

SCIENTIFIC AMERICAN **MIND**

BEHAVIOR • BRAIN SCIENCE • INSIGHTS

January/February 2014

Mind.ScientificAmerican.com

**Beat Stress
and Boost
Your IQ**
page 58

Can Men and Women Really Be “Just Friends”?

Reruns of *Glee*
tonight?

He reminds
me of my
ex.

What would it be
like to kiss her?

Will her new
boyfriend
come
between
us?

I wonder if
he/she
wants more.

PLUS

Give Yourself
a Pep Talk

Do You Have
Adult ADHD?

Stopping
Autism Early

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Astronomy

Speaker: John Brown, Ph.D.

Our High Energy Sun

Eruptions on the sun are dramatic events that have consequences on Earth, such as aurorae (Northern and Southern Lights), as well as disrupted power grids and satellite communications. Learn about the solar science advances that were enabled by NASA's RHESSI spacecraft from the mission's U.K. co-investigator.

Comet-Sun Impacts

The sun is continually pummeled by impacting cosmic debris, and has close encounters with more than 100 comets a year. Learn how these sun-plunging supersonic snowballs interact with the Hellish conditions near the sun, and the possible terrestrial consequences of a large comet-sun impact.

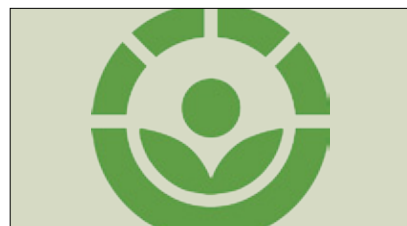
Gravity, Black Holes & White Rabbits

Through the lens of magic tricks, learn what gravity is and how it affects the universe, particularly black holes — the strongest sources of gravity and the most bizarre objects in the cosmos. We'll explore space-time distortion, gravitational lensing, Hawking radiation, multiverse creation, and other cosmic mysteries.



A Historical Tour of Scottish Astronomy

The Scots and their ancient ancestors have recorded aspects of the sky since before the pyramids of Egypt. We'll discuss highlights from the work of some early great astronomers, such as James Gregory, Alexander Wilson and others, and explore the great modern astronomical heritage they created.



Plant Biology

Speaker: Daniel Chamovitz, Ph.D.

What a Plant Knows

Take a captivating journey into the sensory lives of plants, and discover the surprising similarities between humans and green, leafy organisms. Highlighting the latest research in plant science, we'll look into the sensory lives of different types of plants, and even consider whether plants are aware.

Hunger and the Quest to Feed the World

More than half of the world's population suffers from some form of food insecurity. Rapid increases in global population, increased demand for food, and dwindling agricultural resources have put critical strains on our ability to feed the world. We'll examine the problem and some ideas to address it.

A Rational Look at GMO Food

Many of us are concerned by food labeled "GMO." But is GMO food inherently inferior to organic food? We'll examine what happens when GMO technology turns plants into factories, and delve into the scientific basis of genetic engineering with a view toward how it influences our lives.

The Scientific Life

Hear the story of a life in science from a researcher who started as a graduate student studying beta-carotene in bacteria, and became director of an institute trying to solve issues of world hunger. Learn about the hypotheses that have powered the science throughout, and the experiments and findings behind them.



Theoretical Physics

Speaker: Frank Close, Ph.D.

Antimatter: Facts and Fiction

The Big Bang produced matter and anti-matter in equal amounts, yet there is very little antimatter in our universe. Where has all the antimatter gone? Could antimatter solve the world's energy problems, or even make the ultimate weapon of mass destruction? The answer to both questions is no — learn why.

Nothing: Mysteries of the Vacuum

If you take away the Earth, moon and stars, what remains? The concept of the void — nothing — has alarmed and fascinated humans from the dawn of time. We'll move from the philosophical speculations of early civilizations to the cutting edge thinking of modern science to ask: Can we understand nothing?

Neutrino: Ghost Particle of the Cosmos

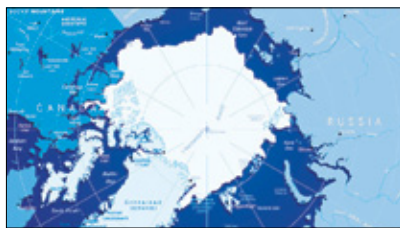
Ghostly neutrino particles stream through Earth by the billions as if it wasn't there. This is the story of how these extraordinary particles were sought and found — a story of heroic endeavor, of lifetimes spent chasing the near-impossible — and the scientific revelations neutrinos have enabled.

A Lopsided Universe

Nature produces structured asymmetric patterns prolifically: Even human life is lopsided, with spherical embryos somehow giving rise, ultimately, to creatures whose inner organs are asymmetric. This is the story of a quest for the origins of structure in nature, which has culminated in the discovery of the Higgs Boson particle.

The Story of the Higgs Boson

Roughly 50 years ago a new theory of the basic structure of matter was inspired by the work of Peter Higgs and others. In July 2012, Higgs's boson was finally found. Hear the story behind this amazing discovery, and delve into the ideas that inspired it.



History of Science

Speaker: Edward Larson, Ph.D.

Scientific Exploration of the Arctic

Scientists and geographers knew virtually nothing about the Arctic until 150 years ago, when Fridtjof Nansen and his protégé Roald Amundsen became legends by exploring this mysterious territory. While cruising through the beginning of the Arctic in Scandinavia, we'll follow their exploits as they opened the Arctic for science.

Amundsen, Scott, and Science in the Antarctic

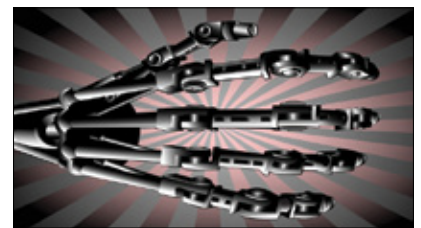
The Antarctic was a mystery to humanity until the Royal Society-backed expeditions of Robert Scott and Ernest Shackleton, followed by Roald Amundsen's entry in the field. We'll follow the adventure and the science of the early research at the South Pole.

The Evolution Controversy

Creationism has changed, creationists say, but has it? Rooted in supposed biblical truths, almost by definition creationism cannot evolve, but creationist tactics do. We'll explore the world of modern creation science, intelligent design, and the 21st-century American battle over teaching evolution.

The Neo-Darwinian Synthesis

Charles Darwin was central to the story of modern evolutionary theory, but he wasn't its founder. We'll trace this grand breakthrough from Lamarck and the dawn of evolutionary science through Darwin to the modern neo-Darwinian synthesis of the 1930s, when genetics finally explained how evolution operated.



Robotics

Speaker: Alan Winfield, Ph.D.

Robotics: The State of the Art

Robots are moving out of factories and into homes, hospitals and offices. Robots are now mobile and working alongside humans. We'll delve into the state-of-the-art in intelligent robotics, defining what a robot is through examples from current research. Learn how the latest robots differ drastically from earlier generations.

A Brief History of Robotics

Trace the history of robotics from Classical Greece to the modern day, from Aristotle's early reference to the idea of an intelligent tool that could replace human labor, to Leonardo da Vinci's programmable automata, and W. Grey Walter's 1940s robot "tortoises," regarded as the first autonomous electronic mobile robots.

Robot Ethics

Like any transformative technology, intelligent robotics has the potential for huge benefit, but is not without ethical or societal risk. We'll explore whether there are situations where robots should be banned, and the issue of whether intelligent robots themselves could or should be ethical.

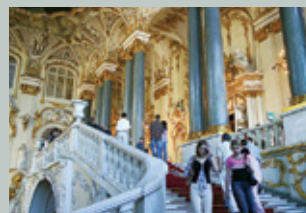
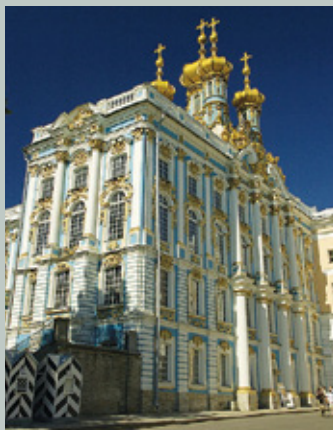
The Thinking Robot

Could robots ever truly think like humans, or have feelings? We'll explore how intelligent present-day intelligent robots really are, and the future prospects of designing robots that not only have increased abilities, but also have a sense of self.

SCIENTIFIC AMERICAN Travel

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Some of the articles in Scientific American Mind are adapted from articles originally appearing in Gehirn & Geist.



Controversial Friends

“Friendship is certainly the finest balm for the pangs of disappointed love,” Jane Austen writes in her 1817 novel *Northanger Abbey*. What if one’s friend is the source of those pangs? Can he or she still *be* a friend? Journalist Carlin Flora explores this question in our cover story, “Just Friends,” starting on page 30.

Despite massive gains in gender equality, platonic friendship between heterosexual men and women still draws some suspicion. This intuition rests on two related assumptions. First, that physical attraction is inevitable in such a union. Second, that selfishness or subterfuge weakens the bond as a friend angles for more intimacy. As Flora reveals, neither of these conjectures holds up. And should unrequited feelings arise, she offers tips from science to help friends navigate mismatched expectations.

We rely on friends for good conversation—but we also maintain a silent inner dialogue with ourselves. Studies suggest that such self-talk helps us craft the conscious narrative of our lives. Turn to page 45 to read “Speak for Yourself,” by Ferris Jabr, an associate editor at *Scientific American*.

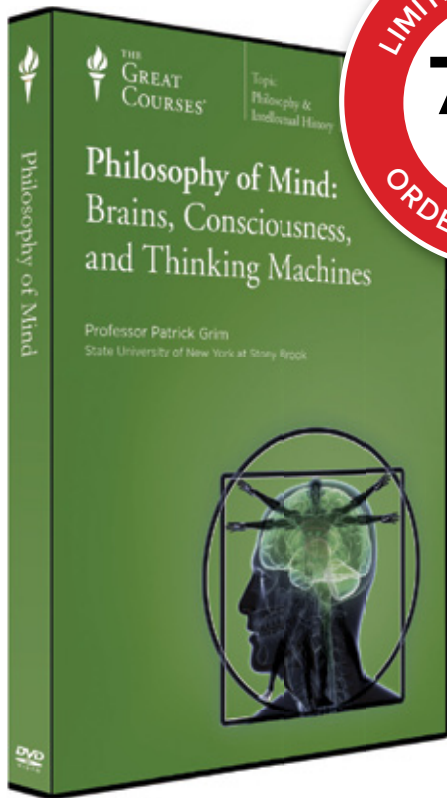
Talking through a task—this time aloud—appears to help children with autism overcome language difficulties, Jabr notes. A new trend in autism therapy targets such deficits at age one or two, when the brain is still highly malleable. See “Taking Early Aim at Autism,” by journalist Luciana Gravotta, beginning on page 52.

Early intervention is also the goal in another public health concern, the brain deterioration that multiple hits to the head can trigger. In “Fatal Strikes,” starting on page 36, neuroscientists Jacqueline C. Tanaka and Gregg B. Wells investigate the rapidly evolving science of chronic traumatic encephalopathy, a disorder involving damaged neurons that threatens to reshape the game of football.

If you take one thing away from this issue, let it be this: integrity at the cellular level, the dynamics of our inner universe and the richness of our social world contribute equally to mental well-being. May your brain thrive on all levels.

Sandra Upson
Managing Editor
editors@SciAmMind.com

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BY LUCIANA GRAVOTTA

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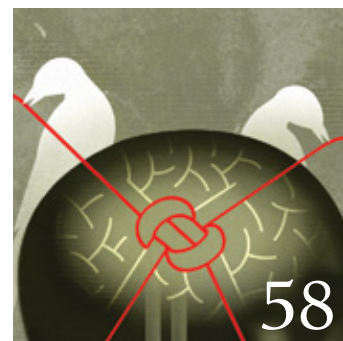
A preoccupation with scarcity diminishes IQ and self-control. Simple measures may counteract this cognitive tax.

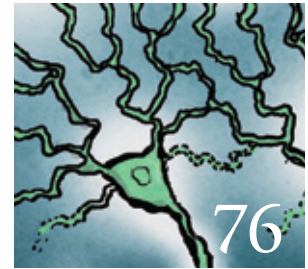
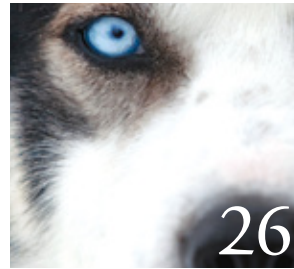
BY SENDHIL MULLAINATHAN
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Newly recognized, adult ADHD threatens the success and well-being of 4 percent of adults. A combination of treatments can help the afflicted lead a more productive life.

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FIRST-WORLD PROBLEMS

What a fantastic article by Jennifer Crocker and Jessica J. Carnevale, “Letting Go of Self-Esteem.” I am always interested in new insights into self-esteem. As a youth worker for many years, I believe it is a major area to explore. Sometimes I work with people who do not grasp the alternatives to their mind-set. I reflect with them about what we find essential that other people survive without: closure, explanation, certainty, hope, and so on. In Third World countries, people live without any certainty of food, money, medicine or even much future. Yet they do not all commit suicide. It is Westerners, with our certainty of income, food and shelter, who have problems with low self-esteem, depression and suicide. Why? Well, there is a fascinating opportunity for research!

Richard Waddy
 Usher, Australia

EVIDENCE-BASED LEARNING

I appreciated your straightforward findings regarding how we learn in “What Works, What Doesn’t,” by John Dunlosky, Katherine A. Rawson, Elizabeth J. Marsh, Mitchell J. Nathan and Daniel T. Willingham. During my 20-year career in preparing new teachers, I have seen the reshaping of education policies to essentially reject many proved learning strategies as “old-fashioned.”

Given the more popular goal of meeting every child’s unique learning style, teacher education (and therefore student learning) has been sidetracked with trendy approaches to learning, such as multiple intelligences, multicultural education, investigative learning, and so on. Although I am no champion of the onslaught of state and national testing, the benefit of rigorous standards and measurable results of learning has brought renewed interest in “doing what works.” Thank you for a nudge in the right direction.

Barbara Dautrich
 American International College
 Springfield, Mass.

HEARING VOICES

I read Eleanor Longden’s article, “Listening to Voices,” with interest. I have lived with hallucinations and delusions for 18 years—also following a trauma at a university—but followed the different path that she suggested. I never told friends or family or sought medical help. About six years after the hallucinations started, I learned through a colleague who conducted research in acceptance and commitment therapy that I may have been doing the right thing, by accident, all along. By following a mindful and accepting approach to my unusual cognitions, I have learned to live in harmony with my hallucinations and delusions. In fact, rather than labeling them as such, I prefer to think of them as “odd thoughts,” and I do not act on them. I followed a career in academic psychology and secured positions at good universities, and I have even been promoted.

You can learn to live with odd thoughts; there are alternatives to stepping onto the psychiatry “hamster wheel.”

Name withheld
 via e-mail

Although I am deeply impressed and moved by Longden’s story and ideas, I cannot totally agree with her conclusion that “people who are diagnosed ... with schizophrenia are not victims of chemical imbalance or genetic mutation.” Her observations, while supported with some research, seem largely anecdotal, and



there is a range of neuroscience research that continues to find connections between the physical properties of the brain and all forms of mental illness. As someone who has unfortunately been involved with numerous close relatives (a daughter, a brother and a wife who were given this diagnosis) and having worked in state psychiatric wards and witnessed seriously ill schizophrenics firsthand, I am convinced there is organic impairment of some kind responsible for this very painful disease. My relatives' schizophrenia, like that of the Alzheimer's patients I have witnessed, progressed in stops and starts regardless of medication or therapies. Most psychiatrists and therapists are sadly ineffective. I think that whatever works for each patient, regardless of theories and points of view, is the key to success. Causes, theories and hypotheses are a necessary basis for research, but so far I have not seen any of them produce long-lasting results.

Bill Bauer
Wailea, Hawaii

GLOBAL WARMING HOAX?

Regarding "What a Hoax," by Sander van der Linden: Do you editors realize that you have been pranked? The article is almost completely geared to "proving" that global warming skeptics are conspiracy theorists. Regarding conspiracy theories, the author says: "A likely function of this cognitive bias is to help

people make sense of the world by offering simple explanations for complex events." It seems to me that blaming humans for global warming is a simple explanation for a complex event.

J. R. Kennedy
Largo, Fla.

The only real hoax here is that van der Linden is throwing global warming skeptics under the bus with conspiracy theorists who believe that NASA faked the moon landing, the government holds aliens hostage in Area 51, and the Boston Marathon bombings were an inside job. No one really questions climate change. It is natural to have ice ages and periods of global warming as part of the earth's history.

The real question in many people's minds, which van der Linden completely ignores, is the percentage of current global warming that is caused by humans. As a biologist, I suspect that the actual value is less than 10 percent of the total. Consider the endemic influences of phenomena such as volcanoes, wildfires and natural gas emissions from the earth. And how do you explain away the melting of ice caps on Mars and other planets if nobody lives there?

It is necessary that we continue to have discussions about remedies for cleaner air and water and

conservation of our precious lands. But to include climate change skepticism under the umbrella of a conspiracy theory is misguided if not malevolent.

Jeff S. Wyles
Oroville, Calif.

VAN DER LINDEN REPLIES: My article seems to have caused a fair amount of upheaval. The critical responses I have received can largely be categorized into two camps: those who feel that the article labels every conspiracy theorist as mentally ill and those who feel that it is unfair to group skepticism toward global warming with other "crazy" conspiracy theories such as aliens and Area 51.

With regard to the first criticism I would like to clarify that the article refers to scientific evidence that suggests that conspiracy ideation has been associated with paranoia and schizotypy. The intention of the article is by no means to label every skeptic as mentally ill.

In response to the second point, the most authoritative international scientific investigation into global warming has recently concluded with 95 percent certainty that human-caused global warming is happening. In addition, numerous studies that have surveyed the state of scientific agreement on the issue report that more than 97 percent of independent climate scientists agree that human-caused climate change is a reality. In the face of this overwhelming evidence, is denying global warming really that different from believing that the government is hiding aliens in Area 51? I will let the reader decide.

ERRATA

In "Calming a Turbulent Mind," by Erica Rex [May/June 2013], LSD discoverer Albert Hofmann's name is misspelled. In "Fertile Women Have a Heightened Sense of Smell," by Tori Rodriguez [Head Lines, September/October 2013], Jessica McNeil is incorrectly listed as a co-author of a study in the journal *Hormones and Behavior*. McNeil is actually a co-author of the study in *Physiology and Behavior*.

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Head Lines

YOUR BRAIN, YOUR LIFE



M NEWS FROM OUR WEB SITE Implanting electrodes appears to reboot the depressed brain, producing immediate relief in some patients.

ILLUSTRATIONS BY HANK OSUNA

DANGEROUS EXPECTATIONS

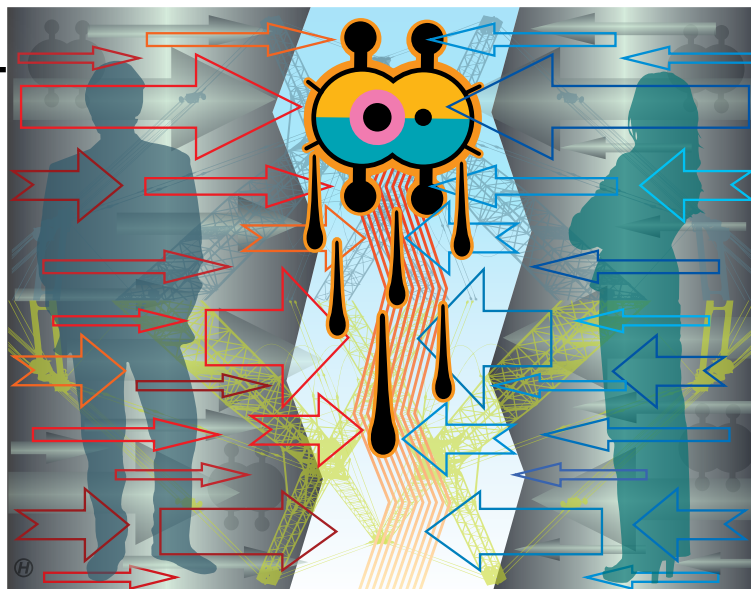
Optimism: A Double-Edged Sword

Seeing the world through rose-colored glasses is linked with greater satisfaction with one's relationship. Seeing your relationship through those same lenses, on the other hand, can actually lead to less satisfaction, according to a longitudinal study of 61 newlywed couples reported in the July 2013 issue of the *Journal of Personality and Social Psychology*.

The study found that for spouses higher in dispositional optimism, a stable personality trait, marital well-being declined less during the first year of marriage. They also took a more positive approach to resolving conflicts, such as trying to define a common goal and brainstorm ways to work toward it. Spouses higher in relationship-specific optimism, however, had greater declines in marital well-being and displayed more negative problem-solving behaviors, such as avoiding tough discussions or trying to suppress their own desires.

The researchers theorize that having unrealistically high expectations of one's relationship can lead to disappointment when even minor conflicts arise and make spouses less likely to respond proactively to difficulties. Study co-author Lisa Neff, a psychologist at the University of Texas at Austin, cautions this finding does not mean pessimism is the way to go. "In my study, no one scored low enough to be considered pessimistic, and I would not expect that to be good for relationships," she says. "It is great to be optimistic, but keep it at a more realistic level."

—Tori Rodriguez



50 percent of couples report improved relationship satisfaction five years after couples therapy.

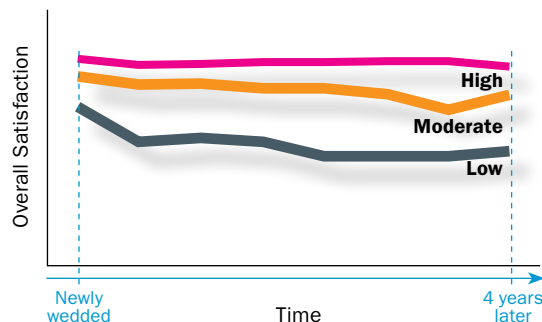
Watch Your Sexism, Women

"Benevolent sexism" is the belief that women deserve to be protected and cherished by men, with the implicit understanding that these are perks in exchange for men's general dominance. In two related studies reported in 2013 in the *European Journal of Social Psychology*, women who held these beliefs had steeper drops in relationship satisfaction when conflict arose. "It is likely that conflict contrasts starkly with beliefs about being cherished and threatens their investment in supporting their partner," says study co-author Matthew Hammond, a psychology researcher at the University of Auckland in New Zealand. He points out that it is important to understand that some disagreement is normal and to reflect on the sources of one's expectations about relationships. "Expectations built from ideas in society about what men and women 'ought' to do will be hard for reality to match," Hammond says.

—T.R.

MARITAL BLISS: Not Necessarily Doomed

Much research claims that relationship satisfaction within marriages inevitably declines over time. This indeed looks like the truth if you average all couples' responses together, but it turns out partners who start out slightly happier may avoid that fate, according to a study in 2012 by psychologist Justin Lavner of the University of California, Los Angeles, and his colleagues.



THINKSTOCK (couch)



According to some scientists, several species of animals are capable of mental time travel, the ability to picture oneself in the past

AFTER AN ARGUMENT

It's Not about the Apology

After a fight, most people want their partner to either disengage or to engage more meaningfully, according to a study of 953 married or cohabitating couples in the June 2013 issue of the *Journal of Social and Clinical Psychology*. Which strategy to use depends on your partner's underlying concern in the argument: is he or she perceiving a threat or neglect? A perceived threat encompasses anything that puts a partner's status in doubt, such as blame, criticism or demands, explains lead author Keith Sanford, a psychologist at Baylor University. In these scenarios, the offended party is more likely to want their partner to passively disengage by halting adversarial behavior and relinquishing power. "Giving up power comes in many forms, among them, admitting faults, showing respect and being willing to compromise," Sanford says.

When perceiving neglect, individuals wanted their partner to actively engage by showing investment, communicating more and giving affection.

No matter what the tenor of the fight, the participants ranked an apology as the least important factor in resolving the issue.

—Esther Hsieh

Forgive Yourself

When you land in the doghouse, you might think staying there could help you get back in your partner's good graces. Not so, according to research published in August 2013 in the *Journal of Family Psychology*: self-forgiveness improves the relationship satisfaction of both the offending partner and the one who was hurt. The study, which examined real-life offenses among 168 couples, found that satisfaction was higher for both partners when the offender had less negative thoughts and feelings toward himself or herself. The researchers distinguished the construct of self-forgiveness (which requires accepting responsibility for one's wrongdoing) from self-excusing, so the findings do not mean it is okay to let yourself off the hook prematurely. Rather than dwelling on self-punishment, acknowledge wrongdoing and focus on rebuilding goodwill. —T.R.

7 out of 10 couples say that money is a source of tension in their relationship

Stay in Your Own Shoes

Well-meaning arguers often attempt to see things from their partner's point of view, but doing so can backfire, according to a paper in the January 2013 issue of the *Journal of Personality and Social Psychology*. In problem-solving discussions among 111 couples, researchers found that the person who attempted to take his or her partner's perspective had an increase in self-focus and overestimated how obvious his or her feelings were.

