation to deplete some of their volunteers' reserves of self-command. The participants had to pay attention to a video while ignoring words flashing on the screen, a regimen that has been shown to tax willpower and leave subjects prone to giving in to their impulses. With their mental discipline temporarily weakened, these volunteers (and the control subjects who had not done the willpower-weakening exercise) read stories about three office managers: one highly disciplined, one undisciplined and one in the middle. All the volunteers then evaluated the three managers.

The results were clear. The volunteers who had been sapped of self-control viewed the highly disciplined managers more positively than the moderately disciplined managers, both of whom they favored over the undisciplined ones. The control subjects showed no preference; they liked all the managers equally. The results support the researchers' hypothesis: undisciplined people seem to be attracted to others, even strangers, who possess the emotional resources that they themselves lack.

Granted, this was an artificial lab situation, exploring a temporary depletion of self-control. What about people like my classmate Tom, in whom this character trait persists? Will they also show a preference for role models of self-discipline? To explore this question, the scientists set up a different lab situation: the Stroop test, in which color words such as "yellow" appear in rapid succession, written in a different color than the word is describing [*see illustration above*]. Subjects must try to ignore the meaning of the word and focus only on the color of the text. Performance on this test has been shown to be a good proxy for willpower as an enduring trait.

After measuring self-control this way, the researchers divided the disciplined and undisciplined volunteers into separate groups. Then they all read stories very similar to those in the first study and rated the person in these stories: Would they be excited to meet this person? Might they become friends? Could they work together?

YELLOW
RED
GREEN

The Stroop test, a classic measure of willpower, is a series of words such as those shown. Subjects must quickly name the color of the ink while ignoring the word's meaning.

As predicted, those who were by nature undisciplined were much more positive toward people who had high self-control. Notably, volunteers who were themselves very disciplined by nature showed no preference for this trait—or lack of it—in others. The researchers suggest that people who are already self-sufficient do not pay much attention to others' level of self-discipline, whereas those who lack restraint scrutinize the trait in others. In terms of Tom, it is at least plausible that he knew on some level that he should be around people unlike himself. He used his wife and new friends to regulate his own destructive impulses.

Opposites Attract

Of course, Tom is real, whereas these studies are made up in the lab. To bring their inquiry closer to the real-life Tom Gordons of the world, Fitzsimons and her team decided to study actual romantic relationships. They evaluated more than 100 couples—both partners—on their self-control and their dependence on their partner. By dependence, they meant: "To what extent is your partner, and only your partner, able to fulfill your needs?"

The findings reinforced the lab results. As described in a forthcoming article in the journal *Psychological Science*, those volunteers with low self-control were more dependent on their partner—they felt the relationship was essential to their personal well-being—but only when their partner was highly disciplined. Those who were themselves disciplined showed no differences in their emotional dependence. They apparently did not have the same powerful need for a partner who would make up for their own impulsiveness.

Taken together, these experiments offer evidence for a social self-regulatory process by which we become close to others to compensate for our flaws. These scientists are not suggesting that such reliance on others can or will trump impulsiveness, not entirely. Indeed, overwhelming evidence points to the opposite—that self-control deficits are very difficult to overcome and that such traits often lead to less fulfilling and less successful lives. Yet these findings do at least raise the hope that people who are naturally impulsive might play an active role in overcoming their own weaknesses—rather than just accepting their unhappy fate. 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 writer in residence at the Association for Psychological Science.

(Further Reading)

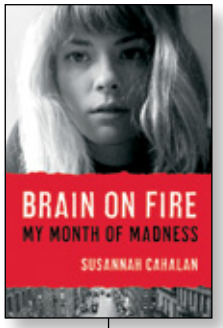
- **Riding Others' Coattails: Low Self-Control Individuals Value Self-Control in Others.** Catherine T. Shea, Erin K. Davisson and Gráinne M. Fitzsimons in *Psychological Science* (in press).

books

CRAZY TALE

Brain on Fire: My Month of Madness

by Susannah Cahalan. Free Press, 2012 ($25)



In early 2009 Cahalan woke up in a hospital with electrodes glued to her head. She was restrained to the bed and unable to breathe a word, with a security guard keeping a watchful eye on her. Just days earlier she had been living a dream life—a 24-year-old rising star reporter at the *New York Post,* with a serious boyfriend and a loving family.

In *Brain on Fire,* Cahalan recounts her gripping story of suddenly and inexplicably going mad. Without warning, Cahalan, a healthy, hard-hitting and even-tempered journalist, had degenerated into a violent, irrational psychotic, at one point ripping off her electrodes and running through the hospital hallways.

For a month Cahalan's friends and family watched helplessly as a baffled medical team struggled to uncover what was happening to her, keeping notes in journals to document their experiences and to inform one another of updates. A team of doctors racked up $1 million in medical bills conducting blood tests, spinal taps, an MRI, an ECG, a seizure-monitoring test, as well as an experimental treatment that cost $20,000 for a single infusion. None of these tests explained her symptoms.

As hope of her recovery waned, her doctor, Souhel Najjar, had an idea. He asked Cahalan to draw a clock. As she struggled through the task, Najjar realized what was wrong: "Your brain is on fire," he said. Cahalan had drawn a one-sided clock, which showed Najjar that only one side of her brain was working properly.