After the discussion, the perspective-taking partner reported feeling less satisfied with the relationship in general, and the other partner reported no change in relationship satisfaction. When subjects were instead instructed to take an objective approach and pay close attention to the other person's behavior, satisfaction increased for both partners—probably because this approach fostered a sense of shared reality. "I think what is critical is paying attention to what the other person says and does, rather than trying to work it all out inside one's own head," says Jacquie Vorauer, one of the study's authors and a psychology professor at the University of Manitoba. —T.R.



TALKING ABOUT MONEY

Who Should Pay?

Dating is supposed to be fun, but the arrival of the check may quickly lead to an awkward situation. According to an online study of more than 17,000 single, heterosexual men and women by Janet Lever of California State University, Los Angeles, and her colleagues, it may be nearly impossible to guess whether your date wants you to pick up the bill. Results show that men cover dating expenses most of the time, as reported by 84 percent of men and 58 percent of women. Yet 64 percent of men expect their partner to chip in, which is unfortunate for the 44 percent of women who are bothered when a man expects them to pay their share. The solution—as in many relationship issues—is probably just to talk about paying openly. "Be direct, and when the check comes you should offer something on the first date," suggests Wellesley College sociologist Rosanna Hertz, an author of the paper. —Ariel Van Brummelen

Long-Term Finances

We all know communication is key to a healthy relationship—but a more important factor may be sharing a vision for how money should be managed. Research published in July 2013 in *Marriage and Family Review* found that mutual financial goals and values predicted relationship satisfaction more strongly than did the communication tactics the couples used during conflict. The roles of each partner in handling finances also mattered less than their satisfaction with those roles. Instead of arbitrarily assigning duties, then, it may be best to divide them based on each partner's enjoyment of the tasks. —T.R.

PORN Just Be Honest

Of things better left unsaid, information about your pornography use may not be among them, suggest findings of a recent study in the *Journal of Sex and Marital Therapy*. Among 340 heterosexual women who answered online questionnaires, those who reported that their partners were honest about their pornography use scored higher on measures of relationship satisfaction and had lower levels of distress related to their partners' viewing of pornography, as compared with women whose partners were deceitful about the topic. Women who reported mutual viewing of pornography with their partners also showed less distress than those who did not report mutual use. The study did not assess frequency or amount of pornography consumption, however, and the authors suggest that future research should include these and additional variables. —T.R.

TOP 4 TYPES OF COUPLE TROUBLE

- **INSECURITY:** Unsafe neighborhoods or a lack of support from family, friends or culture can take a toll.
- **MENTAL DISORDERS:** Depression, substance abuse and anxiety cause strife.
- **STRESS:** Sources include major illnesses, child-rearing and unemployment.
- **POOR INTERACTION:** Bad communication, aggression and insufficient time together can become core problems.



ON THE HORIZON

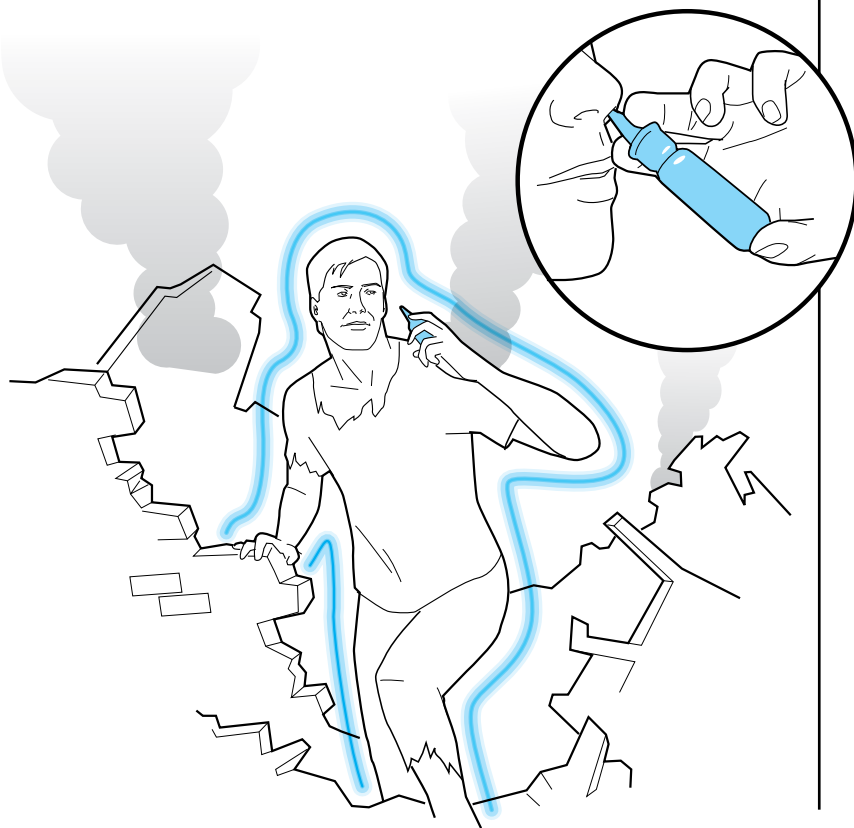
A Spritz That Prevents PTSD

First responders arrive at a disaster scene—a bombing, say—and, after stabilizing victims, treat them with a puff of a nasal spray to prevent post-traumatic stress disorder (PTSD). The spray sends neuropeptide Y (NPY), a tiny but powerful signaling protein, deep into the nose and up into the brain. There it prevents the brain's stress system from kicking into overdrive and causing PTSD, which disrupts sleep, mood and thought in some people following trauma. The idea for this futuristic prophylactic treatment comes from recent studies in rats by neuroscientist Esther Louise Sabban of New York Medical College.

Sabban and her colleagues dosed rats with a nasal spray containing either NPY or saline and then exposed them to a one-time series of traumatic stresses, such as being immobilized and later forced to swim in a Plexiglas tube. Seven days later the researchers tested whether the rats exhibited anxious and depressionlike behaviors. Saline-treated rats did, but “the rats that received NPY looked very similar to the unstressed controls,” Sabban says. Likewise, the researchers found that stress hormones and receptors rose in the saline-treated but not the NPY-treated rats. Rats blasted with NPY immediately after the stressful experience were also protected, according to the study published in 2013 in *Neuroscience*.

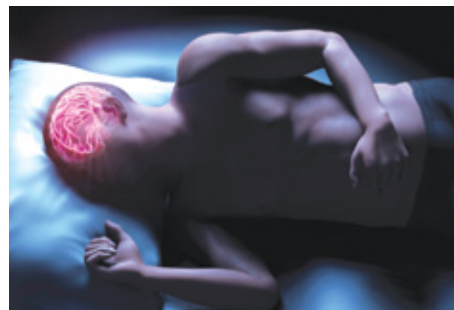
A squirt of NPY into the nose can travel widely throughout the brain—but not the body, where harmful side effects could damage the heart. Recently Sabban determined that the treatment seems to work by reducing the number of receptors for the stress hormone cortisol, particularly in the ventral hippocampus, a brain area where emotional memories are formed. Future work will test whether NPY also alleviates established PTSD-like symptoms in rats.

—Stephani Sutherland



How Sleep Protects the Brain over Time

Gene activity during slumber kicks off production of “support cells”



There is nothing like a good night's sleep to help you feel your best the next day. Now scientists are finding that good sleep habits may do more than restore cognitive function on a nightly basis—they may also fortify the brain over the long term, according to a new study in the *Journal of Neuroscience*.

Researchers at the University of Wisconsin–Madison found that during sleep, activity ramps up in genes that are involved in producing oligodendrocytes—brain cells responsible for coating neurons with myelin. Myelin is the brain's insulating material. The fatty substance surrounds the signal-transmitting tail that extends from every neuron, enabling electrical communications to travel quickly and efficiently to other neurons. Myelin deficiency is at the root of the neurodegenerative disease multiple sclerosis and can contribute to symptoms such as fatigue, vision and hearing impairment, and a loss of coordination.

In this study, sleeping mice had heightened activity in the genes responsible for creating oligodendrocytes, but awake or sleep-deprived rodents showed greater activity in genes involved in cellular stress and death. Chiara Cirelli, a neuroscientist and author on the paper, suggests that sleep helps cells regenerate and repair themselves, by enabling the body to produce new myelin after it has deteriorated. Cellular repair probably takes weeks or even months, however, so pulling an occasional all-nighter is unlikely to disrupt the process.

—Roni Jacobson

JASON LEE (illustration); GETTY IMAGES (sleeping man)



Literary fiction—but not genre novels or nonfiction—improves our ability to infer others' thoughts and feelings, new research finds.

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A UNIFIED THEORY OF DEPRESSION

Antidepressants may work by providing a rosier lens through which to see the world

For decades two very different treatments of depression have existed side by side. Medications act on molecules, cells and synapses in the brain. Psychological therapies focus on cognition and behavior, trying to alter negatively biased thinking. Now a new theory suggests that these interventions may work in more similar ways than anyone realized, providing an opportunity to better integrate the two approaches. More important, it may help provide patients faster, more reliable relief from this crippling condition.

Antidepressant drugs increase the levels of certain chemical messengers in the brain, such as serotonin and norepinephrine. Yet exactly how these neurotransmitters affect mood is unknown. “There was a missing link between the cellular, molecular and synaptic bases of these drugs, on the one hand, and what they affect in humans, which is their experiences, perceptions, memories and feelings,” says Catherine Harmer, a neuroscientist at the University of Oxford.

The psychological explanation, meanwhile, describes depression in terms of distorted information processing. Depressed people are thought to process perceptions, experiences and memories with a negative bias. Many studies confirm that depressed individuals show increased sensitivity to sad faces, greater memory for negative material and reduced responsiveness to rewards as compared with healthy people. Successful therapies teach patients how to correct for this clouded vision.

Harmer now believes that antidepressants may also work by altering this negative emotional processing. About a decade ago she and her colleagues tested the effects of commonly prescribed antidepressants on healthy volunteers and found that many of the drugs skewed emotional processing to the positive. Previous research had shown that antidepressants also change these measures in depressed people, but studies included only patients who had been on medication for six to eight weeks because the drugs were assumed to take that long to kick in. Why antidepressants take so long to work “has been a puzzle in psychiatry for a really long time,” says Jonathan Roiser of the Institute of Cognitive Neuroscience at University College

London. Some patients spend months, or even years, trying one drug after another, with no way of knowing in advance which might work.

But in 2009 Harmer and her colleagues showed that a single dose of a common antidepressant altered emotional processing in depressed patients within a matter of hours. Initially, depressed people showed less sensitivity to happy faces, took longer to respond to positive descriptors of themselves and remembered fewer positive words than healthy volunteers. A dose of reboxetine—but not a placebo—returned all these

measures to normal levels within three hours. Another study Harmer published in 2012 showed that the amygdala of depressed patients became less hyperactive in response to fearful faces after a seven-day course of escitalopram (Lexapro). In both studies, the emotion-processing changes happened well in advance of any improvement in mood.

If antidepressants provide a rosier lens through which to experience the world, the puzzle of their delayed action might finally be solved. A patient presumably needs time to become acquainted with the world that their new, more positive perspective unveils. This experiential learning might also explain why outcomes vary so widely with drugs. “You need to have enough opportunities to pick up on this more positive mode of processing,” Harmer says. She hopes to study whether patients who get out more are indeed the ones who do better. If so, doctors could identify people who need extra help coming out of their shell and reengaging with the world. “It’s a new perspective on how you might best combine pharmacological and psychological treatment,” she says.

Yet perhaps the most exciting aspect of this research is the possibility of predicting early how effective a treatment will be—both for individuals and in the development of new drugs. Initial indications are encouraging. A 2009 study found that patients who had been taking antidepressants for two weeks showed increased accuracy in recognizing certain facial emotions, including happiness. Those whose accuracy changed the most also showed the most clinical improvement after six weeks, suggesting that these early processing changes might predict later outcomes.

Ultimately Harmer’s research may even enable us to stop seeing biology and psychology as competing explanations. “Her work provides us with the ability to bridge between those different levels of explanation,” Roiser says. “That’s very powerful.”

—Simon Makin





(PHARMA WATCH)

BITTER MEDICINE

Prescription painkiller abuse is the newest drug epidemic to sweep the U.S.

Over the past 10 years the number of overdose deaths from prescription painkillers—also known as opioid analgesics—has tripled, from 4,000 people in 1999 to more than 15,000 people every year in the U.S. today. Prescription pain medication now causes more overdose deaths than heroin and cocaine combined. In 2010 one in

20 Americans older than age 12 reported taking painkillers recreationally; some steal from pharmacies or buy them from a dealer, but most have a doctor's prescription or gain access to pills through friends and relatives.

Yet millions of people legitimately rely on these medications to cope with the crippling pain they face every day. How do we make

sure prescription opioids are readily available to those who depend on them for medical relief but not so available that they become easily abused? Here we break down the steps taken at various levels—and the experts' recommendations for future interventions—to curb prescription opioid addiction and overdose in the U.S.

—Roni Jacobson

Teaming Up to Fight Overdoses

	DONE	FUTURE
Tracking Prescriptions	In 2005 Congress passed the National All Schedules Prescription Electronic Reporting (NASPER) Act, which funds state programs to monitor drug prescriptions electronically. Currently all but one state, Missouri, collect data on opioids using such programs. The systems can flag patients with multiple opioid prescriptions or providers whose practices deviate from industry norms.	In 2011 the NASPER Act came up for reauthorization, but Congress has not yet enacted it. The updated act would require states to report their data to the government to help track national drug abuse trends. In Missouri, legislation on a drug-monitoring program is pending.
Cracking Down on Pill Collecting	Almost all states have enacted laws to limit "doctor shopping," a type of fraud in which a person secretly maintains prescriptions from multiple providers. In 2007 Louisiana became the first state to pass a law targeting "pill mills," the pain management clinics that prescribe opioids indiscriminately, often without examining a patient. Texas and Florida, among the states highest in reported opioid abuse, soon followed.	To further inhibit doctor shopping, the Department of Justice is piloting efforts to help states share data on drug prescriptions. Momentum is building for pill mill legislation. As of October 2013, nine states had passed laws regulating pain clinics—six of them last spring. Indiana is poised to be the next one: its "pill mill bill" goes into effect in December 2013.
Rethinking Pain Management	In September 2013 the Food and Drug Administration changed the labeling requirements for long-acting opioids such as OxyContin. These drugs are now to be used only for severe, rather than moderate, pain. Experts now advise physicians to prescribe such addictive medications as a last resort for severe pain and only in the smallest quantity needed for relief.	The new labeling plan also requires drugmakers to research nonaddicting treatments for chronic pain. These alternatives could discourage abuse physically, such as by altering how the drug is delivered, or chemically, by combining the opioid with a substance that makes a higher dose unpleasant to take.
Protecting Good Samaritans	Most opioids are classified as controlled substances, which makes them illegal to possess without a prescription. As a result, victims of an overdose—or their companions during the event—are often reluctant to seek aid. Good Samaritan laws, enacted by 14 states to protect people who report overdoses from prosecution, can help.	Wisconsin is now considering a Good Samaritan law pioneered by State Representative John Nygren, whose daughter almost died of an overdose after her friends fled the scene. Policy experts are encouraging other states to follow suit, as many overdose deaths are preventable if a victim receives medical attention in time.

ISTOCKPHOTO (pills icon)

What Are Opioids?

Oxycodone, hydrocodone, methadone, fentanyl: opioids are molecules that reduce the perception of pain by attaching to proteins called opioid receptors, found mainly in the brain, spinal cord and digestive tract. By stimulating these receptors, the drugs mimic the effects of the brain's endogenous opioid system, which is involved in feelings of pleasure and relaxation. With extended use, an individual can develop a tolerance for the drug as their opioid receptors become acclimated to stimulation, requiring higher and higher doses to alleviate pain.

to brain surgery, to add to all the other risks: you could get infected with prions, the misfolded proteins that account for mad cow disease.

ILLUSTRATIONS BY ALEX NABAUM

HEAT-FUELED RAGE

Hotter weather sparks aggression and revolution

As the climate heats up, tempers may follow suit, according to a study published in August 2013 in *Nature*. Analyzing 60 quantitative studies across fields as disparate as archaeology, criminology, economics, geography, history, political science and psychology, University of California researchers found that throughout history and across the world, higher temperatures, less rainfall and more drought were consistently linked to increased violence. The correlation held true for aggression between individuals, such as domestic abuse and assault, but was even more pronounced for conflict between groups [see *timeline on opposite page*].

“We didn’t expect for there to be nearly so many convergent findings among so many different researchers,” says economist Solomon Hsiang, now at U.C. Berkeley, who led the study. “We were actually really stunned by the level of consistency in the findings that were out there and by the size of the effects we were observing.” The researchers used statistical modeling to show that aggression scales with a combination of temperature, place and time—for example, if one U.S. county is three degrees Celsius warmer for three months or one African country is 0.6 degree C warmer for a year, statistics reveal an uptick in crime, violence and revolutionary fervor.

The reasons behind the climate-violence link are complex and not fully understood, although anyone who has lived through a heat wave can attest to one simple fact: “When people are hot, it makes them cranky,” says Brian Lickel, a social psychologist who is on the faculty of the Psychology of Peace and Violence program at the University of Massachusetts Amherst and who was not involved in the study. “It makes people more prone to anger, it makes people more frustrated, and it makes decision making more

Too Hot to Be Angry? Multiple studies have proposed a link between hot weather and violent crime rates. Yet debate rages over whether aggression wanes at very high temperatures. Some interpretations of data for U.S. cities suggest temperature and violent crimes such as aggravated assault share a linear relation, with violence increasing at ever hotter temperatures. Other researchers argue that crime curves level off or even dip in supersweltering situations in ways that can vary with the time of day, the nature of the crime and even the season studied.

—Andrea Anderson



impulsive. And that can lead to altercations that escalate to more extreme levels of aggression.”

Discomfort aside, the physical temperature of the brain may also play a role, according to Glenn Geher, director of evolutionary studies at the State University of New York at New Paltz, who also was not involved in the study. “There really is something to the idea of being ‘hot-headed,’” he says. “Brain temperature, which is affected by ambient temperature, does seem to be associated with aggressive mood states and aggressive behavior.” The bellicosity relates to a lack of oxygen in the regions of the brain that control our impulses, as the body directs more blood to the skin’s surface in an effort to cool off, Geher explains. “So you get more emotional reactions and less prefrontal, step-back, cognitive-processing kinds of actions.”

As for the protests, wars and revolutions supposedly fueled by sweat, the key factor may be survival, especially in drought-ridden areas. “When there are resource constraints—when there is lack of food, when there is lack of access to



Is it more stressful to be a boss or an underling? Top dogs may have the tougher job, but feeling in control can protect people from stress.

water, when there is economic destruction—then that is a potent predictor of conflict between groups,” Lickel adds. “When you’re in a society under stress and there is a danger of violence, people’s group identities become incredibly important, and violence begins to get organized around these group terms.”

Some critics have accused the study authors of scaremongering, playing up their dramatic results to take advantage of public concern about climate change. Yet decades of research support the link between hotter temperatures and increased violence, and this study—one of the largest analyses ever attempted—aligns well with an existing body of work. “I think the current study is impressive in how encompassing it is and how integrative it is,” Geher says. “If the data are right, there are some scary implications that I think people need to take into account.”

—Ajai Raj

COLD CONFUSION

The effects of low temperatures are harder to parse



Heat gets a bad rap for fueling human hostility. But what’s the deal when the mercury drops? The cold effect has been somewhat less studied, although there are hints that being uncomfortably chilly can contribute to conflict in some situations and quell it in others.

A Swiss-led group using tree-ring data to look at Central European summer climate patterns during roughly 2,500 years saw that periods of prolonged warming and of colder than usual spells coincided with social upheavals. As they reported online in January 2011 in *Science*, the researchers uncovered cold periods that overlapped with raucous historical events ranging from a Celtic expansion

around 350 B.C. to modern migrations from Europe to the Americas in the 1800s.

Likewise, a series of laboratory experiments dating to the mid-1970s suggest uncomfortable cold, as with uncomfortable heat, can push people’s aggression buttons. There is a debate about whether this effect tapers off at temperature extremes [see box on opposite page]. But from lab findings alone, it seems feasible that cold could stir up as much trouble as heat.

Nevertheless, most real-world studies suggest assaults—and many other crimes—wane in winter months and during cold snaps when temperatures dip below what is considered comfortable in a given climate. There are exceptions, including crime spikes in December and January, although researchers tend to attribute those to confounding circumstances such as the holiday season rather than the cold and more hours of darkness.

Such real-life patterns

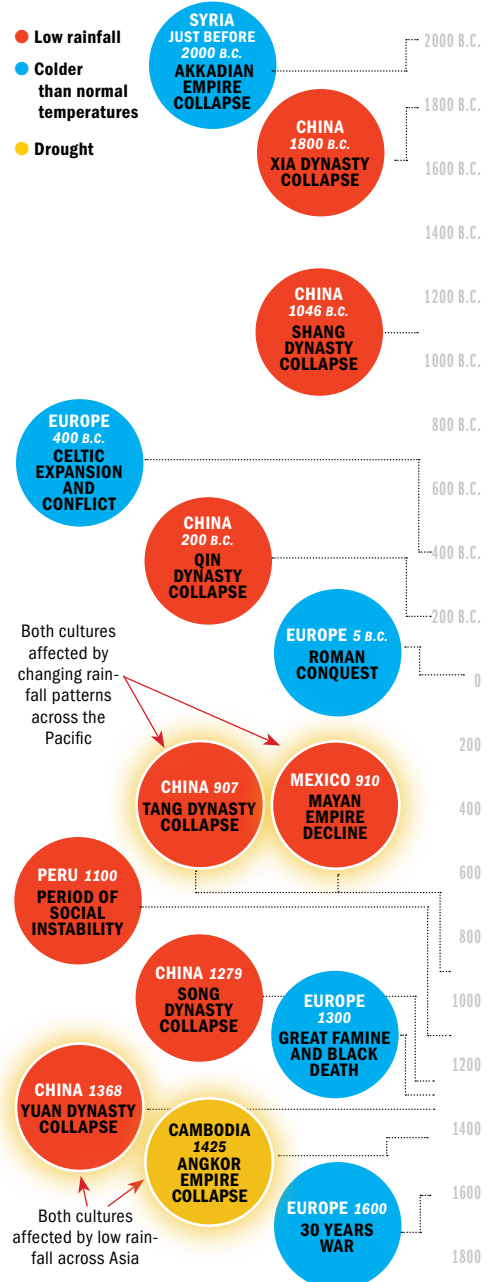
point to cold’s potential for curbing crime and reflect some of the difficulties associated with trying to study crime triggers in a controlled setting. Unlike the lab, for instance, where scientists get final say over the temperature, people at large in the world are typically at liberty to add a layer or two. Experts also note that it is generally easier to get back to a comfortable body temperature when it gets nippy than when it is excessively hot.

Hot and cold weather prompt very different human behaviors. Whereas many head outside when the heat is on, extreme cold dissuades all but a hardy few from venturing out more than necessary, decreasing the chances that a would-be victim will run into a potential perpetrator. So although there are hints that cold snaps hasten upheavals and spark some forms of social stress, it seems that chilly temperatures could be off the hook when it comes to causing crime—at least for now.

—A.A.

CONFLICTS DRIVEN BY CLIMATE

Many societal upheavals throughout history may have been brought on or exacerbated by local changes in climate, such as unusual temperatures or rainfall patterns, according to a study by U.C. Berkeley public policy researcher Solomon Hsiang and his colleagues. Below are a few of the events the scientists statistically linked to climate shifts:



Learning to play a musical instrument can help the brain process sounds better, making it easier to stay focused in many of life’s pursuits.

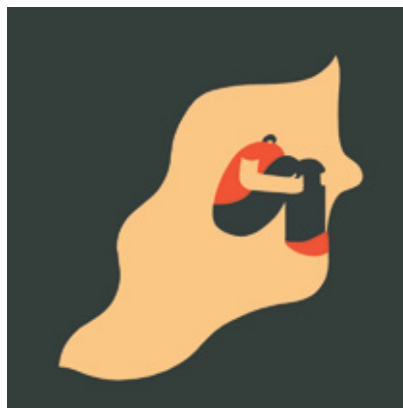
» Dare to Feel Overcoming fear of emotions

AFRAID OF HAPPINESS

Learning to embrace good feelings can lay the groundwork for future therapy

Unhappiness is often viewed as something to be prevented, avoided or eliminated. Yet recent studies reveal that for some people, feeling good is what scares them. Recognizing this fear and targeting it with therapy may be a critical first step before other mental illnesses can be treated.

People fear positive emotions for many reasons, such as feeling unworthy or believing good fortune inevitably leads to a fall, according to two new studies. Mohsen Joshanloo, a psychology graduate student at Victoria University of Wellington in New Zealand, developed a Fear of Happiness Scale, on which participants indicate their level of agreement with statements such as “Having lots of joy and fun causes bad things to happen.” Such beliefs can plague people in many countries, according to a study by



Joshanloo published online in October 2013 in the *Journal of Cross-Cultural Psychology*. The study found the scale to be reliable in 14 different cultures.

Using a similar scale, psychiatrist Paul Gilbert of Kingsway Hospital in England and his colleagues found in 2012 that a fear of happiness correlates highly with depression—but that the dread manifests in numerous ways. “Some people experience happiness as being relaxed or even lazy, as if happiness is frivolous and one must always be striving; others feel un-

comfortable if they are not always worrying,” Gilbert says. “It is not uncommon for people to fear that if they are happy about something, it will be taken away.”

Past research supports the idea that an aversion to positive emotions often coexists with mental disorders. Patients with major depressive disorder, for example, have been found to fear and suppress both negative and positive emotions more than healthy people do. These findings highlight a critical but often overlooked aspect of treatment, according to Gilbert. “It is very important that the fear of happiness become a focus for therapy in its own right, and that means treating it as you would any other fear,” he says, such as with exposure therapy or mindfulness techniques whereby practitioners allow themselves to feel happy without judgment. Traditional therapeutic approaches often encourage depressed patients to participate in enjoyable situations, yet the new findings suggest that some people may first need to practice allowing themselves to feel any pleasant emotions at all. —T.R.

WHEN UNCERTAINTY HURTS

A need to know is linked with anxiety



Joy is not the only experience that people try to avoid, to their detriment. Many people cannot tolerate the feeling of uncertainty, and according to mounting evidence, this fear affects mood and health.

Intolerance of uncertainty is linked with mental disorders such as anxiety and depression, researchers confirmed in a paper in the June 2013 issue of the *Journal of Clinical Psychology*; their results also revealed a strong link to panic disorder.

People with this fear try to feel more certain with strategies such as excessive checking, planning and reassurance seeking, worry and rumination, and avoidance of unfamiliar situations. Perhaps unsurprisingly, intolerance of uncertainty has been found to be related to obsessive-compulsive disorder and hoarding—although many more people experience subtle symptoms that disrupt quality of life without meeting the diagnostic criteria for a mental disorder.

A combination of therapeutic strategies can help people whose fear of uncertainty is holding them back. One variety of cognitive-behavior therapy, a well-researched method of psychotherapy, targets beliefs about the nature of uncertainty and lack of control, says study co-author James F. Boswell, a research psychologist at Boston University. In a session, “we might challenge assumptions that uncertainty is bad, avoidable, and inevitably leads to negative outcomes,” he suggests. Gradually increasing exposure to uncertainty—such as by eating at a new restaurant without looking up the menu online first—can also help patients learn to manage the distress. Usually the expectation that uncertainty will lead to negative outcomes is proved to be false. “The ultimate goal is learning to experience uncertainty differently,” Boswell says. —T.R.

Are You Afraid of Happiness?

Rate each item from 0 (Not at all like me) to 4 (Extremely like me). The questionnaire is not intended for diagnostic purposes, but a score above 20 may indicate that you have a higher fear of happiness than most people.

1. I am frightened to let myself become too happy.
2. I find it difficult to trust positive feelings.
3. My good feelings never last.
4. I feel I don't deserve to be happy.
5. Feeling good makes me uncomfortable.
6. I don't let myself get too excited about positive things or achievements.
7. When you are happy, you can never be sure that something is not going to hit you out of the blue.
8. I worry that if I feel good something bad could happen.
9. If you feel good, you let your guard down.

MÁGOZ (Illustration); GHISLAIN AND MARIE DAVID DE LOSSY Getty Images (profile); SOURCE: “FEARS OF COMPASSION AND HAPPINESS IN RELATION TO ALEXITHYMIA, MINDFULNESS, AND SELF-CRITICISM,” BY P. GILBERT ET AL., IN *PSYCHOLOGY AND PSYCHOTHERAPY*, VOL. 85, NO. 4; DECEMBER 2012 (questionnaire)



Does brain training work? The evidence is mixed. Now a study finds that our mind-set, among other variables, can determine its effectiveness.

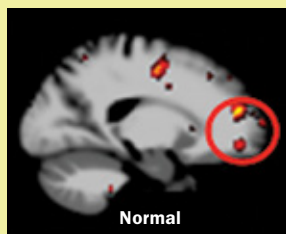
» PSYCHOPATHS' BROKEN EMPATHY CIRCUIT

Social apathy may arise from deficient connections among emotional brain centers

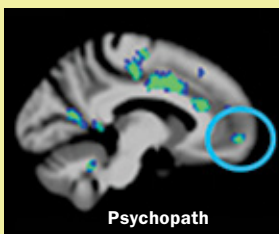
When most of us imagine someone in pain, we feel uncomfortable and want to help. Psychopaths do not: a callousness toward others' suffering is the central feature of a psychopathic personality. Now an imaging study finds that psychopathic inmates have deficits in a key empathy circuit in the brain, pointing to a potential therapeutic target.

Jean Decety, a psychologist at the University of Chicago, and his colleagues used functional MRI to scan the brains of 121 male prison inmates while they looked at photos of a painful moment, such as a foot stepping on a nail or a finger being smashed in a drawer. The inmates were instructed to imagine the scenario happening to themselves or to another person, a perspective-switching technique that easily elicits empathy in most people.

Inmates who scored the highest on a standard psychopathy test showed a normal response in pain perception and brain centers for emotion when imagining the pain for themselves. Yet when asked



Normal



Psychopath

A psychopath's ventromedial prefrontal cortex (circled) is much less coordinated with other empathy areas.

to imagine the scenario happening to others, their brains did not show typical connectivity between the amygdala, an area important for fear and emotional processing, and the ventromedial prefrontal cortex, a region vital for emotion regulation, empathy and morality. Some results even indicated that pleasure regions might have become active instead.

The brain areas that are undercommunicating in psychopathy "are key for experiencing empathetic concern and caring for one another, which is what empathy is all about and what individuals who score high on psychopathy do not have," Decety says. Cognitive therapy may help some psychopaths; he suggests clinicians could measure changes in these faulty connections to home in on the best strategies to stimulate empathy. [For more on psychopathy, see "Inside the Mind of a Psychopath," by Kent A. Kiehl and Joshua W. Buckholz; SCIENTIFIC AMERICAN MIND, September/October 2010.]

—Meredith Knight

» Calling All Amateur Scientists

Citizen science projects finally start exploring the mind

Researchers and the public alike have waxed enthusiastic about citizen science projects, in which professional and amateur scientists collaborate on experiments. And why not? Interested laypeople can engage directly in science, and for scientists like me, the setup provides manpower to tackle otherwise infeasible tasks.

Until recently, prospective citizen astronomers or biologists have had their choice of projects, but few opportunities existed for amateurs interested in the human mind. Now the tide is turning. Here are three mind-related projects, currently enlisting new amateur investigators:



The Small World of Words. This brainchild of Gert Storms and Simon De Deyne of the University of Leuven in Belgium seeks to understand the relations among words. Citizen scientists see a series of words and are asked to name what other words come to mind.

Gathering this information helps researchers determine, for instance, how people's intuitive associations between words change over time. Two decades ago most people's first response to "climate" would be to think "weather." Now around 40 percent say "change." Associations also depend on culture: whereas Americans most commonly say "baseball" in response to "pitch," the British say "football." The lead scientists have built impressive visualization tools for exploring their preliminary results. <http://smallworldofwords.com>



The Baby Laughter Project. Caspar Addyman of Birkbeck, University of London, hopes to discover when babies laugh and why. Parents can fill out a survey about their baby's laughter, and anyone can file a field report on any particular episode in which they saw a baby laugh. As Addyman explained in a recent interview, what babies find funny gives us insight into what they understand about the world around them. <http://babylaughter.net>



VerbCorner. This is my own project, with the Computational Cognitive Science Group at the Massachusetts Institute of Technology. It aims to determine what words mean. You might think the problem is already solved: just look them up in a dictionary! Dictionaries simply define words in terms of other words, however, which themselves are defined in terms of other words, and so on without end.

At the Web site, both volunteers and researchers in my laboratory answer questions designed to elucidate specific aspects of word meaning. As with many citizen science projects, the tasks are gamelike, with badges and points to be earned and fanciful backstories for each series of tasks. <http://gameswithwords.org/VerbCorner> @ gameswithwords

—Joshua K. Hartshorne

For more on citizen science, visit ScientificAmerican.com/citizen-science

COURTESY OF JEAN DECETY (fMRI scans); THINKSTOCK (thought bubble, baby and clippings)

A new study finds that the relatives of people with autism or a personality disorder are much more likely than others to hold creative jobs.



How to Be a Better

artist

My mother is a self-taught painter—one of her watercolors hangs framed in our living room. I, on the other hand, can barely draw a dog. My lack of skill in the visual arts never really bothered me until I had a child. Now, suddenly, the ability to sketch a chicken, horsey or princess on demand has become very important to my toddler (and therefore to me). In reality, the urge to be creative, for most of us, goes far beyond drawing for our children's entertainment. How can I and other aspiring artists become better writers, dancers and craftspeople without signing up for continued? Here is what psychology research and working artists have to say about releasing your inner creator.

#1 Get outside. Spending time camping and hiking boosts creativity, a study in *PLOS ONE* found. Backpackers who were given a 10-item creativity test four days into their trip did about 50 percent better on it than people who were tested before the trek. Neal Overstrom, director of the Nature Lab at the Rhode Island School of Design, has seen firsthand how the lab's trove of fossils, plants and animals affects his students. "The fact that this collection of natural science specimens still inspires students 75 years after the founding of the lab tells me that nature and creativity are intimately linked," he says. "I think most people intuitively understand the restorative value of a walk on the beach or time spent in the woods, but research is showing that humans seem to have an innate affinity for the patterns and forms we find in nature." He adds that even images of nature can evoke positive emotional reactions and reduce stress.

#2 Let your freak flag fly. All of us are weird in our own ways. John Rich, a playwright who teaches creativity at the School of the Art Institute of Chicago, has observed that strangeness can come in handy: "I find that my students who exhibit 'odd' behavior make compelling, creative



work. Their oddness is a result of their making space for an encounter that opens doors to new thinking." Not all artists may agree, but some researchers do: Vanderbilt University psychologists asked people with schizophrenia, control subjects, and people who exhibited some offbeat behavior and speech, such as talking to themselves or holding strange beliefs, to dream up new uses for common household objects and found that the quirky but healthy folks were by far the most creative.

#3 Leave the country. There is a reason the classic scene of a young artist fleeing to Paris to work on his craft is, well, classic—a surprisingly robust body of research suggests that spending time abroad boosts creativity. In one study, merely remembering something they learned about a different culture increased people's ability to creatively solve problems in multiple ways. "As artists, we have to show people the world in a way they can't see themselves," says Stephan Eirik Clark, author of the upcoming novel *Sweetness #9*

(Little, Brown), who teaches creative writing at Augsburg College. "Before you can do this, you have to first see those things that make up your world, even those things that are so easy to overlook. The easiest way to do that is to live in a foreign country because every difference you observe there brings your homeland into stark relief."

#4 Just play. Try not to worry too much about how "good" the art you are creating is. "It keeps you from exploring," says Thomas Arena, an American contemporary artist best known for iconic advertising images he created for Tanqueray gin and Guinness. "I worked for a legend in advertising, Diane Rothschild, who created witty ads for Land Rover. The first day we worked together she said, 'I'm going to say a lot of stupid things. I'd appreciate it if you do the same.'" If being an artist is in part about acting stupid, now *that's* something I can do. The next time I paint a purple birdie at my daughter's request, I'll quit focusing on how goofy the eyes look and just try to have fun. —Sunny Sea Gold

DANIEL HERTZBERG

Filling in the _____

Your brain fills in all kinds of visual gaps

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

Nature abhors a vacuum.

—François Rabelais, 1534
(after Aristotle)

Nature just loves a vacuum.

It's most of the universe.

—Neil deGrasse Tyson, 2013

AN AMAZING FACT: most of what you see is a confabulation of your brain. Sounds hard to believe, right? After all, you are reading this page. So how inaccurate could your visual system be? Well, it is not that our eyes themselves are inaccurate ... just that our brain makes stuff up based on the sparse data it gets from our eyes and then leads you down the garden path.

Let's start with your retina. A terrible imaging device, by any engineer's estimation. So full of design flaws that it is essentially proof positive against intelligent design. The neural circuits that make up the human retina, and the blood vessels that feed them, sit between the eye's lens and the photoreceptors—which lie against the back of the eye. Light must travel through all this semi-transparent machinery before photoreceptors can transduce it into neural signals. How dumb! Shouldn't the photoreceptors lie just behind the lens to meet the incident light without obfuscation? Well, yes. The retinal layout of some animals such as squids and octopuses is indeed organized in this way. Yet because your brain conjures up most of what you see anyway, trivialities such as pristine optical transmission are not that important.

Case in point: you only have high-resolution vision in the very center of your eye—about 0.1 percent of your



YOUR DIRTY LITTLE MIND

Notice the naked nubile young women behind the orange occlusion (as if you hadn't already!)? Turn to page 23 to see the photograph without the masking.

entire visual field. You are *legally blind* to objects more than a finger width or two from the center of your vision. But it doesn't *feel* that way. Instead you perceive your entire visual field as a high-resolution and perfectly formed image that is always in focus: a load of pure baloney provided compliments of your brain. In fact, very near the part of your retina where your photoreceptor density is highest lies a region devoid of sensory cells, in which you are completely blind. It is fascinating and counterintuitive, so let's discuss the illusion that makes you think you see in this

blind spot, as well as several other algorithms used by your brain to achieve filling in. **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.

SCIENTIFIC AMERICAN MIND (orange overlay); GETTY IMAGES (girls on beach)

(Your retina is a terrible imaging device. **So full of design flaws** that it is essentially proof positive against intelligent design.)

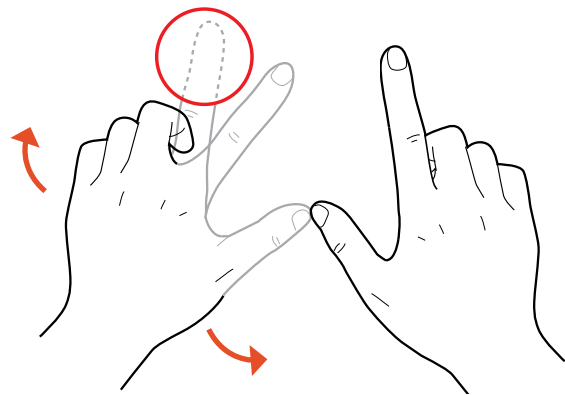
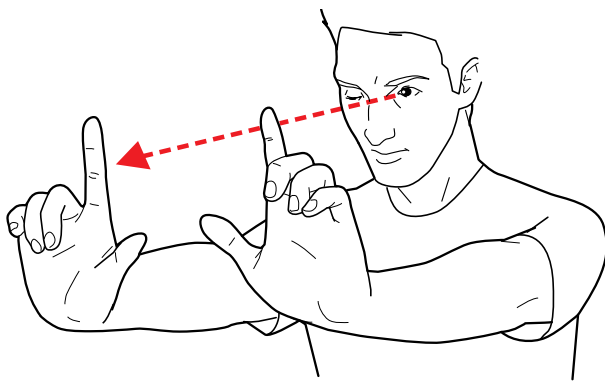
(illusions)

THE BLIND SPOT

You won't be too surprised to learn that your retinal photoreceptors do not communicate visual signals to the brain via radio waves. A bunch of nerve fibers—more than one million individual wires—come bundled in a structure called the optic nerve, which exits the back of your eyeball to connect the retina to the brain. If your photoreceptors pointed toward the front of your eye, as any sensible sensory cell should, the nerve fibers would gather at the back of the eye—behind the photoreceptors—and the optic nerve could leave the eye without disturbing your visual field. Yet in the human retina, the circuits connecting the photoreceptors to the brain congregate toward the middle of the eye, so nerve fibers must dive back down through the retina to form the optic nerve. The result is a spot where no visual image can exist. Even though this spot lies surprisingly near to the center of your retina, you cannot see a hole in your vision, because your brain fills it in.

To prove this to yourself, first read this paragraph completely

and then try this exercise: Hold out your hands at arm's length with elbows straight, thumbs touching, and point your two index fingers straight up [see *Illustration below*]. Close your right eye and look at your right fingertip with your left eye. At the same time, pay close attention to your left fingertip. You will notice that it has disappeared into the blind spot of your left retina (if not, rotate your left wrist up and down while maintaining contact between your two thumbs to see your left fingertip disappear). Once your fingertip is gone, notice that *you can still see what is behind it!* Now be honest with yourself, do you have x-ray vision in your blind spot, or are you blind in your blind spot? Assuming that you agree that you are indeed blind in your blind spot, we can now analyze how the brain fills in the hole to understand how filling in works. Notice that the filled-in area looks like the area immediately surrounding your blind spot: your brain fills in the hole with the nearest visual information available. Yet the algorithm is not smart enough to fill in your finger.

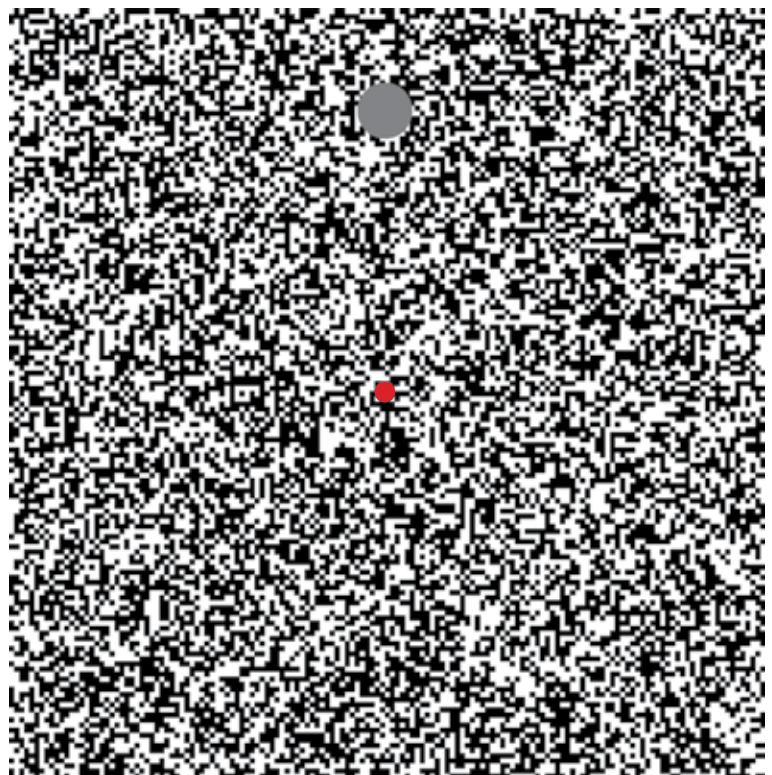


DYNAMIC FILLING IN

In this demonstration, the observer fixates his or her gaze on a small, red spot within a field of noise (for instance, the snow on a television when there is no cable link) while paying attention to a solid gray area—with the same average brightness of the black and white dots. After a few seconds of steady visual fixation, the gray area fills in with the surrounding noise and becomes indistinguishable from the background. This phenomenon is remarkable in that it shows that the brain not only fills in static patterns but can also simulate dynamic changes. Interestingly, there is no real reason why the brain should fill in the gray area in the first place. There is actually a physical gray spot in the visual field (rather than a hole in the retina). The fact that filling in happens in such conditions suggests that the visual system must regularly analyze the visual field for anomalies and fills them in just in case they are errors.

To experience this illusion, go to <http://smc.neuralcorrelate.com/illusions-and-demos/dynamic-filling-in>

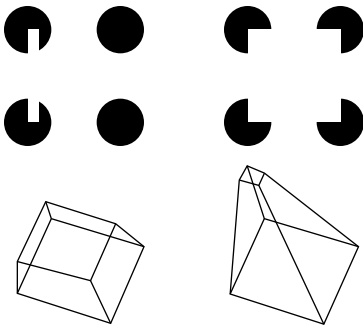
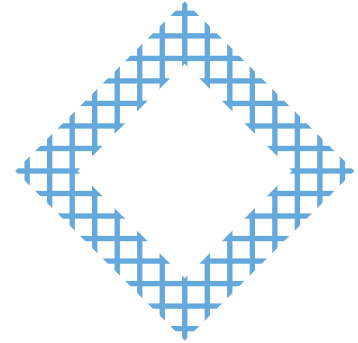
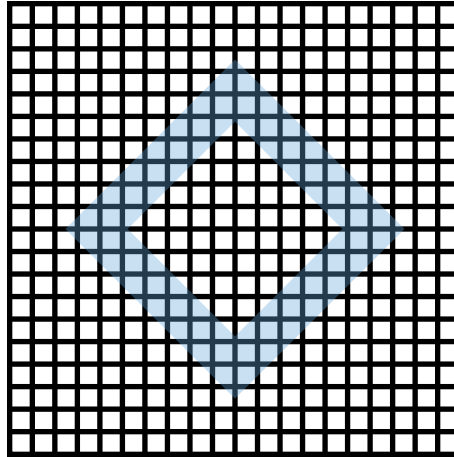
Alternatively, tune your TV to a field of flickering noise and stick to the screen a fixation target (a little corner of a Post-It will do) and a small square (about the size of your thumbnail) of newspaper (use some tape on the back of the square that you can easily remove afterward). The fixation target and the gray square should be four to five inches apart, and your eyes should be at about arm's length from the TV screen, where you can see both the fixation target and gray square easily. Now hold your gaze still on the fixation target and watch the square fill in with the surrounding noise.



JASON LEE (top); COURTESY OF HÉCTOR RIEIRO (bottom)

NEON COLOR SPREADING

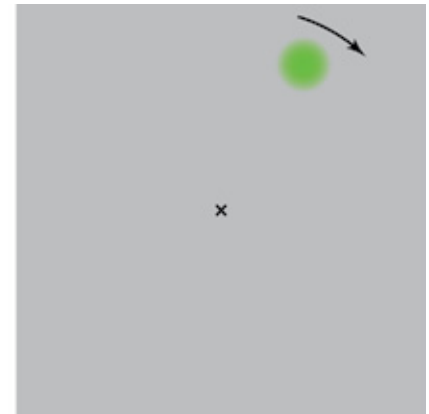
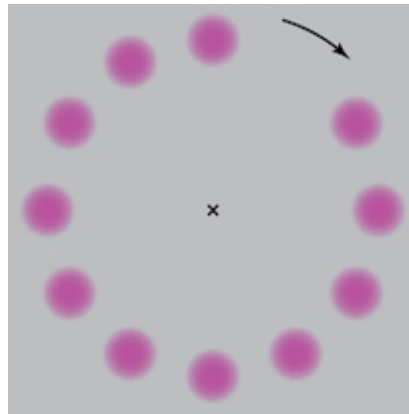
The brain can fill in color information even if no gap is apparent. H.F.J.M. van Tuijl's neon color spreading effect shows an illusory blue field that appears to emanate from a grid of blue crisscrossing lines (embedded in a larger black grid), like glare from a neon light. The illusion is attenuated when the blue grid stands alone against a white background.



FILLING IN BY MORPHING

Neuroscientist Peter U. Tse of Dartmouth College discovered that two similar, but different, two-dimensional or three-dimensional objects presented in sequence can appear to transform (morph) into each other and that the brain fills in the "missing frames" with illusory motion between the two physical shapes. Instead of two objects, your brain provides you with the perception of a single object changing shape and position in space.

See the demonstrations at www.dartmouth.edu/~peterutse/tamdemo2a.htm and www.dartmouth.edu/~peterutse/tamdemo3d.htm



LILAC CHASER

This illusion consists of a rotating gap in a circular array of lilac dots over a gray field. When you fix your gaze on the center of the display, the dots fade because of visual adaptation, and what emerges is a single rotating green dot (lilac's opposing color) that does not actually exist. The brain fills in the places occupied by the lilac dots with the gray field around them, but it is still subject to the opposing-color afterimage that each faded lilac dot generates.

See an interactive demonstration of this effect at www.michaelbach.de/ot/col_lilacChaser



Apparently your mind was in the gutter because in reality the women are wearing bathing suits and only appeared to be naked because that is what your crude mind expected you to see.

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- **Perceptual Filling in of Artificially Induced Scotomas in Human Vision.** V. S. Ramachandran and R. L. Gregory in *Nature*, Vol. 350, pages 699–702; April 25, 1991.
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Psychiatry's New Surgeons

Brain-stimulation procedures for psychiatric disorders are on the rise. Should we be concerned?

BY CARL ERIK FISHER

AFTER 22 YEARS of failed treatments, including rehabilitation, psychotherapy and an array of psychiatric medications, a middle-aged Dutch man decided to take an extraordinary step to fight his heroin addiction. He underwent an experimental brain surgery called deep brain stimulation (DBS). At the University of Amsterdam, researchers bored small holes in his skull and guided two long, thin probes deep into his head. The ends of the probes were lined with small electrodes, which were positioned in his nucleus accumbens, a brain area near the base of the skull that is associated with addiction.

The scientists ran the connecting wires under his scalp, behind his ear and down to a battery pack sewn under the skin of his chest. Once turned on, the electrodes began delivering constant electrical pulses, much like a pacemaker, with the goal of altering the brain circuits thought to be causing his drug cravings. At first the stimulation intensified his desire for heroin, and he almost doubled his drug intake. But after the researchers adjusted the pulses, the cravings diminished, and he drastically cut down his heroin use.