After a brain biopsy and an additional spinal tap, Najjar discovered that Cahalan had contracted a rare and potentially fatal autoimmune disease called NMDA receptor autoimmune encephalitis, an attack on the brain by the body's immune system. The team rushed to save her from the mysterious condition, which was first characterized in 2007. With unknown origins and mechanisms, this disorder can elude even the best doctors. What we do know is that the disease is associated with psychiatric symptoms, memory lapses, seizures and tumors, among other problems. Luckily, Cahalan's treatment came quickly enough for her to pull through mostly unscathed, and she eventually resumed her job at the *Post.*

Although Cahalan could not remember anything from her month of madness, she pieced together her story through her family's journals, hospital videos and reports, as well as friends' accounts. In her hospital videos, she recalls watching herself as an angry, terrified stranger. As she reflects on her illness, Cahalan wonders how many people go misdiagnosed or undiagnosed in a psychiatric ward as a result of lesser-known neurological diseases.

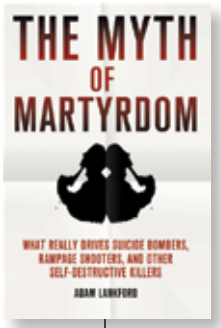
A page-turner, *Brain on Fire* is a true story that reads like fiction. Although the level of medical detail Cahalan provides is limited, she manages to bring this neurological disorder to life. The book walks the line between heart-warming personal story and medical thriller and will appeal to science and biography fans alike.

—Samantha Murphy

DEATH SEEKERS

The Myth of Martyrdom: What Really Drives Suicide Bombers, Rampage Shooters, and Other Self-Destructive Killers

by Adam Lankford. Palgrave Macmillan, 2013 ($27)



The dust had not yet settled after the 9/11 attacks when people began debating whether to call the hijackers cowards. Addressing the nation, President George W. Bush assigned cowardice to the 19 terrorists, articulating a worldview that equates courage with good. Others, including journalists Bill Maher and Susan Sontag, argued that the hijackers could not be cowards, no matter how despicable their methods, because it takes guts to die for a cause. No one, however, questioned the hijackers' dedication to their campaign, until now.

In *The Myth of Martyrdom,* author Lankford, a criminal justice professor at the University of Alabama, rejects the prevailing view of suicide terrorists as radicalized individuals who will do anything for a cause. Rather, he asserts, they are merely unhappy, damaged individuals who want to die. Terrorist organizations recruit people who are in desperate straits for suicide missions and call them martyrs, and we have bought into their propaganda.

Citing recent research, including evaluations of preemptively arrested suicide terrorists, Lankford argues that the psychological profiles of self-destructive killers, whether underwear bombers or school shooters, are not so different from those of the 34,000 Americans who commit suicide every year, burdened by mental illness, social isolation, and personal and professional failures. Underneath the political rhetoric in suicide letters, martyrdom videos and testimonies of grieving family and friends, Lankford finds evidence of deep psychological pain. The young mother who blows herself up in a crowd, for instance, turns out to be escaping the shame of an adulterous affair.

Ironically, most suicide terrorists come from the Muslim world, where the stigma against conventional suicide is high. For those who fear both life and the religious repercussions of suicide, martyrdom seems to offer a loophole—the only honorable death.

But they are only fooling themselves. Lankford draws clear distinctions between true heroism and its pretenders. Real heroes, such as the soldier who throws himself onto a live grenade to save his unit or the firefighter who rushes into a burning building, do not have a death wish; moreover, their actions directly save other people's lives.

Although Lankford builds an impressive case for his view of suicide terrorism, he offers little in the way of practical solutions to reduce these tragic incidents. (Surely airports will not start screening passengers for suicide risk, as he suggests.) In the end, he knows he is playing the propaganda game as well. If the courage assumed of suicide terrorism is its most powerful weapon, we can disarm this threat by denying its practitioners the myth of martyrdom.

—Nina Bai

ROUNDUP

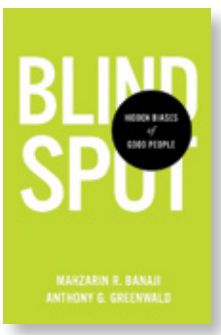
Enriched Living

Three books propose ways we can enhance how we think and feel.

Self-improvement books often claim that only by changing the way you think—perhaps by picturing yourself in the ideal job, say, or with the perfect mate—will you be able to make your life better. Not so, says psychologist Richard Wiseman. In **The As If Principle: The Radically New Approach to Changing Your Life** (Free Press, 2013), Wiseman argues that people need to modify their actions to change how they feel. Research shows, for example, that clenching your fist can motivate you to stay away from unhealthy snacks. He also suggests simple tips for readers, such as smiling to improve their mental state.

Want a smarter, healthier brain? You'll have to exercise it, according to neuroscientist Sandra Bond Chapman. Chapman, director of the Center for BrainHealth in Dallas, with Shelly Kirkland, public relations director there, explain that although the brain has the capacity to strengthen itself, as with any muscle, it requires training to stay strong. In **Make Your Brain Smarter: Increase Your Brain's Creativity, Energy, and Focus** (Free Press, 2012), they delineate a fitness plan for your brain—such as learning how to use your new iPhone or teaching a friend how to play Sudoku—to help you think more insightfully and strategically.