Neurosurgeries are now being pursued for a variety of mental illnesses. Initially developed in the 1980s to treat movement disorders, including Parkinson's disease, DBS is today used to treat depression, dementia, obsessive-compulsive disorder, substance abuse and even obesity. Despite several success stories, many of these new ventures have attracted critics, and some skeptics have even called for an outright halt to this research.

One major misgiving is that recent applications may be outpacing their scientific support. Unlike the cautious early investigations of DBS for depression, carried out by neurologist Helen Mayberg of Emory University and her colleagues, the latest trials have been con-



ducted less meticulously. Although these procedures are often considered low risk, as Mayberg once pointed out, “there is no such thing as minor brain surgery.”

Psychosurgery's Legacy

Lobotomies are perhaps the most infamous example of “psychosurgery.” This procedure, which involved cutting the connections between different parts of the brain, has always been controversial. Only in the 1970s did concerns about its misuse drive these surgeries to extinction in the U.S. Similar techniques, such as freezing or cutting certain brain areas, persisted in China and Russia at least through the early 2000s.

DBS seems more palatable than these gruesome-sounding methods and rightly so. It is more precise: electrodes are guided to within a millimeter of their target to stimulate a specific brain area. DBS is

also considered reversible because the electrical stimulation can easily be turned off. The risks of this procedure—including brain hemorrhage, infection or even death—are dire but uncommon.

The first brain area targeted for depression was chosen after years of painstaking neuroimaging research, but recent advancement in DBS has come as much from luck as from planning. Consider, for example, the serendipitous manner in which it was discovered that DBS might treat addiction. In 2006 psychiatrist Jens Kuhn of the University of Cologne in Germany and his colleagues tried DBS on a patient with a particularly bad case of panic disorder. The man's anxiety did not change, but he reduced his alcohol intake considerably without intending to do so. The researchers realized that in other experiments, stimulation to the same brain region, the nucleus accumbens, had also

RICHARD MIA

led to unintended, spontaneous reductions in drinking and smoking. Soon researchers were testing DBS on cocaine- and morphine-dependent rats, and in the past few years scattered reports of DBS for people with drug and alcohol problems have also emerged.

Other unintended side effects have also spurred new uses of this poorly understood technology. The case of obesity is instructive here. Despite not being a traditional mental disorder, obesity has become an enticing target for DBS. In 2013 neurosurgeon Donald Whiting of the

broaden its use so quickly, and they call for further studies in animal models and in better-understood conditions first. The selection of some stimulation sites, as in the Alzheimer's and addiction trials, has been driven not by theory so much as happenstance. Even the fundamental mechanisms of DBS remain elusive. Initially researchers thought that it produced the equivalent of a lesion by deactivating brain areas, but it is now clear that the effects are more complicated.

The quality of the trials themselves

cedure—so perhaps it is no surprise that he went on to fiddle with his device.

Ultimately the reason we do experiments at all is because questions remain about whether new techniques and technologies truly work. Case reports may not seem dangerous, especially when the procedure seems effective. Yet using DBS outside of careful clinical trials might obscure unknown risks or side effects, such as more subtle changes to someone's thinking or behavior. Further, successful trials are more likely to be published while unknown numbers of failed at-

(He was overtaken by memories from 30 years prior. When the stimulation increased his **recollections became more intense.**)

West Penn Allegheny Health System and his colleagues reported that by stimulating the lateral hypothalamic area (the “feeding center” of the brain) of three people with intractable obesity, they could reduce their patients' urge to eat. Two of the three participants lost a significant amount of weight during the two-year study.

At a different institution, DBS failed to help another man with obesity. Yet he experienced a surprising side effect as soon as the electrodes were turned on. Suddenly, he was overtaken by vivid memories from 30 years prior, and when the stimulation was increased his recollections became more intense. This man did not lose any weight (in part because he turned the device off at night to binge), but his experience made investigators curious about how stimulation might enhance memory. Now a larger experiment is under way to see if DBS can help reverse the effects of Alzheimer's disease. In this case, one man's unsuccessful surgery opened up a new avenue of research, but one could imagine a scenario in which the retrieval of painful memories brings back old trauma. Such potential risks underscore the uncertainty inherent to DBS today.

Cause for Caution

Indeed, some bioethicists contend that not enough is known about DBS to

has also come into question. Recently single-person case reports have proliferated, which are less useful than larger, placebo-controlled clinical studies. The device maker Medtronic contributed to this trend when it obtained a “Humanitarian Device Exemption” from the Food and Drug Administration, which permits the company to apply DBS to obsessive-compulsive disorder. In doing so, Medtronic sidestepped the FDA's usual channels, which would have required more rigorous experiments to establish DBS's effectiveness for this illness.

A leading concern with this piecemeal approach is that it is not clear which patients are best suited to psychiatric DBS. In several cases, patients chose to receive a stimulator before they had tried all other treatments that might have assuaged their conditions. For example, the obese man who turned off his implant so that he could binge had declined bariatric surgery—in fact, he had justified his decision by arguing that he would continue to overeat after the pro-

tempts go unreported, skewing our scientific understanding. The incentive to develop new psychiatric treatments is enormous—approximately 50 percent of people will meet criteria for a psychiatric disorder at some point in their life—but sound science must counterbalance this drive to expand DBS.

One last example: Spanish investigators recently used DBS in six people with intellectual disabilities to curtail their out-of-control aggressiveness. The intention was to prevent harmful behavior. Yet conducting brain surgery on individuals with mental disabilities will very likely alarm the public no matter the circumstances. The promise of psychiatric DBS is immense, but considering psychosurgery's dubious past, today's practitioners must proceed with caution. **M**

CARL ERIK FISHER is a psychiatrist in the division of law, ethics and psychiatry at Columbia University. He teaches in the university's masters of bioethics program.

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Ubiquitous Minds

Panpsychism, the ancient doctrine that consciousness is universal, offers some lessons in how to think about subjective experience today

BY CHRISTOF KOCH



For every inside there is an outside, and for every outside there is an inside; though they are different, they go together.

—Alan Watts, *Man, Nature, and the Nature of Man*, 1991

I GREW UP IN A DEVOUT and practicing Roman Catholic family with Purzel, a fearless and high-energy dachshund. He, as with all the other, much larger dogs that subsequently accompanied me through life, showed plenty of affection, curiosity, playfulness, aggression, anger, shame and fear. Yet my church teaches that whereas animals, as God's creatures, ought to be treated well, they do not possess an immortal soul. Only humans do. Even as a child, to me this belief felt intuitively wrong. These gorgeous creatures had feelings, just like I did. Why deny them? Why would God resurrect people but not dogs? This core Christian belief in human exceptionalism did not make any sense to me. Whatever consciousness and mind are and no matter how they relate to the brain and the rest of the body, I felt that the same principle must hold for people and dogs and, by extension, for other animals as well.

It was only later, at university, that I became acquainted with Buddhism and its emphasis on the universal nature of mind. Indeed, when I spent a week with His Ho-

liness the Dalai Lama earlier in 2013 [see "The Brain of Buddha," *Consciousness Redux*; *SCIENTIFIC AMERICAN MIND*, July/August 2013], I noted how often he talked about the need to reduce the suffering of "all living beings" and not just "all people." My readings in philosophy brought me to panpsychism, the view that mind (*psyche*) is found everywhere (*pan*). Panpsychism is one of the oldest of all philosophical doctrines extant and was put forth by the ancient Greeks, in particular Thales of Miletus and Plato. Philosopher Baruch Spinoza and mathematician and universal genius Gottfried Wilhelm Leibniz, who laid down the intellectual foundations for the Age of Enlightenment, argued for panpsychism, as did philosopher Arthur Schopenhauer, father of American psychology William James, and Jesuit paleontologist Teilhard de Chardin. It declined in popularity with the rise of positivism in the 20th century.

As a natural scientist, I find a version of panpsychism modified for the 21st century to be the single most elegant and parsimonious explanation for the universe I find myself in. There are three broad reasons why panpsychism is appealing to the modern mind.

We Are All Nature's Children

The past two centuries of scientific progress have made it difficult to sus-

tain a belief in human exceptionalism.

Consider my Bernese mountain dog, Ruby, when she yelps, whines, gnaws at her paw, limps and then comes to me, seeking aid: I infer that she is in pain because under similar conditions I behave in similar ways (sans gnawing). Physiological measures of pain confirm this inference—injured dogs, just like people, experience an elevated heart rate and blood pressure and release stress hormones into their bloodstream. I'm not saying that a dog's pain is exactly like human pain, but dogs—as well as other animals—not only react to noxious stimuli but also consciously experience pain.

All species—bees, octopuses, ravens, crows, magpies, parrots, tuna, mice, whales, dogs, cats and monkeys—are capable of sophisticated, learned, nonstereotyped behaviors that would be associated with consciousness if a human were to carry out such actions. Precursors of behaviors thought to be unique to people are found in many species. For instance, bees are capable of recognizing specific faces from photographs, can communicate the location and quality of food sources to their sisters via the waggle dance, and can navigate complex mazes with the help of cues they store in short-term memory (for instance, "after arriving at a fork, take the exit marked

by the color at the entrance”). Bees can fly several kilometers and return to their hive, a remarkable navigational performance. And a scent blown into the hive can trigger a return to the site where the bees previously encountered this odor. This type of associative memory was famously described by Marcel Proust in *À la Recherche du Temps Perdu*. Other animals can recognize themselves, know when their conspecifics observe them, and can lie and cheat.

have bigger brains. Only an expert neuroanatomist, armed with a microscope, can tell a grain-size piece of cortex of a mouse from that of a monkey or a human. Biologists emphasize this structural and behavioral continuity by distinguishing between *nonhuman* and *human* animals. We are all nature’s children.

Given the lack of a clear and compelling Rubicon separating simple from complex animals and simple from complex behaviors, the belief that only hu-

man of consciousness in the sense that it feels like *something* to be that system. If the system falls apart, consciousness ceases to be; it doesn’t feel like anything to be a broken system. And the more complex the system, the larger the repertoire of conscious states it can experience.

My subjective experience (and yours, too, presumably), the Cartesian “I think, therefore I am,” is an undeniable certainty, one strong enough to hold the weight of philosophy. But from whence does

(The past two centuries of scientific progress have made it difficult to sustain a belief in **human exceptionalism.**)

Some people point to language and the associated benefits as being the unique defining feature of consciousness. Conveniently, this viewpoint rules out all but one species, *Homo sapiens* (which has an ineradicable desire to come out on top), as having sentience. Yet there is little reason to deny consciousness to animals, preverbal infants [see “The Conscious Infant,” *Consciousness Redux*; *SCIENTIFIC AMERICAN MIND*, September/October 2013] or patients with severe aphasia, all of whom are mute.

None other than Charles Darwin, in the last book he published, in the year preceding his death, set out to learn how far earthworms “acted consciously and how much mental power they displayed.” Studying their feeding and sexual behaviors for several decades—Darwin was after all a naturalist with uncanny powers of observation—he concluded that there was no absolute threshold between lower and higher animals, including humans, that assigned higher mental powers to one but not to the other.

The nervous systems of all these creatures are highly complex. Their constitutive proteins, genes, synapses, cells and neuronal circuits are as sophisticated, variegated and specialized as anything seen in the human brain. It is difficult to find anything exceptional about the human brain. Even its size is not so special, because elephants, dolphins and whales

are capable of experiencing anything consciously seems preposterous. A much more reasonable assumption is that until proved otherwise, many, if not all, multicellular organisms experience pain and pleasure and can see and hear the sights and sounds of life. For brains that are smaller and less complex, the creatures’ conscious experience is very likely to be less nuanced, less differentiated and more elemental. Even a worm has perhaps the vaguest sense of being alive. Of course, each species has its own unique sensorium, matched to its ecological niche. Not every creature has ears to hear and eyes to see. Yet all are capable of having at least some subjective feelings.

The Austere Appeal of Panpsychism

Taken literally, panpsychism is the belief that everything is “enminded.” All of it. Whether it is a brain, a tree, a rock or an electron. Everything that is physical also possesses an interior mental aspect. One is objective—accessible to everybody—and the other phenomenal—accessible only to the subject. That is the sense of the quotation by British-born Buddhist scholar Alan Watts with which I began this essay.

I will defend a narrowed, more nuanced view: namely that any complex system, as defined below, has the basic attributes of mind and has a minimal amount

this experience come? Materialists invoke something they call emergentism to explain how consciousness can be absent in simple nervous systems and emerge as their complexity increases. Consider the wetness of water, its ability to maintain contact with surfaces. It is a consequence of intermolecular interactions, notably hydrogen bonding among nearby water molecules. One or two molecules of H₂O are not wet, but put gazillions together at the right temperature and pressure, and wetness emerges. Or see how the laws of heredity emerge from the molecular properties of DNA, RNA and proteins. By the same process, mind is supposed to arise out of sufficiently complex brains.

Yet the mental is too radically different for it to arise gradually from the physical. This emergence of subjective feelings from physical stuff appears inconceivable and is at odds with a basic precept of physical thinking, the Ur-conservation law—*ex nihilo nihil fit*. So if there is nothing there in the first place, adding a little bit more won’t make something. If a small brain won’t be able to feel pain, why should a large brain be able to feel the god-awfulness of a throbbing toothache? Why should adding some neurons give rise to this ineffable feeling? The phenomenal hails from a kingdom other than the physical and is subject to different laws. I see no way for

(consciousness redux)

the divide between unconscious and conscious states to be bridged by bigger brains or more complex neurons.

A more principled solution is to assume that consciousness is a basic feature of certain types of so-called complex systems (defined in some universal, mathematical manner). And that complex systems have sensation, whereas simple systems have none. This reasoning is analogous to the arguments made by savants studying electrical charge in the 18th century. Charge is not an emer-

Internet or the United States of America? Furthermore, panpsychism does not explain why a healthy brain is conscious, whereas the same brain, placed inside a blender and reduced to goo, would not be. That is, it does not explain how aggregates combine to produce specific conscious experience.

Integrated Panpsychism

These century-old arguments bring me to the conceptual framework of the integrated information theory (IIT) of

derlying this unity of consciousness is a multitude of causal interactions among the relevant parts of your brain. If parts of the brain become fragmented and balkanized, as occurs in deep sleep or in anesthesia, consciousness fades.

To be conscious, then, you need to be a single, integrated entity with a large repertoire of highly differentiated states. Even if the hard disk on my laptop exceeds in capacity my lifetime memories, none of its information is integrated. The family photos on my Mac are not

(A healthy brain is conscious, whereas the same brain, placed inside a blender and **reduced to goo**, would not be.)

gent property of living things, as originally thought when electricity was discovered in the twitching muscles of frogs. There are no uncharged particles that in the aggregate produce an electrical charge. Elementary particles either have some charge, or they have none. Thus, an electron has one negative charge, a proton has one positive charge and a photon, the carrier of light, has zero charge. As far as chemistry and biology are concerned, charge is an intrinsic property of these particles. Electrical charge does not emerge from non-charged matter. It is the same, goes the logic, with consciousness. Consciousness comes with organized chunks of matter. It is immanent in the organization of the system. It is a property of complex entities and cannot be further reduced to the action of more elementary properties. We have reached the ground floor of reductionism.

Yet, as traditionally conceived, panpsychism suffers from two major flaws. One is known as the problem of aggregates. Philosopher John Searle of the University of California, Berkeley, expressed it recently: “Consciousness cannot spread over the universe like a thin veneer of jam; there has to be a point where my consciousness ends and yours begins.” Indeed, if consciousness is everywhere, why should it not animate the iPhone, the

psychiatrist and neuroscientist Giulio Tononi of the University of Wisconsin–Madison. It postulates that conscious experience is a fundamental aspect of reality and is identical to a particular type of information—integrated information. Consciousness depends on a physical substrate but is not reducible to it. That is, my experience of seeing an aquamarine blue is inexorably linked to my brain but is different from my brain.

Any system that possesses some non-zero amount of integrated information experiences something. Let me repeat: any system that has even one bit of integrated information has a very minute conscious experience.

IIT makes two principled assumptions. First, conscious states are highly differentiated; they are informationally very rich. You can be conscious of an uncountable number of things. Think of all the frames from all the movies that you have ever seen or that have ever been filmed or that will be filmed! Each frame, each view, is a specific conscious percept.

Second, each such experience is highly integrated. You cannot force yourself to see the world in black and white; its color is an integrated part of your view. Whatever information you are conscious of is wholly and completely presented to your mind; it cannot be subdivided. Un-

linked to one another. The computer does not know that the boy in those pictures is my son as he matures from a toddler to an awkward teenager and then a graceful adult. To my computer, all information is equally meaningless, just a vast, random tapestry of 0s and 1s. Yet I derive meaning from these images because my memories are heavily cross-linked. And the more interconnected, the more meaningful they become.

These ideas can be precisely expressed in the language of mathematics using notions from information theory such as entropy. Given a particular brain, with its neurons in a particular state—these neurons are firing while those ones are quiet—one can precisely compute the extent to which this network is integrated. From this calculation, the theory derives a single number, Φ (pronounced “f”) [see “A Theory of Consciousness,” *Consciousness Redux*; *SCIENTIFIC AMERICAN MIND*, July/August 2009]. Measured in bits, Φ denotes the size of the conscious repertoire associated with the network of causally interacting parts being in one particular state. Think of Φ as the synergy of the system. The more integrated the system is, the more synergy it has and the more conscious it is. If individual brain regions are too isolated from one another or are interconnected at random, Φ will

be low. If the organism has many neurons and is richly endowed with synaptic connections, Φ will be high. Basically, Φ captures the quantity of consciousness. The quality of any one experience—the way in which red feels different from blue and a color is perceived differently from a tone—is conveyed by the informational geometry associated with Φ . The theory assigns to any one brain state a shape, a crystal, in a fantastically high-dimensional qualia space. This crystal is the system viewed from within. It is the voice in the head, the light inside the skull. It is everything you will ever know of the world. It is your only reality. It is the quiddity of experience. The dream of the lotus eater, the mindfulness of the meditating monk and the agony of the cancer patient all feel the way they do because of the shape of the distinct crystals in a space of a trillion dimensions—truly a beatific vision. The water of integrated information is turned into the wine of experience.

Integrated information makes very specific predictions about which brain circuits are involved in consciousness and which ones are peripheral players (even though they might contain many more neurons, their anatomical wiring differs). The theory has most recently been used to build a consciousness meter to assess, in a quantitative manner, the extent to which anesthetized subjects or severely brain-injured patients, such as Terri Schiavo, who died in Florida in 2005, are truly not conscious or do have some conscious experiences but are unable to signal their pain and discomfort to their loved ones [see “A Consciousness Meter,” *Consciousness Redux*; *SCIENTIFIC AMERICAN MIND*, March/April 2013].

IIT addresses the problem of aggregates by postulating that only “local maxima” of integrated information exist (over elements and spatial and tempo-

ral scales): my consciousness, your consciousness, but nothing in between. That is, every person living in the U.S. is, self by self, conscious, but there is no su-



In this map of the Internet, different colors indicate different countries and domains. Although the Internet contains 10,000 times as many transistors as one human brain, it is unknown whether its connections are integrated enough to allow a sense of feeling or consciousness to emerge.

perordinate consciousness of the U.S. population as a whole.

Unlike classical panpsychism, not all physical objects have a Φ that is different from zero. Only integrated systems do. A bunch of disconnected neurons in a dish, a heap of sand, a galaxy of stars or a black hole—none of them are integrated. They have no consciousness. They do not have mental properties.

Last, IIT does not discriminate between squishy brains inside skulls and silicon circuits encased in titanium. Provided that the causal relations among the circuit elements, transistors and other logic gates give rise to integrated information, the system will feel like something. Consider humankind’s larg-

est and most complex artifact, the Internet. It consists of billions of computers linked together using optical fibers and copper cables that rapidly instantiate specific connections using ultrafast communication protocols. Each of these processors in turn is made out of a few billion transistors. Taken as a whole, the Internet has perhaps 10^{19} transistors, about the number of synapses in the brains of 10,000 people. Thus, its sheer number of components exceeds that of any one human brain. Whether or not the Internet today feels like something to itself is completely speculative. Still, it is certainly conceivable.

When I talk and write about panpsychism, I often encounter blank stares of incomprehension. Such a belief violates people’s strongly held intuition that sentience is something only humans and a few closely related species possess. Yet our intuition also fails when we are

first told as kids that a whale is not a fish but a mammal or that people on the other side of the planet do not fall off because they are upside down. Panpsychism is an elegant explanation for the most basic of all brute facts I encounter every morning on awakening: there is subjective experience. Tononi’s theory offers a scientific, constructive, predictive and mathematically precise form of panpsychism for the 21st century. It is a gigantic step in the final resolution of the ancient mind-body problem. **M**

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“JUST FRIENDS”

▶ CAN MEN AND WOMEN BE FRIENDS?

ATTRACTION PLAYS A SIGNIFICANT ROLE IN OPPOSITE-SEX FRIENDSHIP, BUT THAT DOESN'T MAKE THE BOND ANY LESS BENEFICIAL

BY CARLIN FLORA

Kate and Dan met on the job in Boston, when they were in their early 20s. He thought she was attractive; she thought he was an arrogant jerk. At a work party, it came out that both had lost a parent in recent years, and a mutual feeling of “you must really get me” washed over them. A few years later, when they both found themselves in New York and single, the friendship ramped way up, into multiple-phone-calls-per-day, soul-baring, belly-laughing territory.

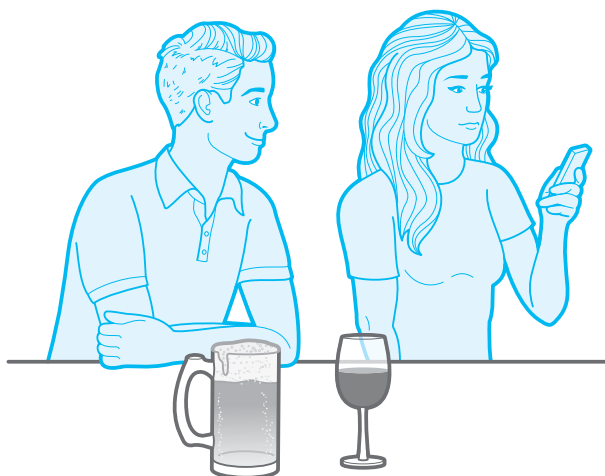
ILLUSTRATIONS BY BROWN BIRD DESIGN



It is that feeling that someone truly understands us that lends friendship its power to ward off existential loneliness. Kate and Dan share it, yet their brand of friendship is often seen as suspect—as less than pure and true. Friendships between people who could conceivably date come with built-in suspense for on-lookers: Will they get together, or won't they?

For philosophers and scientists alike, friendship has proved as difficult to pin down as love. And don't we, after all, love our close friends? Ancient Greek philosopher Aristotle and French essayist Michel de Montaigne in the 16th century felt that true friendship could exist only between virtuous men—holding up a high yet subjective bar that also happened to avoid women altogether. Plato, who lent his name to the term “platonic relationship” (or “platonic love”), described love as a window on true beauty, best kept free of venereal pursuits. Contemporary usage equates platonic relationships with amity rather than love, yet the origin of the term underscores friendship's multifaceted nature. All friendships begin with a spark of mutual attraction, and sometimes that attraction extends to the physical.

In the scientific literature, many scholars have settled on a definition for friendship that was coined by psychologist Robert Hays of the University of California, San Francisco. He described the bond as “a voluntary interdependence between two persons over time that is intended to facilitate socioemotional goals of the participants and may involve varying types and degrees of companionship, intimacy, affection and mutual assistance.” Depending on those “types and degrees,” friendship can look an awful lot like courtship or love. This raises the question: Can hetero-



Almost half of cross-sex friends experience romantic attraction at some point, so the potential for unrequited feelings is high.

sexual men and women be just friends, or is there always an inkling of desire?

The data suggest that a romantic spark is not uncommon among friends. Yet the truth is that all forms of companionship are complicated. We often shift our behaviors to try to nudge a relationship one way or another. Our actions only sometimes reflect the disinterested care and concern we assume must characterize an ideal friendship. Even so, romantic or sexual attraction between two friends can be a bonus—a sign of one's social worth—rather than a flaw.

The Rise of Opposite-Sex Friendship

The question of whether men and women can be friends is relatively new, as is research into the dynamics of cross-sex friendships. (Scientific insights into homosexual same-sex friendship are even more scant, so this article will deal primarily with attraction between heterosexual friends of the opposite sex.)

Male-female friendship received its first big break from the feminist movement of the 1960s, which placed men and women on more equal ground in social and work situations. In addition to creating more opportunities for the sexes to interact, the changing social order made men and women more compatible as friends. We overwhelmingly choose friends who resemble us in attitudes and behaviors. It follows that when women and men occupied different and unequal spheres of life, they had less in common and thus were less likely to be close pals.

In the half a century since those social changes set in, opposite-sex friendships have become increasingly common. In 2002, for example, *American Demographics* magazine found that at the time of their survey, 18- to 24-year-olds were nearly four times as likely as people older than 55 to have a best friend of the opposite sex. More recent research also documents the historical novelty of male-female friendships. In a 2012 study psychologist April Bleske-Rechek of the University of Wisconsin–Eau Claire asked college students how many of them had friends of the opposite sex—nearly all did. Compare that with what sociologist Rebecca G. Adams of the University of North Carolina at Greensboro found in 1985, when she asked 70 female senior citizens the same question: fewer than 4 percent of their friends were male.