Asking a person out to dinner or auditioning for the school play can leave you feeling judged or rejected. Yet putting ourselves in vulnerable positions, no matter how difficult, is essential for our well-being and personal development, says Brené Brown, a research professor who studies emotions. In **Daring Greatly: How the Courage to Be Vulnerable Transforms the Way We Live, Love, Parent, and Lead** (Gotham, 2012), Brown explores our need to expose ourselves emotionally so as to form meaningful bonds, fall in love or push for a promotion. *—Victoria Stern*



ISTOCKPHOTO

TYPE SET

Blindspot: Hidden Biases of Good People

by Mahzarin R. Banaji and Anthony G. Greenwald. Delacorte Press, 2013 ($27)

When journalist Brent Staples walks down the street, he whistles classical music. Staples, who is African-American, does not do this to share his love of Mozart. Rather he wants to ease the fears of white pedestrians who might not realize how nervous they feel when passing a black man.

As psychologists Banaji and Greenwald discuss in *Blindspot,* Staples is attempting to counteract unconscious bias. Our social and cultural surroundings influence these attitudes in ways we may not notice. They argue that forming implicit biases is an innate, often helpful, ability that allows us to distinguish friend from foe and to find our place in a complex social world. Psychologists study this phenomenon using tests that force us to make rapid associations. The speed with which we connect words from two categories, such as "good" and "thin" or "good" and "fat," reveals our underlying preferences. One study showed, surprisingly, that ambitious, professional women often prefer a male boss, for instance, and another found that people who proclaim the earth is flat unconsciously accept that it is round.

Implicit biases influence our behavior in complex and often subtle ways. A doctor may inadvertently give a patient special treatment because the patient is a professor at Yale. Or a white philanthropist who sees himself as open-minded may still contribute to racial inequality by donating to charities that primarily support white people.

The book's main shortcoming is the absence of nuanced brain-based explanations for how implicit biases form. The authors only briefly describe how the same neural networks become active in our brain's decision-making center when we consider our own actions and those of individuals similar to ourselves. In addition, they—unwilling to impose values on their readers—offer minimal advice to head off implicit racism or sexism.

Despite these gaps, *Blindspot* successfully reveals how our unconscious minds influence our beliefs and behaviors and remind us to think twice about our instinctive reactions and to acknowledge how bias might creep into our lives. *—Daisy Yuhas*

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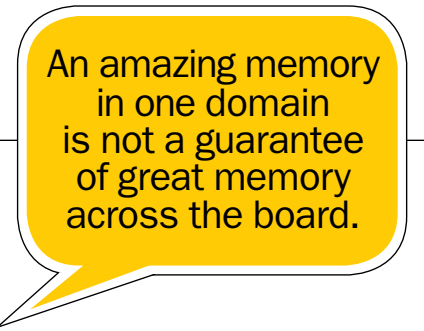
askthe**Brains**



I developed what appears to be a photographic memory when I was 16 years old. Does this kind of memory truly exist, and, if so, how did I develop it?
—***Peter Gordon,*** *Scotland*

Barry Gordon, *a professor of neurology and cognitive science at the Johns Hopkins University School of Medicine (and no relation), offers an explanation:*

THE INTUITIVE notion of a "photographic" memory is that it is just like a photograph: you can retrieve it from your memory at will and examine it in detail, zooming in on different parts. But a true photographic memory in this sense has never been proved to exist.

Most of us do have a kind of photographic memory, in that most people's memory for visual material is much better and more detailed than our recall of most other kinds of material. For instance, most of us remember a face much more easily than the name associated with that face. But this isn't really a photographic memory; it just shows us the normal difference between types of memory.

Even visual memories that seem to approach the photographic ideal are far from truly photographic. These memories seem to result from a combination of innate abilities, combined with zealous study and familiarity with the material, such as the Bible or fine art.

Sorry to disappoint further, but even an amazing memory in one domain, such as vision, is not a guarantee of great memory across the board. That must be rare, if it occurs at all. A winner of the memory Olympics, for instance, still had to keep sticky notes on the refrigerator to remember what she had to do during the day.

So how does an exceptional, perhaps photographic, memory come to be? It depends on a slew of factors, including our genetics, brain development and experiences. It is difficult to disentangle memory abilities that appear early from those cultivated through interest and training. Most people who have exhibited truly extraordinary memories in some domain have seemed to possess them all their lives and honed them further through practice.

Various parts of the brain mature at different times, and adolescence is a major time for such changes. It's possible Mr. Gordon's ability took a big jump around his 16th birthday, but it's also possible he noticed it only then. Mr. Gordon might want to have formal testing, to see just how good his memory is and in what areas. Then we can debate the nature-nurture question from harder evidence.

Why did sleep evolve? —***James Ridgeway,*** *via e-mail*

Christopher French, *a professor of psychology at Goldsmiths, University of London, replies:*

THIS IS A FASCINATING question, and the honest answer is that no one knows for sure. At first sight, sleep appears to be incompatible with survival because it prevents feeding and procreation and could expose the sleeper to attack by predators. Sleep must confer some essential benefits to outweigh these serious disadvantages.

Some theorists have argued that sleep helps to forge new neural connections and solidify memories, whereas others have posited that sleep allows the brain to filter out unimportant connections. It may also help the brain repair itself.