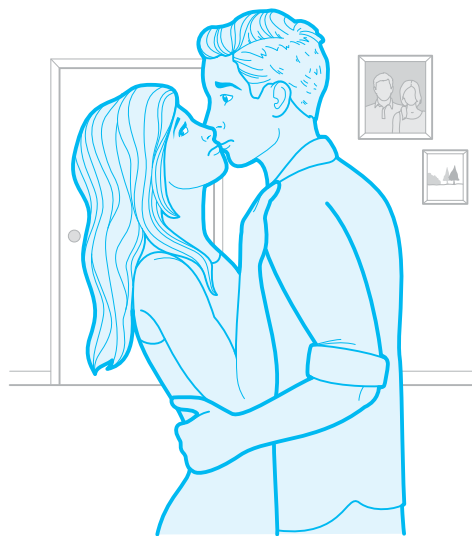
Certain types of men and women are more likely to have

FAST FACTS

FRIENDLY ATTRACTION

- 1 An inkling of romantic or sexual attraction is common between heterosexual opposite-sex friends.
- 2 Yet the friendship is not necessarily weaker or less legitimate as a result.
- 3 Opposite-sex friendships offer unique benefits, including insight into how the other gender thinks, and contribute to our mental and physical well-being.

more cross-sex friends. In a 2003 study Heidi Reeder, a communications professor at Boise State University, found that “feminine” men and “masculine” women (as measured by the Bem Sex Role Inventory) had a significantly higher proportion of cross-sex friendships than did “masculine” men and “feminine” women. The inventory is based on traditional sex roles, wherein subjects describing themselves as very “warm” or “sensitive,” for example, would score as more “feminine” than those describing themselves as “aggressive” and “analytical.” The interpretation is simple: whatever our sex, we prefer friends who are just like us.



An awkward encounter need not doom a friendship. Pals should reaffirm the importance of their bond and tone down flirtatious behavior.

with feeling less satisfied with their romantic partner. Widespread press coverage trumpeted the implication that men and women cannot be platonic, even if they are not having sex. Yet it is important to note that friendships persisted *in spite of* romantic or sexual attraction—quite the opposite conclusion.

Attraction is the basis of all friendship, and the carnal variety is common but not ubiquitous. Reeder analyzed hundreds of interview transcripts of people reflecting on their closest friend of the other gender and identified four types of attraction among the individuals. Almost all respondents reported feeling “friendship attraction,” that emotional resonance that Dan and

Justified Doubt of “Just Friends”

With the data clearly indicating that male-female friendship is thriving, perhaps it is time to abandon the old trope that men and women can’t be “just friends.” Yet the idea has persisted for the simple reason that attraction can cause boundaries to blur. Consider, for example, one rare high-profile opposite-sex friendship from the late 1940s, when the young, religious and Southern Flannery O’Connor met the older, WASPy Robert Lowell at a retreat in upstate New York. Lowell brought O’Connor around to literary parties in Manhattan, with his fiancée also in tow. As O’Connor reportedly once wrote to a friend about Lowell, “I feel almost too much about him to be able to get to the heart of it.... He is one of the people I love.”

Psychological research has also documented the ambiguity of many cross-sex friendships. In 2000 psychologist Walid Afifi, then at Pennsylvania State University, surveyed 315 college students and found that approximately half had engaged in sexual activity with an otherwise platonic friend. In a 2012 study Bleske-Rechek and her colleagues asked 88 pairs of opposite-sex college-age friends about their friendship. They also sent questionnaires probing the pros and cons of opposite-sex friendships to 107 people between the ages of 18 and 23 and to 322 adults aged 27 to 55. In general, the men reported feeling slightly more attracted to their female friends than vice versa. Across age groups, participants described the friendships as beneficial overall, although they—and women in particular—tended to consider attraction a cost. For young women and for both sexes in the sample of older subjects, more attraction to their closest friend was associated

Kate experienced once they shared their family histories. Only 14 percent reported “current romantic attraction,” defined as the desire to become a couple, although almost half said they had felt it earlier in the friendship. One third felt “subjective physical/sexual attraction,” which is a physical urge without a yearning for a serious partnership, and just more than 50 percent reported “objective physical/sexual attraction,” meaning they could see why others found their friend attractive even if they were not thus charmed. In short, the odds are pretty good that an opposite-sex friend did, or does, feel some pull toward the prurient.

The Myth of Pure Friendship

With attraction abundant, the question becomes: So what? Skeptics of male-female friendship argue that if one person in the pair wants romance, the friendship is not truly platonic. With emotional skullduggery afoot, a pal’s trustworthiness and dependability are thrown into question. Yet this argument oversimplifies the nature of friendship.

First, friends regularly factor into mating goals. Peers can introduce us to a potential partner, help evaluate who is a good match and instruct us in the social nuances that support romantic overtures. “Evolved mating strategies are operating in the

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background of any relationship,” Bleske-Rechek says. “But that doesn’t mean we can’t have constructive friendships with people we can count on.”

Some might argue that currying favor with an opposite-sex pal in the hope of kindling a physical relationship is not in keeping with the tenets of friendship. Yet this kind of behavior is common among companions. Without even noticing it, people routinely adjust their behavior to manipulate how their nearest and dearest feel about them. You might become more diligent about doing the dishes to maintain a peaceful environment at home. Or you might spend extra time composing a witty e-mail to a same-sex friend because you want to preserve that person’s respect and admiration. “The idea that there is ‘pure’ friendship on one hand and friendship with an ulterior motive on the other is false and silly,” Bleske-Rechek says.

Indeed, the bulk of our friendships are imperfect in one way or another. About half of a person’s social network is typically made up of ambivalent ties, according to work published in 2009 by psychologists Julianne Holt-Lunstad of Brigham Young University and Bert Uchino of the University of Utah. These are people we are reluctant to give up but who can be unpredictable or irritating. Such friendships extract a physical toll, as the researchers learned after having 107 study participants wear blood pressure monitors. When the subjects interacted with ambivalent friends, their blood pressure spiked higher than when they were with people whom they flat out did not like. Friendships come in many forms, and only a few of them live up to the ideal of selfless, supportive confidantes.

Dealing with Challenges

The stress and uncertainty that romantic attraction brings to burgeoning friendships are not altogether different from the stress and uncertainty of any developing relationship, points out Geoffrey Greif, a professor of social work at the University of Maryland. “When you’re beginning a same-sex friendship, you have to evaluate: ‘How am I going to pursue him? If I invite him to watch the Super Bowl and he says no, do I invite him to a movie some other time?’ You’re always trying to gauge the other person’s interest.” As to whether or not one should



Boundaries inevitably shift when a best friend falls in love. To avoid feeling left out, invest more in developing other friendships.

confess a desire for a romantic relationship with a friend, Greif recommends asking yourself if you will be unhappy a few years down the road should the person settle down with someone else.

To study the repercussions of such a baring of the soul, Reeder looked at the aftermath of friends’ bold (but unsuccessful) disclosures of their secret passion. In friendships that survived the awkward conversation, both people tended to reaffirm the importance of their bond, acknowledge that the disclosure was acceptable, tone down any flirtatious behavior

or innuendo, and resume their earlier contact patterns. The friend who demurred also acknowledged that the confessor’s assumptions about the relationship’s potential were justified, after which the confessor dropped the topic. Down the line, both pals openly discussed new prospective romantic partners.

In doomed friendships, the confessor complained and acted bothered when the friend did not agree to shift into romance and avoided contact with the object of their affection. The rejecter dangled false hope (“It’s just that I’m with someone else right now”) and told other friends about the episode.

After Dan moved to New York, “we were hanging out as friends, and Dan was being flirtatious. He’s so charming and funny,” Kate recalls. One night Dan went to Kate’s apartment for dinner, a romantic setting that brought the question of dating into stark relief. “One little kiss happened,” Dan recalls, “and it felt like kissing my sister.”

“Part of the awkwardness,” Kate says, “was [me thinking] ‘I like this guy so much. We are never going to work out romantically—I can’t even explain why—but we are destined to be really good friends. I felt so certain about that.’”

Later, when Dan got married, the two friends learned to adjust to new boundaries. They pulled back on the number of hours they spent on the phone together, and Kate realized she could not lean on him as much for emotional support. “I started to develop some of my other friendships more,” she says. Dan’s wife took on the role of his primary confidante, and he became more mindful that his outings with friends not eclipse their time together at home. As for Kate’s potential threat as an attractive female: “My wife never expressed discomfort,” he notes, “be-

cause I think she realized, just from being around us, that it was platonic and that it was a nourishing friendship. But I had to adjust to the change, too.”

Friends with Many Benefits

The good news is that most cross-sex friendships survive the pangs of romantic tension. Potential awkwardness aside, having a friend who is attracted to you can be beneficial. “Anytime someone expresses interest in you,” Reeder says, “they are affirming your worth in the social world.” She speculates that partners in a stagnant romantic relationship might feel empowered by the admiration of an opposite-sex friend.

Indeed, these friendships offer a few unique benefits beyond the standard assets of having a buddy. Men and women both report turning to opposite-sex pals to glean insights into how the other gender thinks. Dan, for example, describes how he often hears Kate’s voice in his head as he contemplates relationship issues and dealings with women in general: “It’s a necessary counterbalance to my male brain.”

Advice regarding a love interest might be the key dividend in one kind of cross-sex friendship: those between gay men and straight women. A 2013 study found that straight women are more likely to heed mating counsel from a gay man than from other sources, and gay men are likewise more inclined to trust advice from straight women than from straight men or lesbians. Unlike other alliances, friends who cross both sex and sexual orientation neither compete for mates nor weather the turbulence of unrequited desire. As a result, this bond has the potential to foster more trust than other ties, especially when it comes to unbiased dating insights.

More generally, strong friendships of any stripe are a tremendous boon to physical and mental physical health. To wit: Holt-Lunstad conducted a meta-analysis (a quantitative review of numerous studies) and concluded that having few friends is the mortality risk equivalent of smoking 15 cigarettes a day. People with a close friend at work are more productive and more innovative and have more fun than those without one. Couples, too, benefit when both partners have opposite-sex friends. Those who have a larger percentage of shared friends, as opposed to individual friends, tend to have happier and longer-lasting rela-



No matter the gender, friendships promote health and improve the quality of romantic relationships.

tionships. Strong social connections, in fact, are the biggest predictor of happiness in general.

Given the importance of social support to a healthy mind and body, it is unwise to kick half of the population out of your pool of potential friends. “Kate has made me less selfish,” Dan says. “Between us there’s a sense of acceptance of the other person’s neuroses, flaws—and even enjoyment of them. I take great comfort in a relationship that has stability even though it ebbs and flows in intensity.”

“Dan has influenced me—his work ethic has been inspiring,

how seriously he takes his work. And I thrive on his sense of humor,” Kate says. “He’s a friend I can completely trust. What a rare feeling that is, to be able to say anything to someone, without feeling censored.” Their decade-plus friendship, she says, “feels like one ongoing conversation.”

Kate and Dan have reached the highest levels of friendship, where life’s great rewards—love, pleasure, and the ability to grow and learn—abound. They exemplify Aristotle’s view on the best kind of friends. As described by philosopher Massimo Pigliucci of the City University of New York in his book *Answers for Aristotle*, such friends “hold a mirror up to each other; through that mirror they can see each other in ways that would not otherwise be accessible to them.” Whether the person holding the mirror is male or female hardly matters. **M**

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THE RISE OF **CHRONIC TRAUMATIC ENCEPHALOPATHY** AMONG SOME ATHLETES SUGGESTS THAT REPEATED BLOWS TO THE HEAD MAY TRIGGER THE BRAIN'S UNRAVELING

BY JACQUELINE C. TANAKA AND GREGG B. WELLS

FATAL



S T R I K E S



Mike Webster played

for 17 seasons in the National Football League (NFL). He was instrumental to the Pittsburgh Steelers' four Super Bowl victories during his career. In 2002 he died of heart failure in the coronary care unit of Allegheny General Hospital at age 50. His medical history included serious neuropsychiatric problems beginning around the time he left the NFL.

After Webster retired at age 38, his family watched him disintegrate into a tormented, wandering soul living out of his Chevrolet S-10 pickup truck. After his death, an astute neuropathologist at the University of Pittsburgh, Bennet Omalu, performed an autopsy on Webster and preserved regions of his brain for later microscopic analysis.

When Omalu examined the specimens, he observed atrophy similar to that seen in Alzheimer's disease patients—but in different areas of the brain. Omalu recognized the abnormalities as chronic traumatic encephalopathy (CTE), a form of brain deterioration previously reported in boxers and associated with the repeated traumatic brain injuries experienced in that sport. The 2005 report that Omalu published on Webster's brain was the first known case of CTE in a professional NFL player.

In the eight years since, the number of reports of the behavioral and cognitive changes experienced by NFL players has exploded. And the athletes themselves have taken notice. When Chicago Bears player Dave Duerson committed suicide in 2011, he shot himself in the chest and left a note requesting that his brain be donated to science. Analyses revealed that he, too, had developed CTE. The year of Duer-

son's death, approximately 4,500 players sued the NFL for concealing information about the dangers of traumatic brain injuries. Last August the league agreed to an out-of-court settlement for \$765 million. Since then, former players have launched new suits against the NFL, the National Collegiate Athletic Association (NCAA) and a helmet manufacturer, Riddell.

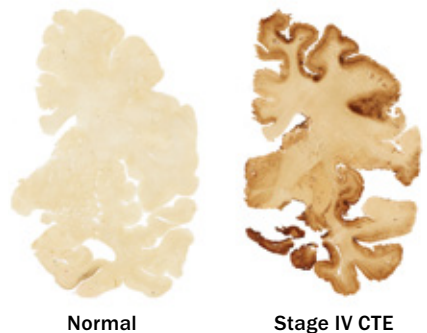
The legal furor has been matched by a frenzy of activity on the scientific side. More than 100 NFL players and athletes from other sports have pledged their brains to the study of CTE. So far few of the mysteries of this disorder have been solved, but scientists have nonetheless gleaned compelling insights. Participating in contact sports and sustaining brain trauma raise a person's risk of several forms of cognitive impairment and dementia, not only CTE. Yet the neuropathology of CTE is distinct, and its link to sports raises important questions regarding athletes' safety. Science is progressing rapidly, and its message is clear: to preserve the game and its players, the culture of football must change.

Brains under Fire

Although CTE is most commonly associated with football, brain trauma is anything but rare. Annually in the U.S., traumatic brain injuries account for more than a million emergency room visits; an unknown number of brain injuries are treated outside the hospital or go unremarked. Head injuries from car accidents or, for military veterans, from explosive blasts take a toll, as do hits incurred in several sports, including hockey, soccer and martial arts. Yet the gut-wrenching stories of American football players who excelled on the field—only to face psycho-

logical difficulties off of it and to die in abrupt, often violent ways—have put this sport at the center of the CTE controversy. Cullen Finnerty, a former professional player, disappeared into the woods last May at age 30 before turning up dead two days later. Andre Waters, renowned as one of the NFL's hardest hitters, committed suicide at age 44. Twenty-six-year-old Chris Henry, a wide receiver for the Cincinnati Bengals, fell off the back of a moving truck and died in 2009. When their brain tissue was later examined, all three athletes showed signs of CTE.

Even more disturbing are the cases of young, nonprofessional players who developed CTE. Among them is a former captain of the University of Pennsylvania football team, 21-year-old Owen Thom-



Slices of brain tissue were stained to reveal the presence of the protein tau, which appears dark brown. The tissue at the right shows an advanced stage of CTE.

as. In 2010 Thomas hanged himself in his off-campus apartment. According to his mother, he had never been diagnosed with a concussion. An examination of his brain nonetheless showed marks of the trauma-induced disease. Younger still was the 18-year-old multisport high school student who died from complications related to a brain injury on the field. The frontal cortex of his brain featured telltale protein buildups that also indicated a very early stage of CTE. Such cases have led parents to worry whether they should sign their kids up for youth football leagues—and if so, at what age.

The controversies surrounding head injuries may be new to football, but the

FAST FACTS

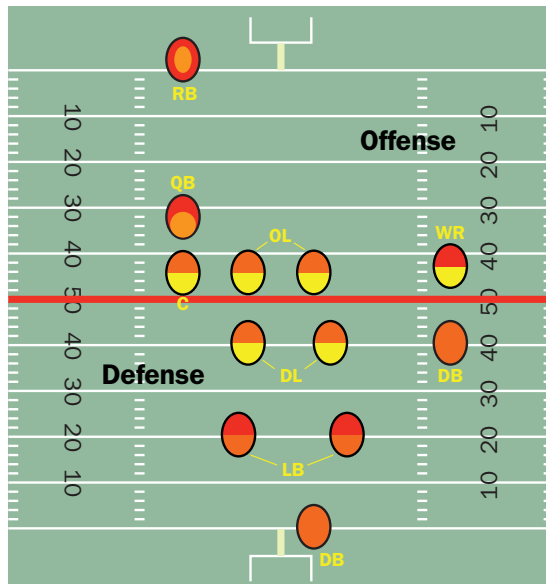
CONCUSSION CONUNDRUM

- 1 Repeated traumatic brain injuries increase a person's chances of developing a neurodegenerative disorder called chronic traumatic encephalopathy (CTE).
- 2 Players of many sports, but most notably football, appear to be especially vulnerable.
- 3 New techniques for observing the disorder's warning signs promise to help coaches and clinicians identify vulnerable players before they fall victim to CTE.

SOURCES: BRANDON MC MANUS (chart); "HEAD IMPACT EXPOSURE IN COLLEGIATE FOOTBALL PLAYERS," BY JOSEPH J. CRISCO ET AL., IN JOURNAL OF BIOMECHANICS, VOL. 44, NO. 15, OCTOBER 13, 2011 (chart data); AP PHOTO (football players)

HELMET INSIGHTS

In one study, helmet sensors collected data from 286,636 head impacts in three college teams over three years. A subset of players are shown here. The colors indicate the rotational acceleration of a hit, with yellow indicating lowest and red, highest. Defensive linemen (DL), offensive linemen (OL, and the center, C) and linebackers (LB) sustain the largest number of hits. Quarterbacks (QB), wide receivers (WR) and running backs (RB) endure the most intense blows.



deleterious effects of multiple blows to the brain have been known anecdotally for almost a century. The first published report dates back to 1928, when pathologist Harrison S. Martland wrote of “punch drunk” boxers’ bizarre speech patterns, unsteady gait and progressive loss of cognitive function. He even drew a connection between traumatic encephalitis—an inflammation of the brain—and multiple head injuries. Subsequent

postmortem analyses of boxers characterized the changes in more detail and introduced the term “chronic traumatic encephalopathy.”

Nowadays CTE refers to a constellation of brain changes, some of which can be seen with the naked eye during an autopsy. A CTE-afflicted brain weighs less than a healthy one, with atrophy visible across numerous areas. Two of the brain’s four ventricles—cavities filled with cere-

brospinal fluid—appear enlarged. Under the microscope, the brain is peppered with tangles of a protein called tau that clump irregularly around blood vessels and inside brain cells. Sometimes other proteins also accumulate—namely, beta amyloid (implicated in Alzheimer’s) and TDP-43 (a major factor in amyotrophic lateral sclerosis, also known as Lou Gehrig’s disease).

The brain degeneration can only be observed postmortem, yet certain behavioral changes might signal its presence in a living person. Symptoms include memory impairment, erratic behavior, depression and problems with impulse control; suicidal behavior also appears to be endemic. Also telling is a 2007 study of more than 2,500 retired NFL players. The scientists found that cognitive impairment, memory problems and depression rose in step with the number of concussions a player had endured.

Yet questions remain as to whether the same disorder that left younger players psychologically crippled also explains the cognitive decline that seems to manifest only decades after some players have retired. Researchers recently concluded that CTE afflicts people in one of two ways. In one cohort, aged 20 to 40, the disease progresses rapidly and instigates major changes to behavior and mood,

FACES OF CTE

THESE PLAYERS SHOWED SIGNS OF BRAIN DEGENERATION POSTMORTEM



NAME AND POSITION	Mike Webster Center	Justin Strzelczyk Offensive lineman	Andre Waters Defensive back	Chris Henry Wide receiver	Dave Duerson Defensive back	Junior Seau Linebacker
AGE	50	36	44	26	50	43
CAUSE OF DEATH	Heart attack 2002	Car chase 2004	Suicide 2006	Accident 2009	Suicide 2011	Suicide 2012
TEAM	Steelers, Chiefs	Steelers	Eagles, Cardinals	Bengals	Bears, Giants, Cardinals	Chargers, Dolphins, Patriots
SEASONS PLAYED	17 seasons; 4 Super Bowl wins	9 seasons	12 seasons; All-Pro in 1991	5 seasons	11 seasons; 4 Pro Bowls	20 seasons; 12 Pro Bowls

which can lead to suicide. For an older cohort, roughly between the ages of 50 and 70, cognitive impairment is more notable, with dementia as a common end point.

The afflictions of this older cohort appear more acute than the mild cognitive decline often seen in the aging brain, as neurologist Christopher Randolph of Loyola University Medical Center and his colleagues observed in a study published in 2013. They administered a questionnaire to the spouses of 513 retired NFL players with a mean age of 64 years. When asked whether the athletes exhibited significant cognitive impairment, 35 percent of the spouses said yes. In the general population of men under age 75, the figure is less than 5 percent.

A Shaken Brain

The core question is how a history of head hits can trigger the brain's disintegration. The most widely accepted theory builds

on the observation that rotational forces, in which the brain twists to one side, seem to deal the most damage.

The brain floats in its skull mostly unattached, buoyed by cerebrospinal fluid, a colorless liquid that cushions the brain and spine. After a hit, the brain deforms. If shaken hard enough, and especially if the brain twists, parts of neurons can stretch and even shear. The twisting motion tears open axons, the long, slim fibers that connect one neuron to another neuron (or to a muscle or organ).

With the axon's outer protective sheath ripped open, the thin filaments inside start to unravel. These filaments, called microtubules, allow cargo to travel from the nucleus to target cells. When the microtubules are damaged, molecules of glutamate leak from the cell. The cell also releases several proteins: tau (a structural element that helps to hold together microtubules), amyloid precursor

A SAFE WAY TO TACKLE?

HEADS UP—A MUCH HYPED NEW APPROACH TO TACKLING—SEEKS TO AVOID THE MOST FEROCIOUS HELMET-TO-HELMET COLLISIONS OF FOOTBALL

It's a moment football fans relish: A running back breaks through the line and heads up the field for a big play. A defender streaks toward the ball carrier, intent on stopping his forward progress as quickly as possible. The spectacularly violent collision that follows brings the cheering crowd to its feet. That hit—and the dozens more like it in any given game—have helped make American football enormously popular worldwide.

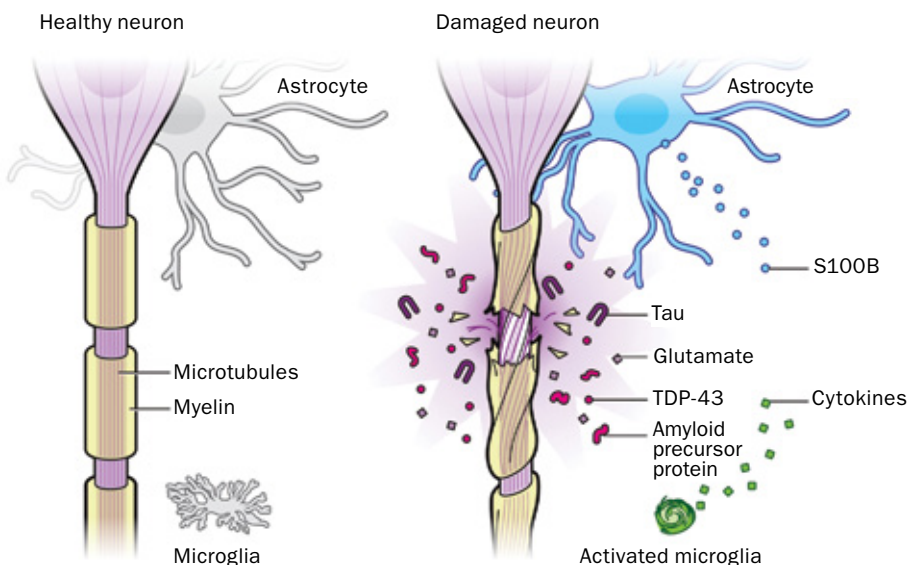
Such electrifying plays have also placed the sport in a great quandary because the concussive forces at work, particularly when helmets collide, put players at risk for traumatic brain injury. Head injuries are nothing new to football—the sport has been grappling with its brutal nature since its inception nearly 150 years ago. Now research is connecting several high-profile former players' repeated gridiron head impacts with the emergence of chronic traumatic encephalopathy (CTE), a neurodegenerative disorder characterized by atrophied, abnormal brain tissue.

The proposed link between football head injuries and CTE in former players has put the National Football League (NFL) on the defensive. The NFL has identified poor tackling technique as the main culprit in players' brain injuries, reasoning that this aspect of the game explains why concussions have persisted despite improvements to helmets and rules banning helmet-to-helmet collisions.

Acknowledging that pro and college players are too far along in their careers to make major adjustments to their style of play, the league teamed up with Indianapolis-based national youth organization USA Football to convince coaches, parents and young players to buy into a new approach

Axons under Stress

A head impact can cause a neuron's axon to twist, tearing open its protective sheath, called myelin. Inside the axon, exposed microtubules can snap, releasing several proteins—tau, amyloid precursor protein and TDP-43—and glutamate, a neurotransmitter. The molecules signal nearby microglia and astrocytes to initiate repairs. Microglia ball up and release cytokines, and astrocytes release S100B. S100B is now being studied as a possible marker for CTE in a living person.



called Heads Up Football, which was introduced in 2012.

Heads Up's centerpiece is a campaign to teach young players to tackle without using their heads as battering rams. In principle, the defender makes contact with his opponent using the front of his shoulders and his chest, just above the numbers on his jersey. Instead of lowering his helmet into the ball carrier, the defender's head should travel up and away from his opponent's helmet.

The technique's effectiveness for both taking down opponents and preventing concussions is debatable, particularly when players are moving at full speed. What is not debatable is work that shows that hits to the top of the helmet create the greatest risks for head and spinal injuries. Steven Broglio, director of the University of Michigan's NeuroSport Research Laboratory, has for years studied the forces exerted on high school players' helmets using Head Impact Telemetry System (HITS) technology. HITS consists of several battery-powered sensors in the helmet's padding that record every impact's location, magnitude, duration and direction.

Broglio's data indicate that blows to

the top of the helmet have an average acceleration equivalent to about 35 g, whereas those to the facemask average less than 25 g. Concussions typically occur beginning in the 90-g range; nonetheless, research suggests that subconcussive blows also can cause damage. "If you're not hitting with the top of the helmet, you're reducing concussion risks," he says. "Whether [Heads Up tackling] can be carried out on the field in real time, no one's shown those data, but I can't disagree with the theory behind it."

Heads Up might diminish the number of head injuries to some degree. Yet it is no guarantee against brain trauma, which can happen anytime a person is involved in a collision, says Robert Cantu, co-director of the Boston University Center for the Study of Traumatic Encephalopathy. A better idea would be limiting contact in practice or even prohibiting tackle football for kids younger than 14, he adds.

Even if Heads Up's tackling initiative is just a start, the broader program promises to educate coaches, young players and their families about concussion risks and consequences, says Donald Marion, a senior clinical consultant at the Defense and Veterans Brain Injury Center in

Silver Spring, Md. Marion studies the impact of concussions on both athletes and military personnel. Even as researchers investigate the causes of CTE, "it's becoming increasingly clear that multiple concussions can be a problem, especially if they're not reported or if the [player] is not appropriately diagnosed and treated," he says.

Contact sports such as football will never be truly safe, nor is scrubbing them of all risk anyone's intention. Still, the collateral damage is evident—at press time 71 NFL players had sustained concussions this season, with 160 suffering similar injuries the previous season. With the Heads Up campaign, both professional and youth football leagues are finally acknowledging players' vulnerability to head injuries. The question is whether new approaches to tackling and heightened awareness of concussions are enough to prevent future generations of players from suffering the same neurodegenerative conditions that plague many of their retired gridiron heroes.

—Larry Greenemeier

Larry Greenemeier is an associate editor at Scientific American.

HEADS UP TACKLING: 5 KEY MOVES

Breakdown Position

A defender first crouches, feet spread, knees bent.

Buzzing the Feet

The player maintains rapid foot movement to ensure he is not caught flatfooted or off balance when preparing to tackle.

Hit Position

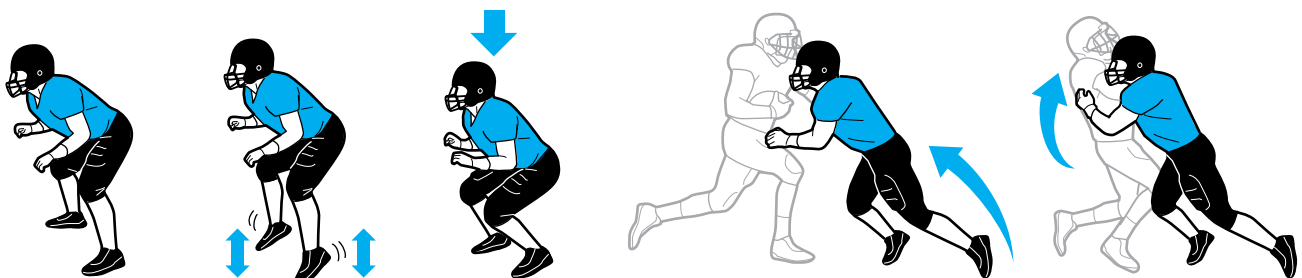
Just prior to the tackle, the player drops his lower body while keeping his torso upright.

The Shoot

The player comes out of his crouching position with a quick, explosive opening of the hips. This movement thrusts him forward and generates power for the tackle.

The Rip

The defender's knuckles and his elbows are down as he makes a double upper-cutting motion below the ball carrier's armpits and lifts that player up and backward. Most important, from this position, the tackling player's head should travel up and away from the opponent during the follow-through.



JASON LEE

protein and TDP-43. The dispersal of these molecules signals nearby cells that damage has occurred, triggering an immune and inflammatory response. Part of that reaction involves the release of a protein called S100B, which plays an important role in generating and repairing axons, among other things [see box on page 40].

What exactly these molecules do once released and how long they linger in the brain are critical open questions. Notably, we know that tau and amyloid precursor protein are critical constituents in Alzheimer's. When a microtubule disintegrates, tau comes loose and can aggregate into unruly tangles. An abundance of tau is a hallmark of Alzheimer's (among other forms of dementia), although whether these tangles cause the disease's devastating effects or are a mere by-product remains unknown. The

After a hit, the brain deforms. If shaken hard enough, and especially if the brain twists, parts of neurons stretch and even tear open.

breakdown of amyloid precursor protein, for its part, can lead to the buildup of amyloid plaques, which constitute another major sign of Alzheimer's.

A crucial shortcoming in CTE research is that we have no way of identifying axonal damage in a living brain. To this end, S100B, one of the proteins released in response to a damaged axon, has recently come under closer scrutiny by researchers. After a traumatic brain injury, molecules of S100B can leak across the blood-brain barrier, which typically seals off the brain from any contaminants circulating in the blood-

stream. Testing a player's blood for levels of S100B could offer a quick read on the athlete's brain health after an injury.

Looking Ahead

Only a small percentage of athletes experience profound changes in personality

THE AUTHORS

JACQUELINE C. TANAKA is an associate professor of biology at Temple University and a recreational hockey player. **GREGG B. WELLS** is an associate professor of molecular and cellular medicine at Texas A&M Health Science Center.

CHRONIC TRAUMATIC ENCEPHALOPATHY A Player's Perspective

Coaches, trainers and athletes need to work together to prioritize brain safety

I HAVE BEEN a sports lover for as long as I can remember. As a young kid, I played soccer, baseball and basketball. When I was three years old, my dad started taking me to the Philadelphia Eagles home games, and I fell in love with the competitiveness of football.

Wrapped up as I was in other sports, I started playing football only in the seventh grade, when I decided to join my middle school team. Over the years I began to see football as an opportunity for a college scholarship. I made it onto my high school football team as a kicker, and I used the sport as my ticket to Temple University, where I majored in biology.

At the high school level, the

words of wisdom from our coaches were to "keep your head up, and see what you hit." At the time, I had no reason to question that level of guidance. Yet as the emerging data on the dangers of repeated brain traumas make clear, we need to do far more to educate young players.

Attitudes toward athlete safety have changed radically during my career on the field. As little as two years ago players were far more likely than they are today to play through a concussion, driven as they were by the will to win. Now players and the coaching staff are more inclined to speak up if a concussion occurs. And last fall Pop Warner, the largest

youth football league, partnered with the NFL and USA Football, the organization that governs the sport at the non-professional level, to train coaches in ways to prevent concussions.

Tackling technique is only one factor influencing safety on the field. In middle school, for example, a tight budget meant that our helmets and shoulder pads came out of an aging pool of gear. We wore old, oversized T-shirts as jerseys over our pads during practice. In high school we had better equipment and, more important, we started training to increase upper-body and neck muscles—critical to a player's ability to withstand impacts. An equipment manager (in our case, a janitor who worked with our team part-time) gave every player what he considered the best-fitting helmet and shoulder pads from the existing stockpile.

All that changed at the college level. Every year before workouts began for the new season, I was fitted by a trained equipment manager for my helmet and pads. Not only did we have professional strength coaches, we also had an experienced training staff familiar with spotting and handling head injuries, even if a player tries to hide symptoms to remain in the game.

Because these resources are often not available to younger players, parents may wonder whether their children are more vulnerable to head injuries. The answer is not so simple, as the risks differ by age group.

Of greatest concern is that a child's brain is not fully developed until adulthood. Namely, the axons of their neurons are not fully coated in myelin, the protective insulation that comes under stress in some of the most harmful brain inju-

and cognition, and one of scientists' most pressing goals is to determine who is most at risk. The fact that not all players succumb to CTE suggests that given time, the brain can repair damaged areas. Repeated blows within some critical window seem to prime the brain for CTE: they either amplify existing injuries or prolong the recovery, or both. A subsequent hit could rev up the inflammatory processes already at work, potentially setting off toxic cascades. Assuming future research pans out, a timely blood test for S100B might let team physicians monitor the extent of damage caused by a head hit and thus determine whether it is safe for a player to return to the field. The test might even serve as a simple, if crude, way of tracking players' risk of developing CTE game by game.

Another promising advance could turn brain imaging into a diagnostic tool

by monitoring the presence of tau in a living person. A new radioactive tracer can bind to tau, exposing it in brain scans produced by positron-emission tomography. In a 2013 pilot study led by psychiatrist Gary Small of the University of California, Los Angeles, five retired NFL players with CTE symptoms underwent brain scans after being injected with the new tracer. The resulting images showed significantly higher levels of tau than the control subjects had. Though preliminary, this approach opens up the possibility of early detection, a significant first step before clinicians can begin delivering therapy.

As for treatment, the NFL Alumni Association is working with a company called Neuralstem to develop drugs that might combat the symptoms of CTE. Neuralstem's proposed intervention targets atrophy in the hippocampus, a

memory center of the brain. By introducing neural stem cells into the hippocampus, the thinking goes, we can stimulate new neurons to grow, replacing the lost brain cells and potentially restoring memory or at least halting the deterioration. In studies using human neural stem cells grown in culture, the company's drug, called NSI-189, was shown to stimulate the development of new neurons in the hippocampus. Yet these are early days—the drug is undergoing safety testing in two dozen patients and is, at best, years away from showing up on pharmacy shelves.

Protection for Players

The biggest gains, at least in the short term, will come not from drugs but from changes in how players protect themselves and how the game is played. Several measures can encourage teams at all



The author kicks off in a 2011 NCAA game against the Buffalo Bulls.

ries [see box on page 40]. Thus, a head impact has the potential to inflict more damage than a concussion later in life. Moreover, a child's weak neck and torso muscles—as compared with a burly pro whose neck is the size of a milk jug—permit the head to whip around precariously. Yet weaker muscles also mean softer tackles, as children are

unlikely to deliver the crushing blows that can cause bones to crumple at other levels of play.

High school is when proper technique starts to make the most difference, especially because seniors can dwarf freshmen in size. Building up neck and shoulder muscles and rehearsing safe technique (such as keeping the head up, rather than letting it drop into an inju-

ry-prone position) become paramount—high schools need to embrace these practices if they have not already.

Collegiate football, in which such measures are routine, also comes with its own set of risks: with players still refining their skills, full-contact practice is more common than in the NFL. As a result, collegiate players may encounter more dangerous situations than professionals. Ultimately, though, the greatest risk factor is simply the number of years a person stays in the sport. The more seasons a player devotes to football, the greater the chances of sustaining multiple traumatic brain injuries.

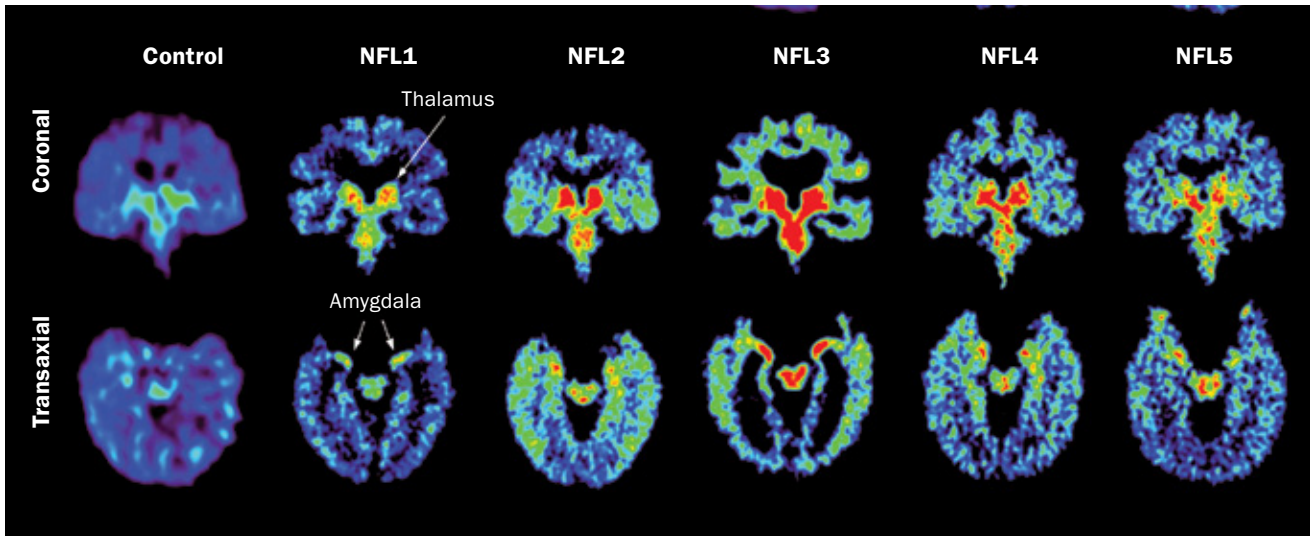
I first learned about chronic traumatic encephalopathy (CTE) in the fall of 2012, when several former NFL players committed suicide, and players and their families sued the league. Although awareness

has spread throughout the NFL, I estimate that as many as 80 percent of college players still do not know about CTE. This needs to change.

Even though I have now educated myself about CTE, I have no second thoughts about going pro. I signed with the Indianapolis Colts last spring and remain excited about being a part of the NFL. My position as a kicker means that I run a low risk of experiencing a traumatic brain injury during a game. Yet if I felt at risk of CTE because of multiple head impacts, I would leave the game and encourage others to do the same. My fellow athletes should have the same opportunity to make a well-informed decision about their future.

—Brandon McManus

Brandon McManus was signed by the Indianapolis Colts in 2013. He plans to apply to medical school after the NFL.



Five retired NFL players underwent PET scans (above) using a tracer that binds to tau. Red and yellow indicate strong signals from the tracer.

levels and ages to adopt safer standards and help to prevent the spread of CTE.

During a game, referees should penalize players who make reckless tackles or who wear protective equipment improperly, such as leaving helmet chinstraps unbuckled. Although well-fitted helmets are important, they are unlikely to protect the brain from rotational forces. Thus, it falls to coaches to teach players proper tackling and hitting, as well as self-protection. The NFL has begun promoting a playing technique called Heads Up tackling, which it has deemed safer than the existing style of taking down opponents [see “A Safe Way to Tackle?” on page 40]. At the college level, coaches need to recognize the risks of full-contact practice and keep head im-

pacts during training to a minimum.

Trainers, too, have a role. They should emphasize neck-strengthening exercises as a way of buttressing the head against the rotational forces of a hit. Several studies, including some that used dummies to simulate the collision mechanics in concussions, have found that the stiffness of the neck influences the degree of head rotation and displacement in a concussion and that building up the muscles of the neck can protect some players.

One suggestion from several research groups is to have players wear helmets equipped with sensors that can

monitor collisions. These commercially available sensors send their data to a computer system on the sidelines that tracks the number and intensity of hits players receive during a practice or game. The technology does not prevent brain trauma so much as allow team personnel to monitor players and pull them off the field should their impact data cross some threshold considered unsafe. Although we do not yet know how long the brain needs to recover after a hit, we can say that a player with blurry vision, balance problems or confusion is at greater risk of getting clobbered a second time. The collision data collected by the sensors can help coaches and trainers decide whether an athlete should continue playing after an impact, even in the absence of any outward signs of instability.

Modifying practices to cut back on concussions—not just in football but also in hockey, soccer and boxing, to name a few—need not deprive competitive athletics of their entertainment value. All sports involve some element of risk, yet engaging in team physical activity also promotes a healthy lifestyle. Just as seat belts reduced the number of road deaths without having to ban cars, so, too, can safer habits and standards spare athletes without overhauling their sports. As the many fallen athletes remind us, the risks are far too great to ignore. **M**

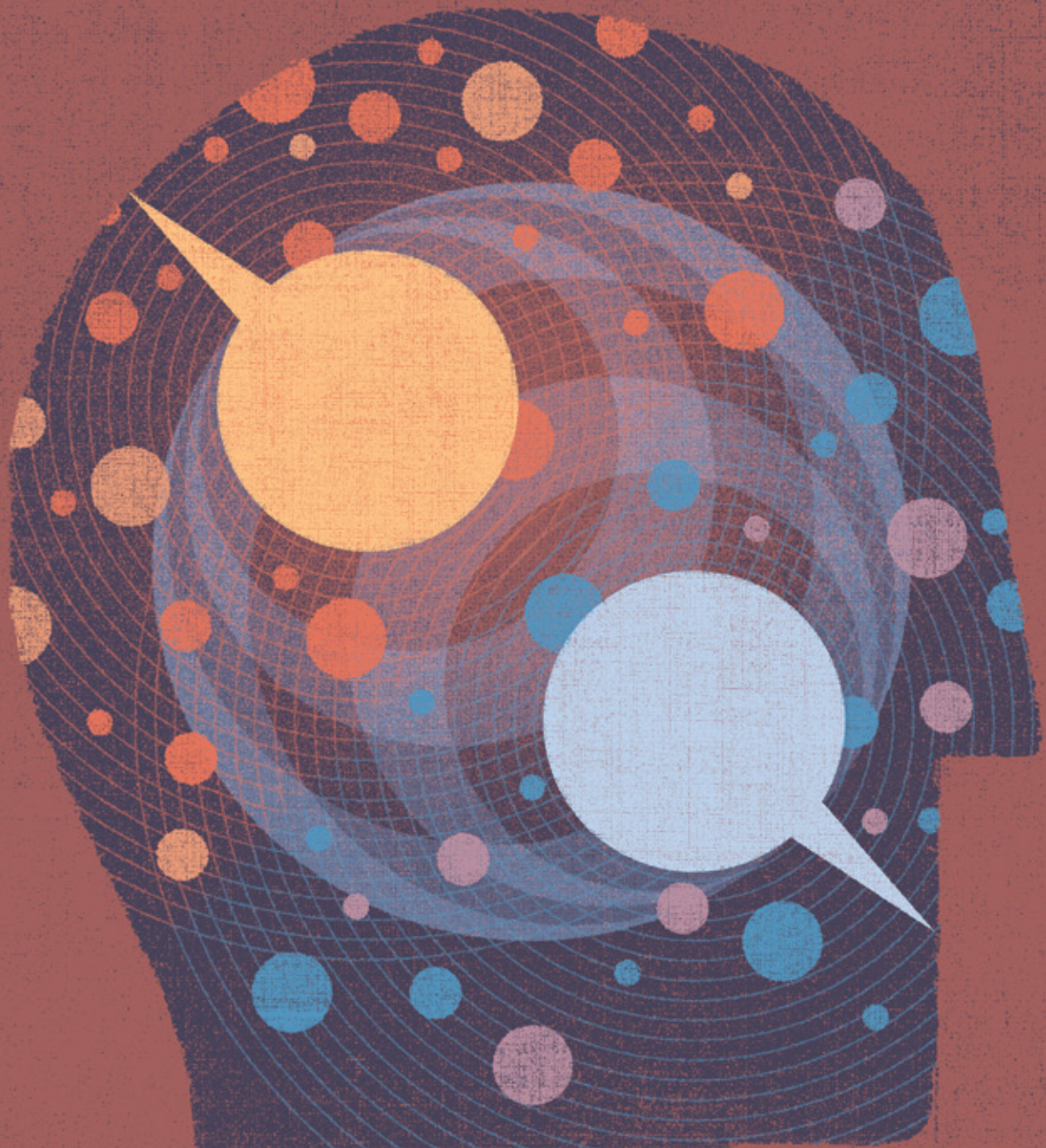
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Speak for Yourself

We talk to ourselves to stay motivated, tame unruly emotions,
plan for the future and even maintain a sense of self

By Ferris Jabr *Illustrations by Jim Frazier*

A few months back, while riding the subway, some words fell out of my mouth: “No, no, don’t worry about it.” Addressing no one but myself, I blurted this phrase while mentally replaying an earlier, embarrassing conversation. Although I have occasionally muttered out loud when alone, this was the first instance in such a public space. No one seemed to care or even notice. Still, I could not help wondering whether my mind was drifting too far from the familiar realm of the functionally neurotic. Was I spending too much time in my own head, obsessed with soliloquy?

To my relief, it turns out that just about everyone talks to themselves, both out loud and silently, much of the time. The habit begins in childhood with what psychologists call private speech: speaking to oneself aloud while playing with a favorite action figure, for example, or making bunny ears out of shoelaces. As we age, most of us converse with ourselves out loud much less often, but at least a couple of studies suggest that most adults and adolescents sometimes speak to themselves audibly. In a 2006 study by psychologist Adam Winsler of George Mason University and his colleagues, 46 of 48 women admitted that they murmured to themselves now and then. And we all talk to ourselves silently throughout life. Psychologists call this type of thought inner speech or self-talk, and it occupies about one quarter of conscious experience.

Precisely defining inner speech is difficult, but it is essentially thinking in language—as opposed to, say, a vivid and involuntary flashback to a scene from childhood or picturing what the sofa would look like against this or that wall before moving it. Self-talk can manifest as a voice or as sign language,

but it always involves words, and it is always a conscious experience. When you wake up in the morning and think, “Thank God, it’s Friday,” that’s inner speech. And when a friend sits you down and asks for advice, and you silently test several different responses in your mind before answering, that, too, is inner speech.

Researchers have studied children’s private speech for decades, but only recently have they seriously focused on self-talk in adults. “We know now that inner speech is used for all sorts of things,” says psychologist Charles Fernyhough of Durham University in England. We depend on it to solve problems, read and write, motivate ourselves, plan for the future and learn from past mistakes.

Inner speech is a ready source of motivation, confidence and guidance in all kinds of scenarios—giving a presentation, hitting the gym or asking someone on a date.

Some people, however, have difficulty recognizing the voices in their mind as their own, resulting in auditory hallucinations. Others—such as those with autism—may have trouble forming inner speech, which might impede their ability to remember complex instructions and solve certain problems. Sometimes our internal speech needs editing, as when self-talk becomes unnecessarily critical, stoking the black flames of depression. Researchers are learning, however, that when silent inner speech is difficult to produce, the audible type can often substitute. And therapists can help people with depression and anxiety silence and rewrite their self-talk to minimize psychological damage. Even if our inner voices sometimes mouth off, we need them. Inner speech, some researchers now suggest, stitches together the many threads of

FAST FACTS

THINKING IN TONGUES

- 1 Inner speech is essentially thinking in language. It occupies about one quarter of conscious experience.
- 2 We depend on inner speech to solve problems, read and write, motivate ourselves, plan for the future and learn from past mistakes.
- 3 Therapists can help people with depression and anxiety silence and rewrite their inner speech to minimize psychological damage and encourage healthy habits.

sensory experience into the tapestry of self-awareness. To know yourself, you have to talk to yourself.