These explanations are not consistently supported by empirical evidence, however, and do not explain why different animals have evolved a wide range of sleep-wake cycles. Some of the theories even contradict one another. Certain animals, such as American black bears and fat-tailed dwarf lemurs, hibernate for days to months, whereas others, especially birds and small mammals, exhibit a milder state of torpor that may last a single night or less. The big brown bat, for example, sleeps for 20 hours a day. In contrast, newborn killer whales and dolphins hardly sleep for weeks if they are born during a migration; the same goes for their mothers.

One plausible explanation for this variation in sleep patterns is that, from an evolutionary perspective, sleep and related states provide periods of adaptive inactivity. Contrary to first impressions, animals may sometimes be less vulnerable to attack by predators while asleep. When an animal is awake and maneuvering in its environment, it can forage for food, eat and mate, but it will also expend energy by engaging in such behaviors and can wander into harm's way.

Most likely sleep evolved to ensure that species are not active when they are most vulnerable to predation and when their food supply is scarce. The big brown bat need not be awake for more than four hours a day given that the insects on which it feeds are active only for a few hours each evening. If it were flying around during the day, the bat would more easily attract the attention of predatory birds. Although slumber seems to serve many roles, sleep patterns across species may enhance survival by optimizing the timing of activity and idleness while also allowing us to maintain the most agile brains. M

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

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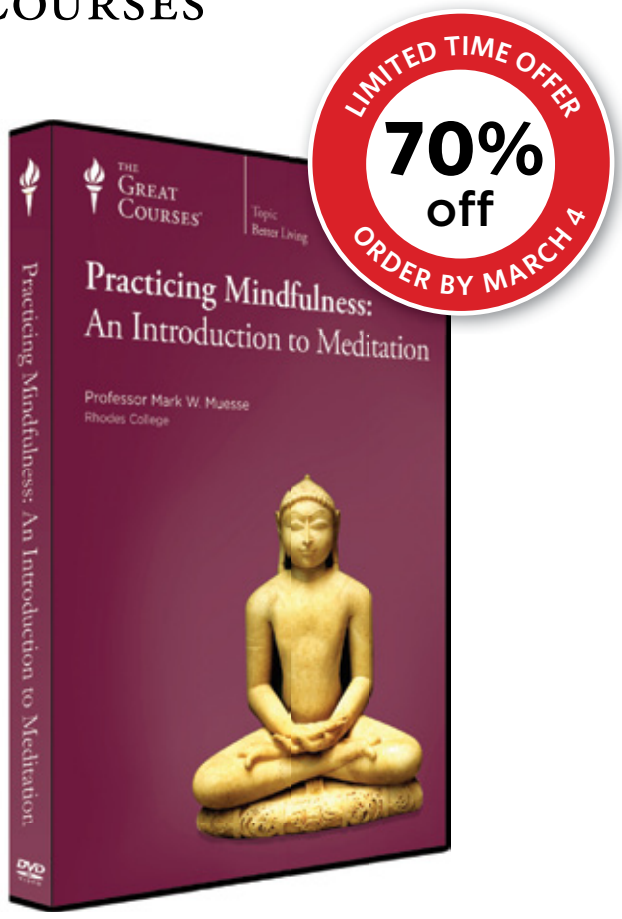

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17. Wishing—May All Beings Be Well and Happy
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19. Speech—Training the Tongue
20. Anger—Cooling the Fires of Irritation
21. Pain—Embracing Physical Discomfort
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BRIGHT HORIZONS™ 17

NORWEGIAN FJORDS, JULY 5–15, 2013

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Are you restless? Seeking new science horizons? Slake your thirst for the latest in science, Viking style, on Bright Horizons 17 cruise conference aboard Celebrity Cruises' Infinity, round-trip Harwich, England to the Norwegian fjords, July 5–15, 2013. Pack your curiosity and join a floating community of keen minds and quick wits voyaging into a landscape of epic beauty.

Top off your fund of knowledge about chemical bonds. Venture into the weird, weird world of quantum mechanics. Go deep into the neurobiology of stress and aggression. Site the Vikings in a context of ingenuity and adaptation. As we travel, you can visit the UNESCO World Heritage sites of Geiranger Fjord and Bryggen, enjoy scenic and noteworthy rail trips, and view glaciers and waterfalls.

Powered by the midnight sun, immerse yourself in essential Norway. Bring a friend and relax amidst scenic beauty from sky to fjord. Refresh the spirit, share downtime with near and dear, savor Nordic cuisine. Absorb new views and innovative thinking from the experts while enjoying the delights of Scandinavia. Join the fun on Bright Horizons 17. Visit www.InsightCruises.com/SciAm-17, contact concierge@insightcruises.com, or call (650) 787-5665.

Cruise prices vary from $2,169 for an Interior Stateroom to $7,499 for a Royal Suite, per person. For those attending our Program, there is a $1,575 fee. Port charges are $235. Government taxes and an Insight Cruises service fee are $215 per person. Gratuities are $150 per person. Program subject to change.

Neurobiology

Speaker: Robert Sapolsky, Ph.D.

The Biology of Memory

Consider the biology of memory. We'll start with the neurobiology of different types of memory, from the pertinent regions of the brain down to the pertinent molecules and genes. Learn about memory's impressive features, wild inaccuracies, and failings in neurological diseases. Examine individual differences in memory skills and find out how to improve your own memory capacities.

Sushi and Middle Age

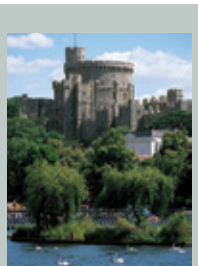
When was the last time you tried a really different, strange type of food, explored the work of a new composer, or made a substantial change in appearance? As we age, we get less interested in novelty and increasingly crave the familiar. Examine the neurobiology and psychology underlying this age-related effect.

Humans: Are We Just Another Primate? Are We Just a Bunch of Neurons?

Dr. Sapolsky both does neurobiology research in the lab and research on wild baboons in East Africa. He'll consider human nature from these two perspectives. Are we just another primate on a continuum with all the others, or are we intrinsically special? Find out a biologist's answer.

The Biology of Aggression and Violence

Examine the biology of violence, dealing with a single fact that makes this one of the most complicated subjects in behavioral biology — we don't hate violence, just violence in the wrong context. Looking at neurobiology, Us/Them dichotomies, hormones, evolutionary biology, and game theory, put the phenomenon of violence in a scientific context.



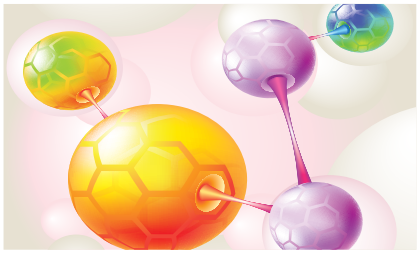
Hampton Court and Windsor Castle (July 2)

Join us visiting two timeless treasures in a day designed to bring British history to life. Enhance your knowledge of Britain's history with an idyllic day trip to Windsor Castle (left) and Hampton Court Palace. They are related yet differing demonstrations of British monarchy, nationhood, and domesticity.

It's good to be Queen, and the evidence is all about you at 1,000 year old Windsor Castle. Rubens, Rembrandt, and a remarkable collection of fine art envelope you in history. Go behind the scenes at the legendary seat of the House of Windsor.

Hampton Court (also known as King Henry VIII's summer palace) is a place of royal passions and competing interests. Pomp and consequence, subterfuge and service inform the history of the palace. Our visit will put the juxtaposed Tudor and Baroque architecture, larger than life personalities, exquisite Chapel Royal, and magnificent gardens in historical context for you.

For more info please call 650-787-5665 or log on to ScientificAmerican.com/Travel



Chemistry

Speaker: Robert Hazen, Ph.D.

Genesis: The Scientific Quest for Life's Origins

— Is life's origin an inevitable process throughout the cosmos, or is it an improbable accident, restricted to a few planets (or only one)? How does a lifeless geochemical world of oceans, atmosphere, and rocks transform into a living planet? Find out how scientists use experimental and theoretical frameworks to deduce the origin of life.

The Diamond Makers

Diamond forms deep in Earth when carbon experiences searing heat and crushing pressure. Decades ago General Electric scientists learned how to mimic those extreme conditions of Earth's interior in the laboratory to make synthetic diamonds. Learn the human drama and technological advances involved in producing this coveted gem and industrial tool from carbon-rich substances.

The Story of Earth: How the Geosphere and Biosphere Co-evolved

Earth is a planet of frequent, extravagant change. Its near-surface environment has transformed over and over again across 4.5 billion years of history. Learn about the work of Dr. Hazen and colleagues that suggests that Earth's living and nonliving spheres have co-evolved over the past four billion years.

Chemical Bonding

— The solid, liquid, and gaseous materials around us depend on the specific elements involved and the chemical bonds that hold those atoms together. By looking at the nature and significance of ionic, metallic, and covalent bonds you'll gain a new understanding of the workings of the world around you.

Quantum Physics

Speaker: Benjamin Schumacher, Ph.D.

Private Lives of Quantum Particles

Quantum systems can exhibit all sorts of bizarre behavior. But many of these phenomena can only be observed under conditions of the strictest privacy, where systems are "informationally isolated" from the world. These are not accidental features of quantum theory. They are inescapable facts about the microscopic world: Quantum physics is what happens when nobody is looking.

2π Is Not Zero (But 4π Is)

— If you rotate any geometrical shape by 360 degrees (2π radians) about any axis, you will end up with exactly the same shape. But this fact, seemingly obvious, is not true for quantum particles with spin. Learn how a rotation by 2π makes a big difference, and how it all comes down to a simple minus sign — probably the most important minus sign in all of physics. Enjoy quantum fun, demystified by Dr. Schumacher.

The Physics of Impossible Things

Physicists find it surprising useful to ponder the impossible. Using the laws of nature, assess the possibility of science fiction's favorite phenomena and explore seemingly impossible things, which while odd, are possible. Venture into the study of impossible things and come away with an affirmation of the consistent logic of nature, and renewed wonder at real phenomena.

The Force That Isn't a Force

— What makes a rubber band elastic? It's entropy, the microscopic disorder of its molecules. Now, entropy may provide a clue to the most familiar and mysterious of the basic forces of nature: gravity. Explore the link between entropy and gravity, and gain fascinating and unexpected insights of contemporary theoretical physics.