First Words

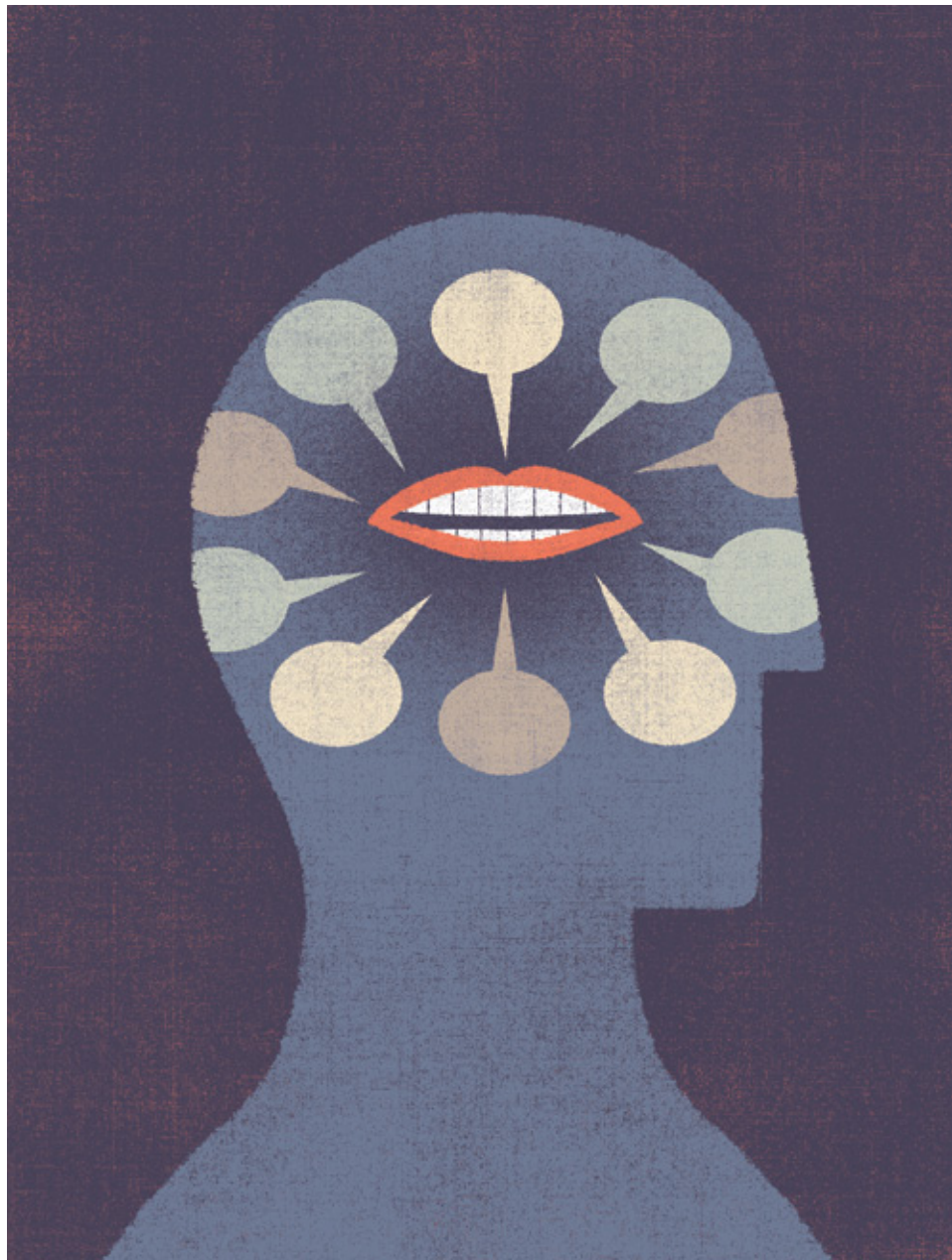
Russian psychologist Lev Vygotsky was the first to seriously investigate inner speech. In the 1920s he proposed that children internalize dialogues they have with their parents and use these linguistic templates to talk themselves through new experiences, summon concentration and calm down. A toddler playing with Legos, for instance, might dictate his plan to build a spaceship block by block—even if no one else is listening. In the decades since, researchers have confirmed that private speech is essential for learning language, and it helps children regulate their emotions. It also improves problem solving. Studies have shown that the more children speak to themselves the more efficiently they solve both jigsaw puzzles and the Tower of London task, in which they must position colored beads in a particular sequence on three pegs using as few moves as possible.

Vygotsky further established that, compared with a child's typical speech, private speech is telegraphic and highly idiomatic—similar to short notes scrawled in the margins of a book. Researchers now know that the same is true for silent inner speech in adults. Because you already know what you mean, you do not have to bother explaining everything in complete sentences.

Over the years researchers have found crafty ways to capture the fleeting thoughts inside a person's mind. Since the 1970s, for example, psychologist Russell Hurlburt of the University of Nevada, Las Vegas, has provided volunteers with beepers that sound at random times. Whenever they hear a bleep, the participants have to stop what they are doing and write down their thoughts. More recently, anthropologist Andrew Irving of the University of Manchester in England asked 100 volunteers to wear a small microphone and narrate their thoughts as they walked the streets

of New York City. The results are Joycean transcriptions of mental chatter.

Such studies and related experiments have uncovered many examples of people using self-talk for self-regulation: steering attention, taming unruly emotions and reminding ourselves of proper etiquette. Inner speech is a readily available source of motivation, confidence and guidance in all kinds of scenarios—giving a presentation to co-workers, getting out of bed early to hit the gym or working up the courage to ask someone on a first date. Particularly well studied is its use in sports.





Pep talks have been a tradition in sport and combat for centuries, from the *lanista* preparing his gladiators for battle in ancient Rome to the modern football coach psyching up his team in the locker room. For at least as long, athletes have whispered certain phrases to themselves to keep their head in the game. Only in the past 10 years, however, have sports psychologists gathered enough evidence to empirically support the notion that inner speech improves athletic performance.

Such self-talk comes in two tones: motivational—consisting of simple encouraging statements,

such as “I can do this” or “I will make this shot”—and instructional, that is, talking through specific motions. The former can boost confidence and mood and increase the energy and effort devoted to a task, whereas the latter enhances focus and hones execution. In a 2008 study by sports coaching scientist Christian Edwards of the University of Worcester in England and his colleagues, 24 college rugby players repeatedly jumped straight up as high as they could in a lab: 16 used either motivational self-talk (“I can jump higher”) or instructional self-talk (“bend and drive”) for 20 seconds before each jump; the other eight did not use self-talk. Rugby players in both self-talk groups jumped with greater force—and athletes in the motivational group jumped higher—than the eight athletes who did not talk to themselves silently.

Sometimes self-disapproval can be motivational, too. Although coaches often advise athletes to banish all disparaging thoughts on the field or court, studies have suggested that mild self-rebuke gives many athletes the impetus to get back out there and play better.

Other work illustrates the benefits of speaking detailed instructions to oneself out loud. In a 2012 study sports psychologist Eleni Zetou of the Democritus University of Thrace in Greece and her colleagues asked 28 novice teenage volleyball players to practice their serves one hour a week for four weeks using private speech to guide their movements: “When I throw the ball,

the arm goes back, over the head, look at the target and hit the ball.” Meanwhile another 29 athletes practiced without such verbiage. Volleyball coaches watched videotapes of the players to evaluate their skill. Both groups improved, but at the end of the training the coaches rated athletes who used self-talk an average of 44 out of 50 points for skill; the players who did not talk to themselves averaged 35. Explicit reminders of how to approach the goal or shoot the free throw seem to be especially helpful for beginners, whose movements are less practiced and not yet automatic.

Beyond helping people regulate their behavior in the present moment, inner speech is essential for learning from the past and planning for the future. By rehearsing and sometimes rewriting previous conversations, we can identify our faux pas and make sure not to repeat them. And by telling ourselves stories about our possible futures, we clarify what we do and do not want to achieve in life. Inner speech may be so fundamental to mental time

“Rumination is important in depression and anxiety, and words that repeat in inner speech can be a target for therapy,” one psychologist says.

travel that if it disappears, so does our understanding of “before” and “after.” In 1972 clinical psychologist Claude Scott Moss described a stroke that rendered him unable to speak or engage in self-talk. “In other words, I did not have the ability to think about the future—to worry, to anticipate or perceive it—at least not with words. Thus, for the first four or five weeks after hospitalization I simply existed.”

Inner Chorus

Although talking to oneself is often advantageous, too much of the wrong kind of inner speech can backfire. Rumination—obsessively mulling over painful experiences—is both a symptom of and a risk factor for depression. Likewise, thoughts of impending doom often intrude on the minds of people with anxiety disorders. Some psychiatrists have tracked the severity of anxiety and depression by monitoring inner speech. In a 2007 study conducted by psychologist Philip Kendall of Temple University and his colleagues, 145 children with generalized anxiety disorder and social anxiety filled out

surveys asking how often anxious self-statements (“I am very nervous”) and positive ones (“I am a winner”) entered their minds in the past week. Kendall found that the more often a child engaged in anxious relative to positive self-talk, the worse the child’s anxiety, and the more this ratio diminished in therapy, the greater the child’s progress.

“People are recognizing that rumination is important in depression and anxiety, and words that repeat in inner speech can be a target for therapy,” Fernyhough says. “Even just telling people about inner speech and where it comes from seems to be beneficial.” Giving an official label such as “inner speech” to verbal thoughts and recognizing that they can be tweaked is immensely empowering. Psychiatrists have devised several strategies that can help people catch themselves in the act of ruminating and quiet pessimistic or critical thoughts before they multiply. When combined, cognitive-behavior therapy and mindfulness meditation, for example, can increase awareness of the mind’s habits, which opens up the possibility of changing them. When depression tries to turn someone’s inner speech against them with irrational thoughts of hopelessness—“There’s no point in getting out of bed today. No one cares about you, and your so-called career is pathetic”—one can fight back with self-talk that contradicts those negative thoughts and provides perspective: “You are lucky to have family and friends who love you a lot and a great job with supportive colleagues.”

Whereas many people with depression and anxiety must learn to mute their unhelpfully loquacious minds, other individuals have the opposite problem: they may not talk to themselves enough. Because children pattern inner speech after dialogue with others, individuals with autism spectrum disorder—who have difficulty recognizing social cues and participating in lengthy, intimate conversations—may have trouble internalizing dialogue to generate inner speech.

In particular, autistic children find it difficult to follow arbitrary rules in tasks psychologists devise, such as “If a card has a red circle, put it in this box. If it has a blue triangle, put it over here,” especially

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when they have to silently repeat detailed instructions in their mind. Yet a 1999 study by psychologist James Russell of the University of Cambridge and his colleagues suggests that children with autism can overcome this mental hurdle when allowed to speak out loud to themselves. Russell challenged 19 children with autism and another 19 typically developing kids between the ages of five and eight to associate cards depicting the moon with daytime and cards depicting the sun with night. Instead of writing down their answers or silently sorting the cards into two piles, the children were asked to say “night” to pic-

tures of the sun and “day” to images of the moon. Both groups did equally well.

A 2007 study by Winsler and his team complements this earlier research. He videotaped 33 people with autism, between seven and 18 years old, and another 28 typically developing children and adolescents as they completed a card-sorting task and a computer game in which they had to construct a virtual stick by adding or subtracting segments. Although the children with autism had a harder time successfully finishing the tasks, when they were able to talk to themselves, their chances of getting a correct answer rose much more than those of a typical child using the same strategy.

For other people, the difficulty is not producing or editing inner speech but identifying it. Auditory verbal hallucinations (AVHs) are voices people hear in their head but do not recognize as their own. Long associated with schizophrenia, AVHs can also accompany bipolar disorder, personality disorders and temporary periods of psychosis, and about 15 percent of healthy people occasionally hear sounds or voices that do not exist outside their mind, according to a 2012 study by Fernyhough and his colleagues.

When we speak to ourselves in our mind, a region of the brain in the frontal lobes known as Broca’s area—which is essential for producing speech—sends commands backward to Wernicke’s area on the border of the temporal and parietal lobes, which is necessary for understand-

ing speech. The relayed message tells Wernicke’s area not to respond to this internal voice the way it would to someone else’s voice. (A similar feedback loop explains why we cannot tickle ourselves; the brain reminds itself that we are the ones doing the tickling.) In a 2001 study psychiatrist Judith Ford of the University of California, San Francisco, and her colleagues discovered that the electrical signals traveling between Broca’s and Wernicke’s areas are weaker than average during inner speech in people who experience AVHs. Similar research has found that in those who hallucinate voices, a range of

Children with autism can more easily follow arbitrary rules such as “If a card has a red circle, put it in this box,” if they are allowed to speak out loud to themselves.

brain areas involved in distinguishing different mental voices—your own voice from the memory of a friend’s speech, for example—are either underactive or show unusually timed electrical activity. Such neurological insights may help researchers develop treatments for people whose inner-speech circuitry could use a little fine-tuning.

Silence Is Selfless

Hallucinated voices often force someone to question reality. In a healthy mind, inner speech does exactly the opposite: it affirms who we are and what we are experiencing. Inner speech’s most important purpose—and the one that is most difficult to study in controlled experiments—may be maintaining a sense of self. Every day our minds write and edit the ongoing narrative of our lives. We depend on a continuous stream of simple silent thoughts—“All right, time to start the day”; “I had better take an umbrella”; “This reminds me of when ...”—to preserve our identities as sentient, self-aware individuals with a past and future.

Helen Keller has written that before she learned language, she did not have self-awareness: “Before my teacher came to me, I did not know that I am. I lived in a world that was a no-world ... When I learned the meaning of ‘I’ and ‘me’ and found that I was something, I began to think. Then consciousness first existed for me.”

Psychologist Alain Morin of Mount Royal University in Calgary has used such anecdotes to support his theory that inner speech is “one of the most important tools we use to become aware of the self. It’s so important that when we lose it, we observe

deficits,” he says. One of the most poignant and recent examples of such deficits is the story of neuro-anatomist Jill Bolte Taylor.

In 1996, when 37-year-old Taylor was sleeping, a blood vessel exploded in her brain. She woke to a pounding pain behind her left eye. That morning she became unable to walk and talk and forgot much about her life. A blood clot the size of a golf ball had formed inside her head, cutting off oxygen supply to both Broca’s and Wernicke’s areas. As a result of her stroke, Taylor temporarily lost much of her ability to converse with herself in her mind and, it seems, much of her self-awareness along with it. In certain moments, her inner chatter vanished, and her mind was totally silent. “Those little voices, that brain chatter that customarily kept me abreast of myself in relation to the world outside of me, were delightfully silent,” she wrote. “And in their absence, my memories of the past and my dreams of the future evaporated.”

The fascinating possibility implicit in such experiences is that our sense of self is an elaborate illusion—a very convenient fiction maintained by our incessantly chatty mind. When our mind shuts up, we disappear. If that is true, we could all stand to balance our self-involvement with a little more humility and humor. “Jill Bolte Taylor died that day,” Taylor says of her ordeal. “I did not have her memories, her likes or dislikes, her education, anger, her love, her relationships. Now I don’t take Jill Bolte Taylor half so seriously as before.” **M**

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TAKING **EARLY AIM** AT AUTISM

By spotting signs of this developmental disorder in young toddlers, parents and therapists may be able to target a child's deficits before they become debilitating

By **Luciana Gravotta**



Soon after Noah turned a year old, his parents, Leslie and Paul, noticed something was not quite right with their son. At 10 months Noah had learned to say “Mama” and “Dada,” but at 14 months he no longer uttered any discernible words. Music had a powerful and strange effect on Noah: when he heard it, he would stop what he was doing and “zone out,” according to Leslie.

Four months later Noah's parents brought up their concerns about their son with his pediatrician. The doctor recommended they wait until his second birthday to see if he would catch up with his peers. The advice did little to allay Leslie and Paul's worries.

Absence of language, heightened sensitivity to sound or other sensory stimuli, and difficulty shifting focus from such stimuli, including music, raise the specter of autism in

very young children. Autism, a complex disorder of brain development, is now estimated to affect one in 88 kids. It is characterized by communication deficits, impaired social interaction, repetitive motor behaviors, and, sometimes, intellectual disability or physical health problems. Because autism is defined by complex behaviors, obvious signs do not emerge until children start stringing words together and engaging in play with their parents, at about two years old. Children with autism may, for example, continue to play alone far longer than is normal.

The concept that autism is treatable is controversial and new. Newer still is the idea that if children receive therapy very early in life, they are more likely to overcome their deficits. Now, however, many experts believe that delivering therapy to children as young as age one or two—instead of four, as is more typical—can garner greater improvements in IQ, language and social skills. Officials at the American Academy of Pediatrics and the Centers for Disease Control and Prevention, among others, now recommend early detection. To identify autism (or autism risk) in younger children, researchers have had to develop novel screening tools. In addition, one new intervention designed for children as young as a year old has been shown to significantly improve social communication skills.

Missing Milestones

During the first year of life, trillions of new neural connections form in the brain. As a child gains experience with the world between age one and adolescence, these links are pruned—some eliminated and others fortified. One theory posits that in autism this crucial shaping goes awry. Indeed, in studies published in 2012 psychiatrist Joseph Piven of the University of North Carolina at Chapel Hill and his colleagues used magnetic resonance imaging to visualize neural connections in the brains of 92 infants who were at risk for autism because they had siblings with the disorder. They discovered that at six months, the 28 infants who were later diagnosed with autism had a higher density of nerve fibers connecting

certain brain regions than did the children who developed normally. At 24 months, however, researchers found that the typically developing toddlers now had greater fiber density in these same regions and that these toddlers also showed a steady strengthening, or thickening, of some initially weak, nonspecific connections. This neural differentiation was far less pronounced in the kids who ended up on the spectrum.

Many experts believe that intelligently guiding the formation, and elimination, of neural connections early in life could sculpt a more functional brain. This belief forms the theoretical basis for early detection. In an initial foray into this area, psychologist Diana Robins of Georgia State University and her colleagues developed the Modified Checklist for Autism

“We saw that for neuroplasticity every month counts,” one father says. “And we had given up months just waiting.”

in Toddlers (M-CHAT) in 1999. The checklist, designed for children between the ages of 16 and 30 months, probes for precursors of the disorder’s main deficits. Is the child using his index finger to point at something he wants or that interests him? If not, his communication skills may not be advancing properly. When Mom or Dad smiles, does the child smile back? If not, she may be lacking another sign of normal social development. A toddler who shows three or more of the 23 behaviors listed on the M-CHAT will be rated “at risk” for autism spectrum disorder.

Leslie and Paul had filled out the M-CHAT during Noah’s last visit to the pediatrician. Noah had passed, but at 22 months he was still missing milestones. His language had not improved, and Leslie and Paul noted he was not making eye contact with them when they spoke to him. He showed more interest in objects than in other children. At a family gathering, Noah focused intently on solitary activities rather than engaging in the goings-on around him.

Noah’s parents found an M-CHAT online. This time they answered yes to new items: Noah was not pointing, was not responding consistently to his name and was not bringing his parents objects that he wanted to show them. Noah now scored “at risk.” Leslie and Paul brought him to a neuropsychologist, who watched him play and tested him for behaviors

FAST FACTS

NO TIME TO LOSE

- 1 Autism, a complex disorder of brain development, is now estimated to affect one in 88 kids.
- 2 Delivering therapy to kids with symptoms of autism at age one or two is likely to result in greater improvements in IQ, language and social skills than does starting therapy later.
- 3 Researchers have developed screening tools that can identify at-risk infants and toddlers, along with a treatment designed for children as young as a year old.

The Modified Checklist for Autism in Toddlers screens for early signs of the disorder. “Does your child look you in the eye for more than a second or two?” it asks. Eye contact does not tend to come naturally to children who develop autism.

that are considered red flags. His parents completed additional rating scales. These assessments indicated that Noah indeed had autism. His was a moderate case; his cognitive abilities outpaced his social skills.

Catching It Early

That diagnosis arrived too late for Leslie and Paul’s liking, however. “We saw that for neuroplasticity every month counts,” Paul says. “And we had given up months just waiting.”

Specialists who share Leslie and Paul’s concerns are developing diagnostic tools that provide preliminary answers sooner. One of these, a checklist called the First Year Inventory (FYI), is geared toward infants as young as 12 months. First proposed by occupational science professor Grace Baranek and her colleagues at U.N.C. Chapel Hill in 2003, the checklist looks for such risk factors as oversensitivity to touch—say, getting upset when hugged or refusing foods that are crunchy—that are precursors to later sensory regulation problems. Other early signs of trouble include a loose or floppy body when picked up, which signals motor deficits, and failing to turn to look at someone who calls the child by name.

In a study published in 2013 Baranek and her colleagues tested the checklist by giving it to the parents of 699 one-year-olds deemed at risk. They later followed up with parents to find out which of the children had received a diagnosis of autism at age three. At first glance, the results were not the most encouraging. The FYI had identified half of those who went on to develop autism and falsely cleared the other half, who showed no early warning signs. Further, approximately 70 percent of the children who received an at-risk score did not develop autism. Yet most of these kids turned out to have a learning deficit or a different developmental disability, such as attention-deficit hyperactivity disorder. The researchers concluded that though far from foolproof and in need of refinement, the test could serve as a useful initial indicator that a child needs evaluation.

Another experimental measure, the Geometric Preference Test for Autism, involves tracking a toddler’s gaze. In previous work, adults with autism have shown a predilection for viewing



patterns over people. (Most individuals show the opposite preference.) Some researchers thus reasoned that very young kids with and without autism might diverge in this respect as well. In a study published in 2011 neuroscientist Karen L. Pierce of the University of California, San Diego, and her colleagues showed 110 kids aged one to four a one-minute movie, in which half the screen displayed moving geometric patterns and the other half kids doing yoga, while they tracked the infants’ eye movements. Then they administered a diagnostic test for autism. If the child was younger than three, the age at which autism becomes evident in virtually all cases, the researchers repeated the test every six months until he or she reached that age.

The researchers found that 40 percent of those who had, or went on to develop, autism spent more than 50 percent of their time looking at the side of the screen displaying geometric patterns. In contrast, 98 percent of the infants who turned out to be developing normally spent most of their time focused on the yoga video. This preference showed up in babies as young as 14 months. Thus, eye tracking as a gauge of interest in people can provide another early hint that a child is, or is not, at risk for autism. Still, this video test catches less than half of those who end up with a diagnosis.

The M-CHAT—the tool that Leslie and Paul used to assess Noah—also has its flaws. It identifies only about 85 percent of kids who go on to develop autism. About 40 percent of those who receive an at-risk score are false positives—they do not end up with autism—although the vast majority turn out to have another developmental disorder or delay, according to Robins.

Like many complex disorders, autism resists being defined by a single behavioral or genetic test. Although researchers

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Most toddlers point out objects of interest to others by the time they are 18 months old. But children with autism may need to be taught how to use this gesture to show people what they like or want.

have associated variants of certain genes with autism, having these variants is far from a sentence: 80 percent of infants with a genetic predisposition do not develop the disorder. Some experts say that combining different methods such as genetic screening, behavioral checklists and eye tracking in clinics could measure a child's risk more accurately.

Treatments for Tots

One major reason to start therapy as early as possible is that infants learn about the world and other people through social interaction. Because children with autism have difficulty communicating and relating to others, they miss out on critical learning opportunities. A child who focuses on objects rather than people will be slower to learn how to read facial expressions or convey emotions appropriately. As a result, problems in communication and behavior worsen with time. Children with autism may throw tantrums, act aggressively, and even injure themselves out of frustration and anxiety from being unable to express their needs. Therapy aims to avoid these troubles by teaching and rewarding more appropriate social behaviors.

In the standard autism therapy, applied behavior analysis (ABA), specific behaviors are introduced systematically. For example, a child might be instructed to imitate a particular gesture or to choose an object on command. A therapist then rewards a child with a lollipop or a favorite toy for doing something right. The intensive form of the treatment requires 25 to 40 hours a week of one-on-one therapy for one to three years, and parents often extend the therapy at home. Studies have shown that ABA improves children's communication and self-care skills, as well as their school performance. Many children with autism also receive speech therapy to help them use language in social settings, occupational therapy to help them get dressed, eat and use the bathroom on their own, and physical therapy to help them sit, walk and run to compensate for poor coordination and balance.

ABA did not work well for Noah, who did not like being told what to do or how to play, and he became upset when he was denied a toy for behaving incorrectly. He refused to do the tasks, threw tantrums, experienced night terrors—and engaged in more autism-typical behaviors such as meticulously lining up toy cars and screaming if anyone touched them.

Paul scoured the Internet for other interventions and found the Early Start Denver Model (ESDM), a therapy for infants as young as a year old developed by Sally J. Rogers of the University of California, Davis, MIND Institute and Geraldine Dawson, now at Duke University Medical Center. Because no ESDM therapists lived near them—only 50 or so individuals are certified to perform it in the U.S.—Leslie and Paul used the manual as their guide. But eventually they realized they needed professional help and contacted Dawson. They began driving three hours each way to get Dawson's advice, as well as therapy for Noah.

The ESDM emphasizes interaction as the basis for learning, and instead of doling out explicit rewards, the therapist aims to make the activities themselves rewarding to the child. An adult first searches for something that engages the child—tickling, say, or driving toy cars. Then the parent or therapist coaxes social behaviors in that context. If a child likes a specific book, for example, the adult might encourage the child to point to the book as a way of requesting it. In Noah's home, toys are now in bins and on high shelves so that he has to point to get what he wants.

Collaborative play involving eye contact and sharing is taught next. For example, Noah's parents try to surprise their son by changing the tone or speed of their voice while reading, so that Noah will look up at them and make eye contact—which they reward with a huge smile. Social skills are also taught as part of everyday activities, such as during bath time or lunch. If Leslie wants Noah to choose between two types of drinks at a meal, she holds both beside her face so that he naturally looks up at her before asking for one of them.

Playing Catch (Up)

ESDM has shown significant promise in moderating the symptoms of autism. In a study of children diagnosed with au-

If Noah's mom wants her son to choose between two types of drinks at a meal, she holds both beside her face so that Noah looks up at her before asking for one of them.

tism published in 2012, Dawson and her colleagues enrolled 48 toddlers in either ESDM-based therapy or a more typical regimen consisting of speech therapy, teaching self-care habits such as brushing teeth and hair, and classroom-behavior training. The researchers also recorded the children's brain activity while they looked at images of objects and faces.