Archaeology

Speaker: Kenneth Harl, Ph.D.

From Old Europe to Roman Provinces

Explore the prehistoric foundations of Scandinavia and the Viking Age from ca. 3000 B.C. to 400 A.D. From Megalithic cultures to the arrival of Indo-Europeans, to Northern Bronze Age innovations and Celtic and Roman contributions, learn the unique environmental, cultural, and social factors that create a context for the Vikings.

Great Halls and Market Towns in Viking Age Scandinavia

— Using archaeology and literary sources (especially saga and Eddas), learn how the "great halls" emerged as the main focus of Scandinavia civilization. Find out how the development of towns facilitated trade and were vital for the transformation and technological advance of Scandinavian society.

Ships and Ship Building in the Viking Age

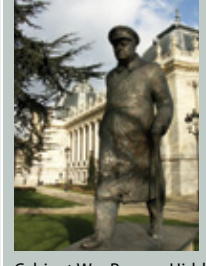
— European history records the effectiveness of the fearsome Viking longship; find out the features and technologies that made it so. Based on archaeological finds, learn about the multi-millennial evolution of the longship, from linden to oak, dugout to mast and sail. Gain an appreciation for the form and function, as well as the wider implications of Norse naval mastery for three hundred years.

Warfare in the Viking Age

— The Viking's applied technologies led to three centuries of robust military and economic power for Scandinavia. Discover what factors made the Vikings accomplished warriors and learn what archaeological finds tell us about Viking exploration, settlement, and development of kingdoms.

SCIENTIFIC AMERICAN Travel HIGHLIGHTS

NORWEGIAN FJORDS
JULY 5–15, 2013

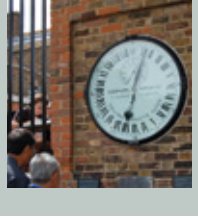


The Royal Observatory and the Churchill War Room/Museum (July 4)

Take the road less traveled in London, visiting two less well known gems of the City, both uniquely fascinating and inspiring.

Courage, duty, shared sacrifice, and conviction are the foundation of the Churchill Cabinet War Rooms. Hidden in plain sight in the heart of London, a scant 600 miles from Berlin. Step back in time and discover how Churchill and Britain's government functioned in secrecy in these quarters, from the Blitz to VE Day. The furnishings, maps, and ephemera are as they were on VE day, May 8, 1945. Hear the stories and imagine life under bombardment in the simple and inspiring environment of the Cabinet War Rooms.

Are you the precise type? Are you a fan of Google maps or GPS? Or Cutty Sark? Join us on a tour of maritime Greenwich, where our prime objective is visiting the Royal Observatory, Greenwich, home of the Prime Meridian of the World and Greenwich Mean Time. Stroll a deeply historic corner of London significant in local, national, and international culture. See the Royal Observatory, the National Maritime Museum, the tea clipper Cutty Sark, and the Royal Naval College. Master the lingo of time — UT0, UT1, UTC, and GMT. Stand astride two hemispheres on the Prime Meridian, a moment sure to be recorded on your timeline.



Stonehenge and Bath (July 3)

Pass a day on the Salisbury Plains and Somerset Hills, absorbing the history of two spots with ancient cultural roots.

Mute, mysterious, and megalithic, Stonehenge calls to us across the millennia. We'll respond, and walk the site in its details. Learn the significant geography, the archaeological and astronomical background, and the key stone names. But those are just the facts — the memories and true meaning of Stonehenge will be up to you.

Bath beckons the seasoned traveler. People are drawn to Bath to see its honey-colored Bath limestone buildings, and to explore its 2,000 year history as a place of relaxation and restoration. Plumb the details and nuances of Bath's fusion of architecture, culture, and history in a city with many echoes of and homages to the ancient world, while embodying the Georgian worldview.

For more info please call 650-787-5665 or log on to ScientificAmerican.com/Travel

SCIENTIFIC AMERICAN Travel

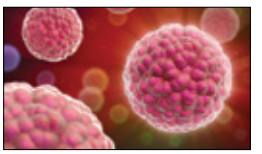
BRIGHT HORIZONS 18

NOVEMBER 29 – DECEMBER 6, 2013 ✷ RHONE RIVER ✷ www.InsightCruises.com/sciam18

In November, the tourists are gone from Provence. The harvest's been gathered. The south of France exhales, resuming her essential rhythms, manifesting her ancient uniqueness, effortlessly. It's the perfect time to relax, recharge, and revel in the latest with Scientific American Bright Horizons 18 on a Rhone River cruise from November 29 to December 6, 2013. We'll explore developments in cosmology, cancer, and wine science, and plumb Roman engineering.

Experience river cruising's panoramic charms on Bright Horizon 18's voyage on AmaWaterway's AmaDagio, sailing from Lyon to Arles, France. The light, colors, and flavors of a legendary land await. Make your reservation at www.insightcruises.com/SciAm-18, call us at 650-787-5665 or email us at Concierge@InsightCruises.com.

The cruise fares start at $2,799 for a Category E. French Balcony cabins start at $3,378. A Junior Suite is available for $4,498. Cruise fares include six half-day excursions. For those attending our educational Program, there is a $1,395 fee. Additional per-person fees include: government taxes and fees ($147) and gratuities (€15 per day). The Program, cruise pricing, and options are subject to change. **For more info please call 650-787-5665 or email us at concierge@insightcruises.com.**



CELLULAR SCIENCE

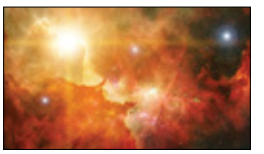
- The War on Cancer: Then and Now
- Know the Enemy: A Biography of the Target
- Targeting the Cancer Genome
- Natural Medicine and the War on Cancer

WINE MAKING

- Climate Change and its Impact on the Wine World
- The Rhone and its Wines
- Wine and Health
- Advances in Grape and Wine Production

CULTURE AND TECHNOLOGY

- Intro to Culture & Technology in Gaul
- Fire-Based Technologies in Gaul
- Building an Amphitheater
- Aqueducts, Baths, and Water Mills

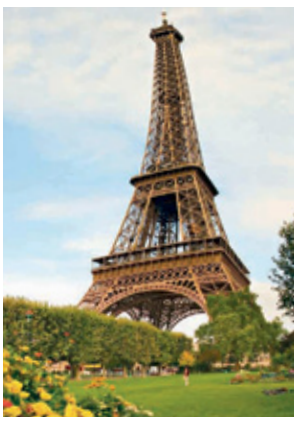


COSMOLOGY

- The Birth of Our Universe
- The Birth and Maturation of Galaxies
- The Universe's First Million Years
- Cosmic Inflation

SPEAKERS

James Kennedy, Ph.D.
Lynne Lancaster, Ph.D.
David Sadava, Ph.D.
Mark Whittle, Ph.D.



INSIDER'S TOUR OF CERN

Pre-cruise: November 28, 2013—From the tiniest constituents of matter to the immensity of the cosmos, discover the wonders of science and technology at CERN. Join Bright Horizons for a private pre-cruise, custom, full-day tour of this iconic facility. (If the LHC is still undergoing its scheduled maintenance it is likely we will go into the LHC Tunnel.)

Whether you lean toward concept or application there's much to pique your curiousity. Discover the excitement of fundamental research and get a behind-the-scenes, insider's look at the world's largest particle physics laboratory.

Our tour will be led by one of our speakers (TBA) and by other CERN physicists. We'll have an orientation; visit an experiment; get a sense of the mechanics of the large hadron collider (LHC); if at all possible, go down inside the LCH tunnel (picture above); make a refueling stop for lunch; and have time to peruse the grounds and exhibits on the history of CERN and the nature of its work — and if you're so inclined, the CERN gift shop.

The price is $899 per person (based on double occupancy). This trip is limited to 50 people. NOTE: CERN charges no entrance fee to visitors.

Head Games

Match wits with the Mensa puzzlers

1 IT'S ELEMENTARY

A first grade class is learning about averages. The teacher passes out buttons to the children. Mark, Meagan and Rebecca had an average of six buttons apiece. "If I give Rebecca three more buttons," the teacher says, "she'll have two more than the new average." How many buttons *did* Rebecca have before she received the additional three?

2 CAR TRICK

In the diagram below, draw four lines so that one box has one automobile in it, one box has two automobiles, and so on, up to eight.

3 A WEIGHTY DILEMMA

After a hurricane battered his store, the wholesale grocer found he had only four pairs of weights for his balance scale left undamaged. With those four pairs, luckily enough, he could weigh anything from one to 170 pounds. What were the four pairs of weights?

4 AN IMPERFECT PROVERB

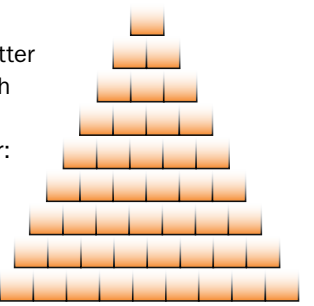
H T S W O
G X X K R
I L M A N
K E D N Y
A M S A H

In a far-off and most unusual land, the electricity wasn't working. One wise man, recalling a proverb, told everyone to place a hand simultaneously on the light switches. The electricity went on. Find the correct starting letter, then move in any direction to reveal the proverb in the slightly garbled form the wise man recalled. (There are two null letters—the two Xs.)

5 WORD PYRAMID

Complete the following pyramid by starting with one letter at the top and adding one letter to make a word in each subsequent row, rearranging the letters if necessary. The words are defined here, but not in the correct order:

An indefinite article; honor or largeness; hang loosely; to the same extent or degree; a noncommissioned officer; lines of mountains; an herb; wiser; peculiar or odd.



6 WORD MATH

Substitute a number for each letter in the addition problem below to make the equation correct. Let C = 5. (There is more than one correct answer.)

```
  C A T S
+ D O G S
= R A I N
```

7 PRODUCT PUZZLE

The following multiplication problem uses each of the numbers from 0 to 9 once and once only. Three numbers have been filled in to get you started.

```
    4 X X
×     3 X
= X X 6 X X
```

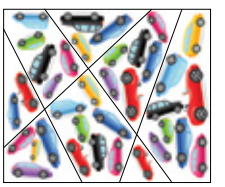
8 CODEBREAKER

Find the coded phrase hidden in the diagram.

A	B	C	M	B	C	E	A	D	S	E	F	S	T	U	A	X	Y	G	Z
W									3										A
X																			E
V	T	U	S	R	O	A	X	Y	N	O	R	O	C	O	I	R	F	E	M

Answers

1. Rebecca had six buttons.

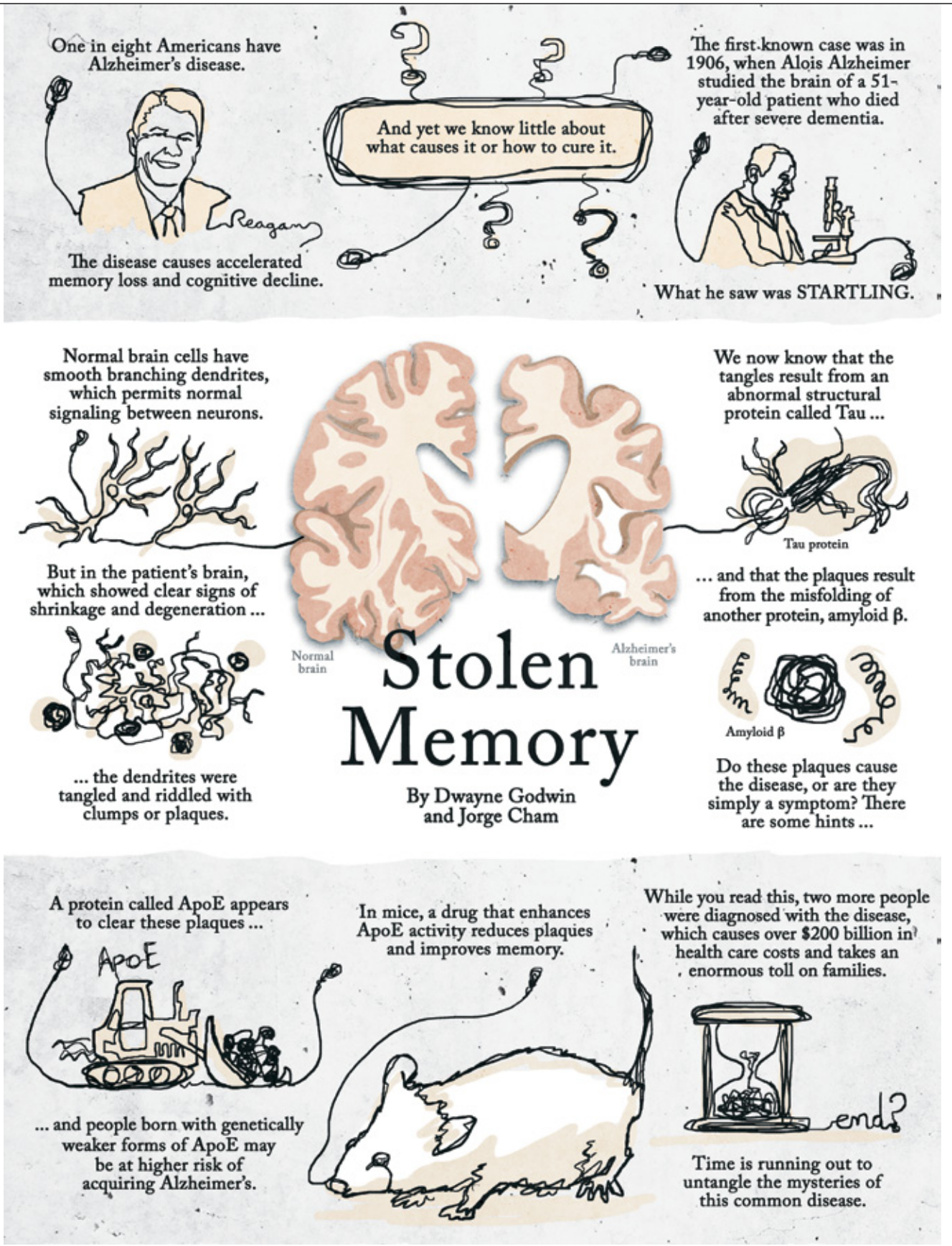


2.

3. Pairs of one-, four-, 16- and 64-pound weights. (Don't forget that the grocer can put a one-pound weight, for example, on the same scale pan as the item to be weighed and a four-pound weight on the other to weigh three pounds.)
4. MANY HANDS MAKE LIGHTS WORK.
5. A, AS, SAG, SAGE, SAGER, RANGES, STRANGE, SERGEANT, GREATNESS.
6. One solution is C = 5, A = 1, T = 6, S = 7, D = 2, O = 9, G = 3, R = 8, I = 0, N = 4.

```
  402
× 39
= 15678
```

7.
8. A MESSAGE FOR YOU. (The "3" is a hint: start in the upper left with "A" and read every third letter.)



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.*

Think Clearly.

Your brain. It makes up only 2% of your body weight, yet it consumes roughly 20% of your body's energy when at rest. That means the human brain needs a whole lot of nutrition to stay alert and focused throughout the day. Citicoline is nature's way of keeping the brain's energy-producing centers firing. Clinically tested for efficacy, Cognizin® delivers a patented form of Citicoline that supplies your brain with the energy it needs to stay sharp.* Cognizin is also pure, vegetarian and allergen-free. So look for Cognizin brand Citicoline on the ingredient panel of your favorite supplements to help keep your mental edge.*

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