After two years of treatment, the kids who received the ESDM intervention showed fewer symptoms than those who had been given the standard therapy. In addition, the brain activity of those in the ESDM group mirrored that of typical children and diverged from those given standard care. Like normally developing toddlers, children treated with the Denver approach had brain patterns reflecting greater attention to the faces than the objects, suggesting the therapy had helped these children establish a normal preference for social information. Those who received traditional treatment, on the other hand, displayed brain activity indicating that they paid more attention to the objects than the faces.

Other data show that the Denver approach, despite its hefty price tag, saves money in the long run, primarily because it appears to work. In a study presented last year at the Autism Speaks Toddler Treatment Network conference, psychiatry researcher David Mandell of the University of Pennsylvania and his colleagues found that at four years posttreatment, the average cost of autism-related services for 18 toddlers with autism who had received ESDM for two years was about \$1,000 less a month than for 21 similar toddlers who had received speech and occupational therapy for the same period. The ESDM recipients needed 100 fewer hours of services every month, and they were more likely to be placed in a regular classroom than an autism-specific one.

Although early treatment is recommended for all affected children, its practical benefits depend on the severity of a child's diagnosis. In a study published in 2013 clinical psychologist Catherine Lord of Weill Cornell Medical College and her col-

leagues followed 100 children diagnosed with autism before age three until they were 20 years old. They found that of the mildly affected children who began therapy before age three, about 40 percent ended up succeeding in college, making friends and showing no obvious symptoms. In contrast, *all* of a group of similarly affected kids who did not receive early treatment continued to show clear signs of autism. For more severely impaired children, Lord has shown that early treatment improves verbal and social skills but does not eliminate the need for special services in adulthood.

In Noah's case, early therapy seems to have produced remarkable results. Within one month of first seeing Dawson, at 28 months old, Noah started pointing spontaneously. About three months later he looked at his parents to request something. One month after that, in April 2013, Noah gestured as a way of sharing information with others: he pointed something out to his younger sister, Elina.

Now three years old, Noah engages in creative play of his own design, telling stories with action figurines and dressing up in costumes. His ability to speak and understand language about facts is equal to that of his peers. His social skills remain at the level of a two-year-old. But that level is enough for him to make friends with younger kids. He now also plays *with* Elina, throwing a ball for her to catch or chasing her around the house. "His world has opened up now," Paul says. "He doesn't have that focused tunnel vision anymore."

Moving kids out of their mental tunnels may hinge on noticing that they are in them while their budding brains are most amenable to change. **M**

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FREEING UP

INTELLIGENCE

A preoccupation with scarcity diminishes IQ and self-control.
Simple measures can help us counteract this cognitive tax

By **Sendhil Mullainathan and Eldar Shafir**

ILLUSTRATION BY STUART BRIERS

Imagine sitting in an office located near the railroad tracks. Trains rattle by several times an hour. As you try to concentrate, the rumble of every train pulls you away from what you are doing. You need time to refocus, to collect your thoughts. Worse, just when you have settled back in, another train hurtles by.

This description mirrors the conditions of a school in New Haven located next to a noisy railroad line. In the early 1970s two researchers decided to measure the impact of this noise on students. They noted that only one side of the school faced the tracks, so the students in classrooms on that side were particularly exposed to the noise but were otherwise similar to their fellow students.

Adapted from *Scarcity: Why Having Too Little Means So Much*, by Sendhil Mullainathan and Eldar Shafir, by arrangement with Times Books, an imprint of Henry Holt and Company, LLC (North America), and Allen Lane (UK). Copyright © 2013 by Sendhil Mullainathan and Eldar Shafir. All rights reserved.



They found a striking difference between the two sides of the school. Sixth graders on the train side were a full year behind their counterparts on the quieter side. Prompted by this study, the city installed noise padding. This intervention erased the difference, the researchers found: students on both sides of the building now performed at the same level. These results mirror many laboratory studies that have documented the powerful effects of even slight distraction.

NOISY TRAINS OF THOUGHT ARE HARD TO IGNORE. ALTHOUGH THE ROOM SEEMS QUIET, IT IS FULL OF DISRUPTIONS—ONES THAT COME FROM WITHIN.

Now picture yourself working in a pleasant, quiet office: no disruptions, no trains. Instead you are struggling with your mortgage and the fact that freelance work is hard to come by. Your spouse and you are living a two-earner life with only one-and-a-quarter earners. You sit down to focus on your work. Soon your mind is wandering. Should we sell the second car? Should we take out another loan? These noisy trains of thought are every bit as hard to ignore. Although the room seems quiet, it is full of disruptions—ones that come from within.

Such internal disruptions stem from scarcity. An unrealized need can capture our attention and impede our ability to focus on other things. Scarcity in one walk of life means we have less attention, “less mind,” in the rest of life. The concept of less mind is well studied by psychologists. Although careful research in psychology employs several fine distinctions to capture this idea, we use the single umbrella term “bandwidth” to cover them all. Bandwidth refers to our cognitive capacity and our ability to pay attention, make good decisions, stick with our plans and resist temptations. It correlates

FAST FACTS

A SCARCITY MIND-SET

- 1 An involuntary preoccupation with an unmet need, such as a shortage of money or time, can capture our attention and impede our ability to focus on other things.
- 2 A fixation on scarcity taxes our cognitive capacity and executive control, thus diminishing intelligence and impulse control, among other things.
- 3 We can free up cognitive bandwidth by converting recurring demands into one-time actions.

with intelligence and SAT performance, impulse control and success on diets. Scarcity creates a powerful goal—dealing with pressing needs—that inhibits other considerations. We argue that by constantly drawing us back to that urgent unmet goal, scarcity taxes our bandwidth and our most fundamental capacities.

Bandwidth Blues

We use the term “bandwidth” to refer to two broad, related components of mental function. The first might be referred to as cognitive capacity, the psychological mechanisms that underlie our ability to solve problems, retain information, engage in logical reasoning, and so on. Perhaps the most prominent in this category is fluid intelligence, the ability to think and reason abstractly and solve problems. The second is executive control, which underlies our ability to manage our cognitive activities, including planning, attention, and initiating and inhibiting actions. Cognitive capacity and executive control are multifaceted. And scarcity affects both.

A prominent and universally accepted measure of fluid intelligence is the Raven’s Progressive Matrices test, named after British psychologist John Raven, who developed it in the 1930s. With our graduate student Jiaying Zhao, we used this test to observe the effect of scarcity on the fluid intelligence of people in a New Jersey mall. First, half the subjects were presented with simple hypothetical scenarios, such as this one:

Imagine that your car has some trouble, which requires a \$300 service. Your auto insurance will cover half the cost. You need to decide whether to go ahead and get the car fixed or to take a chance and hope that it lasts for a while longer. How would you go about making such a decision? Financially, would it be an easy or a difficult decision for you to make?

We then gave them a series of Raven’s matrices problems. Using self-reported household income, we divided subjects into rich and poor.

For the remaining subjects, we ran the same study with a slight twist—we made the service cost \$3,000 rather than \$300. Remarkably, this change affected the two groups differently. Coming up with half of \$300 or \$3,000 was easy for those who were well-off. They could just pay out of savings or put it on a credit card. For the less well-off, finding \$150 for an important need was not too hard either.

Not so for the \$3,000 car expense: finding \$1,500 would be harder for those with low in-

comes. A 2011 study found that close to half of all Americans reported that they would be unable to come up with \$2,000 in 30 days even if they really needed it. Of course, the question we gave the mall respondents was hypothetical. But it was realistic, and it very likely got them thinking about their own financial concerns. They may not have a broken car, but experiencing money scarcity would mean they had monetary issues close to the top of mind. Once we tickled that part of the brain, the all too real nonhypothetical thinking about scarcity would come spilling out.

And this mental racket affected performance. The better-off subjects, with no distractions, did just as well here as if they had seen the easy scenario. The poorer subjects, on the other hand, did significantly worse. Preoccupied by scarcity, they had lower fluid intelligence scores.

In our numerous replications of this study, the effects have been consistent and big. To understand the size of these effects, consider the impact of sleep deprivation on performance on Raven's matrices. In one study, a group of subjects went to bed at a normal time. Another group was forced to stay awake all night. The next morning all the subjects were given a Raven's test. Not surprisingly, those deprived of sleep did much worse. By comparison, our effect at the mall was even bigger.

Another way to understand the size of our findings is in terms of IQ. Because the Raven's test is used to measure fluid intelligence, it has a direct analogue with IQ. Our effects correspond to between 13 and 14 IQ points. A gain of that many points can lift you from the category of "average" to "superior" intelligence. Or, if you move in the other direction, losing 13 points can take you from "average" to a category labeled "borderline-deficient." In our studies, the same person has fewer IQ points when he or she is preoccupied by scarcity than when not. This cognitive penalty is the key to our story.

The second component of bandwidth is executive control, a kind of central processor for the brain. One of the many important functions to which it contributes is self-control. Because executive control helps to direct attention and modulate impulses, reduced executive function will hamper self-control.

A number of experiments have vividly illustrated this connection. One such study gave subjects a memory task. Some people were asked to remember a two-digit number; others were given a seven-digit figure. The subjects were then led to a lobby to wait for further testing. In front of them in the waiting area were slices of cake and fruit. The real test was which food they would select while rehearsing



those numbers in their head. The subjects with the two-digit number chose the fruit most of the time. Those whose mind was busy rehearsing the seven-digit number chose the cake 50 percent more often. The cake is the impulsive choice. When our mental bandwidth is used on something else, such as rehearsing digits, we have less capacity to prevent ourselves from eating cake.

In another study, white Australian students were served food, but in this case it was something they found disgusting: a chicken foot cooked in a Chinese style that preserved the entire foot intact, claws included. The dish was served by a Chinese experimenter, creating some pressure to act civilized. As in the cake study, some subjects' minds were loaded: they were asked to remember an eight-digit number. Those whose mind was not taxed managed to maintain composure, keeping their thoughts to themselves. The cognitively loaded subjects did not. They were more likely to blurt out rude comments, such as "This is bloody revolting," despite their best intentions. Whether it is eating cake we would rather resist or saying things we do not mean to say, a tax on bandwidth makes it harder for us to control our impulses.

To explore whether scarcity reduces executive control, we returned to the mall in New Jersey. We

Recurring distractions can substantially diminish intelligence, thereby affecting performance at school and on the job.

THE AUTHORS

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repeated our earlier design—with the hypothetical financial scenarios—but then tested our participants on their impulse control rather than fluid intelligence. The results were the same. After the financially easy questions, the poor and the well-off looked similar. Yet the financially hard questions made our poorer subjects significantly more impulsive, whereas the well-off subjects were unaffected.

Scarcity in the Field

These experiments tested our hypothesis. Our interest, though, is in people's everyday lives outside the confines of an experiment. Around this time, we were doing fieldwork on farming in India with economist Anandi Mani of the University of Warwick in England, and we noticed something interesting. Farmers get their income in a big lump, all at once at harvest time. This system means the farmer has a very different financial life from most workers, who get paid regularly.

Now picture a farmer who gets paid in June. The next few months are quite good. Yet even if he is prudent and tries hard to smooth his spending during this period, by the time the following April or May rolls around, he will be tight on cash. So the same farmer is rich in the months after harvest and poor in the months before harvest.

This was quite close to what we needed: we could examine the same farmers' bandwidth in the months before harvest and after harvest. Instead of comparing rich and poor people, we would see how the same person's behavior might vary when tight on money and when flush with cash. But there was one wrinkle. Might not harvest months impose different obligations than ordinary months did? For example, festivals and weddings are common during harvest months—exactly because people are

A parent preoccupied with work may appear to be an unskilled caregiver, yet that person's cognitive bandwidth may simply be heavily taxed.



WHETHER IT IS EATING CAKE WE WOULD RATHER RESIST OR SAYING THINGS WE DO NOT MEAN TO SAY, A TAX ON BANDWIDTH MAKES IT HARDER FOR US TO CONTROL OUR IMPULSES.

cash-rich. So instead of seeing the effects of scarcity, we might just see the effects of celebrations.

To get around this, we used sugarcane farming, which has a peculiar feature. Sugarcane requires an enormous factory to crush the cane and extract the juice (which, once evaporated, forms sugar). The factories can process only so much, and the crop cannot sit for long after harvesting. So sugarcane is harvested during a four- to five-month window. Neighboring plots are often on very different harvest cycles. One farmer may be in the process of harvesting, whereas a neighbor might have sold his crop several months earlier. This rather obscure fact gave us the break we needed. We could now study the same farmers when they are poor and rich and know that there is nothing specific about the preharvest and postharvest months.

As we expected, the data showed that the farmers were more financially strapped preharvest. In the month before harvest, 78 percent of them had pawned something (and 99 percent took some kind of loan), but in the month after harvest only 4 percent pawned something (and only 13 percent took any kind of loan). Before harvest, they were also 11 percent more likely to report having trouble coping with ordinary bills.

We again measured fluid intelligence and executive control. We gave the farmers a Raven's matrices task, and for executive control we chose the Stroop task. In this task, subjects see strings of items, such as A F F F, and must quickly say how many items are in the string. When you see 2 2 2 2, quickly saying "four" is quite hard. We found that farmers performed much worse on both these tests before harvest than after harvest. Much like our subjects in the mall, the same person looked less intelligent and more impulsive when he was poor. Yet in this case, it was not us who triggered scarcity-related thoughts or even tried to bring them to the surface—those thoughts were there naturally.

Again the magnitudes were large. The postharvest farmers got about 25 percent more items correct on a Raven's test. Put in IQ terms, this percent-

age corresponds with about nine or 10 IQ points. It is not as big a gap as in the mall, but that is to be expected. After all, here we had not induced them to think about money. We simply measured their mental state at an arbitrary point. On the executive-control task, they were 11 percent slower in responding and made 15 percent more errors while poor, quite comparable to the mall study.

Returning to where we started, we see that the results suggest a major twist in the debate over the cognitive capacity of the poor. We would argue that the poor do have lower effective capacity than those who are well-off. Not because they are less capable but rather because part of their mind is captured by scarcity.

Give Yourself a Break

Tight finances are just one kind of scarcity; dieting is another. Across a variety of cognitive tests, psychologists find that people simply perform worse when they are dieting. And when they interview the respondents, they find a common pattern: concerns related to dieting are top of the mind for these dieters and interfere with their performance. Other research has identified a similar effect from loneliness—a social form of scarcity.

What, then, is so special about scarcity? Scarcity is a clustering of several important concerns. Unlike a marital spat that can happen anywhere and to anyone, preoccupations with money and time cluster around the poor and the busy, and they persist. Whereas only some people who experience abundance will be preoccupied, everyone experiencing scarcity will fixate on their state.

The size of these effects suggests the bandwidth tax has a substantial influence on a full array of behaviors, even those such as patience, tolerance, attention and dedication, that usually fall under the umbrella of personality or talent. When she snaps at her daughter, the harried sales manager looks like a bad parent. The financially strapped student who misses some easy questions on a test looks incapable or lazy. Yet these people are not unskilled or uncarving, just heavily taxed. The problem is not the person but the context of scarcity.

The deeper lesson is the need to focus on managing and cultivating bandwidth, despite pressures to the contrary brought on by scarcity. Increasing work hours, working people harder, forgoing vacations, and so on are all tunneling responses, as is borrowing at high interest. They ignore the long-term consequences. Psychiatrists report an increasing numbers of patients who show symptoms of acute stress: “stretched to their limits and beyond,

TIPS FOR MANAGING SCARCITY

Convert tasks that demand constant vigilance into one-time actions.



Finances: Enroll in an employer’s 401(k) plan so that saving for the future becomes automatic. Sign up for automatic bill payment.



Exercise: Set up appointments with a personal trainer or friend to work out together or make a bet with a friend. These measures raise the stakes of sticking with your exercise plan.



Work: Schedule breaks for walks and stick to a regular bedtime. Sacrificing health to put in longer hours takes a toll on us mentally, physically and emotionally, which diminishes performance.



Family time: Sign up for a weekly activity together, to ensure that even at your busiest you have quality time once a week.



Food: Knowing that stress compels us to make unhealthy choices, plan ahead for tough times by stocking your pantry with nutritious items. Being health-conscious while shopping rather than at every meal frees up cognitive bandwidth.

with no margin, no room in their lives for rest, relaxation and reflection.”

There is nothing magical about working 40 or 50 or 60 hours a week. But there is something important about letting your mind out for a jog—to maximize bandwidth rather than hours worked. **M**

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ADHD GROWS UP

Newly recognized, adult ADHD threatens the success and well-being of 4 percent of adults.

A combination of treatments can help the afflicted lead a more productive life

By Tim Bilkey, Craig Surman
and Karen Weintraub



Zoë Kessler went through the first four decades of her life thinking something must be wrong with her.

When she was a child, Kessler could not understand why she kept misbehaving. “I spent a ton of time in the hall for talking and being the class clown,” she says. “My mom couldn’t control me, and I couldn’t control me.” In adulthood, her behavior improved, but she was so unfocused she had trouble figuring out what she should be doing minute to minute, and she struggled to complete the projects she had once been so excited about starting.

Then, at age 47, Kessler was diagnosed with attention-deficit hyperactivity disorder (ADHD). She realized that a lot of the traits that had long made her feel out of place were actually symptoms of a condition that could be treated. “I’ve had to rethink my entire life,” she says. “Why didn’t anyone tell me?”

During Kessler’s childhood, most people thought only little boys could have ADHD. Clinicians are realizing that ADHD is common in girls, too. Further, they are recognizing that restlessness is not the only smoking gun. Although Kessler was as hyperactive and talkative as stereotypical boys with the condition, now clinicians realize that many children with ADHD seem more spacey than fidgety. In fact, Kessler was relatively lucky to be diagnosed at all. In a study of mental health conditions in the U.S. published in 2006, health care policy professor Ronald C. Kessler of Harvard University (who is no relation to Zoë) and his colleagues screened 3,199 adults for ADHD, conducting fol-

low-up interviews in 154 of them. They concluded that only one in 10 adults in the U.S. with the condition receives a diagnosis of ADHD.

That statistic most likely will improve as more researchers and clinicians acknowledge the adult form of ADHD. During the past two decades multiple studies have confirmed that the disorder can persist across a person’s life span. Indeed, the latest edition of the American Psychiatric Association’s diagnostic manual, the *DSM-5*, is the first to explicitly recognize adult ADHD, which is thought to afflict 4.4 percent of the adult population, in its description of the disorder [see box on page 69].

The need for treatment in adulthood has become increasingly apparent. Recent studies have demonstrated that the disorder can limit professional success and income, strain relationships and diminish well-being. Fortunately, research published during the past decade has shown that stimulant medication, the standard treatment for children, is also effective in adults. Yet evidence also suggests that adults with ADHD must learn new habits to overcome the numerous organizational challenges they face daily.

Researchers have devised new strategies to help these individuals plan, prioritize and organize their lives so that they can accomplish their goals, stay healthy and keep their relationships intact. Many of these techniques would also benefit the vast majority of people, given that virtually all of us could use

ways to more efficiently and effectively run our own lives.

Recognizing Adult ADHD

With time, about half the children treated for ADHD recover completely. For those who do not respond fully to treatment, aspects of the disorder nonetheless change as a person matures. At all ages, people with ADHD face challenges stemming from a combination of three core symptoms: trouble paying attention, restlessness and impulsivity. By adulthood, hyperactive and impulsive traits tend to wane, whereas difficulties with controlling attention more often persist.

In some instances, ADHD may seem to show up suddenly in adulthood. In cases such as Kessler’s, the symptoms are missed in childhood. Yet often the signs very likely are masked. After all, parents, educators and other adults usher children through each day, collecting their belongings, bringing them to school and activities on time, cajoling them to do homework and chores. Such supervision can compensate for a child’s deficits in attending to tasks and working toward goals. As children grow up, much of that support disappears just as responsibilities accumulate, enabling previously hidden deficiencies to become all too obvious. Without parents to remind them of assignments, a college student may find his or her grades dropping dramatically. Later the demands of a job or parenthood may create complexities that a person cannot manage. As important matters fall through the cracks and sufferers become demoralized or overwhelmed, they may finally seek help, leading to a diagnosis of ADHD.

Although the pattern of difficulty varies from one person to the next, one central problem that afflicts adults is an inability to focus. They tend to have trouble getting around to, sticking with or finishing certain types of tasks. Although they can generally focus quite well on stimulating activities such as playing video games or working in a fast-paced environment such as an emergency room, they may be easily diverted from tasks that are repetitive—sorting

FAST FACTS

REMEDY FOR THE DISTRACTED

- 1 Only one in 10 adults in the U.S. who is afflicted with attention-deficit hyperactivity disorder (ADHD) receives that diagnosis.
- 2 The latest edition of the American Psychiatric Association’s diagnostic manual is the first to explicitly recognize adult ADHD.
- 3 ADHD can limit professional success, strain relationships and diminish well-being. Yet medication, along with therapy that teaches patients better habits and attitudes, can help individuals meet their goals, stay healthy and maintain friendships.



Adults with ADHD may have difficulty sticking with a challenging task or attending to an extended dialogue at a meeting with colleagues.

laundry or filling out forms—or mentally challenging, such as writing a speech or term paper. Of course, a person can choose to work in a deadline-driven atmosphere that keeps them invigorated, but laundry still has to be sorted, bills paid and complex problems solved.

Impulsiveness, though often less severe in adulthood, can produce other predicaments. With short-term interests and ideas repeatedly trumping long-term goals, a person with ADHD lives a reactive rather than proactive existence. He or she may be unable to curb the urge to check e-mail or Twitter so as to focus on a challenging project. Spontaneous spending can lead to unnecessary financial burdens and bankruptcy. Sexual impulsivity can cause unwanted pregnancies, and reckless driving may result in accidents. Cutting people off in conversation or blurting out inappropriate remarks—signs of verbal impulsivity—can harm relationships.

Such reactivity, and its consequences, may stem in part from a lack of emotional control. In a study published in 2013 one of us (Surman) and his colleagues at Massachusetts General Hospital used a questionnaire to assess emotional self-regulation—a construct that includes frustration tolerance, temper and emotional impulsivity—among 206 adults with ADHD and 123 without the disorder. They found that 61 percent of those with ADHD had trouble controlling their emotional expression, overreacting with anger more often than 95

percent of those without ADHD. Such difficulty was associated with poorer quality of life, worse social adjustment in many realms, a higher likelihood of divorce (and of having never been married), and a higher risk of traffic accidents.

Many adults with ADHD also display significant problems with organization and planning. Individuals may fail to maintain a schedule, prioritize tasks and keep track of time. At work, they often struggle to finish important assignments—becoming sidetracked by minutiae—run late and spend too much time getting their work done. Sometimes their scattered lives prevent them from making it to the office at all. Results from the World Health Organization's World Mental Health Survey published in 2008 demonstrated that untreated adults with ADHD missed the equivalent of 22 more days of work than those without the condition. This underperformance may explain why adults with ADHD are often passed up for promotions and unable to reach their professional potential.

Challenges with planning and organization also lead to irregular or unhealthy patterns of self-care. Quality of sleep, which can affect health, happiness and success, is often poor in adults with ADHD. In a study published in 2009 Surman and his colleagues found that more than half of 182 adults with ADHD reported either restless sleep or difficulty getting to sleep. Those with ADHD also

said they went to bed more than half an hour later, on average, than did 117 adults without the condition. Individuals with the disorder also had a wider range of bedtimes and greater daytime sleepiness, which can, of course, compound attention problems.

Pills and Skills

Reducing the frustrations and disabilities that accompany ADHD in adults usually requires a multifaceted approach that includes drug and behavioral therapy. Medication can ameliorate distractibility and impulsiveness in the 6 percent of children diagnosed with ADHD. Several studies have now shown that stimulants such as Ritalin and Concerta (both methylphenidate) or Adderall, which is a combination of amphetamine and dextroamphetamine, can improve focus and decrease restlessness in adults as well. Individuals taking medication for ADHD often report that they are better able to get around to, stick with and finish tasks.

But medication alone does not hone the more complex organizational and planning skills that help people hew to a regular routine. For example, in a clinical trial published in 2011 Joseph Biederman and his colleagues at Mass General found that 40 percent of adults who took methylphenidate for six weeks still reported significant challenges planning events and staying organized.

Thus, many adults with ADHD also need therapy to learn and practice organizational and self-regulatory skills. Individuals need different types of support, but therapists may teach them to rank items on to-do lists in order of importance, recognize what distracts them from tasks, and establish new habits, such as setting aside time for planning and prioritizing.

THE AUTHORS

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Adults with ADHD also often need help setting up an organizational structure—typically, a consistent location—for important objects and pieces of information. House and car keys should have a home rather than being tossed in various places. Appointments and phone numbers should similarly be entered into a calendar or contact list that is readily accessible rather than scribbled on the back of an envelope that could get lost or tossed in the trash. People may program an alarm to remind them of an appointment or to pick up the kids or use an electronic calendar that synchs with e-mail and their cell phone so they can easily enter a meeting or event as soon as they learn about it.

In a study published in 2005 psychologist Steven A. Safren of Mass General and his colleagues showed that 12 training sessions, focused on adopting organizational strategies, combined with medication, was more effective for ADHD symptoms than medication alone in 31 adults with ADHD. In a follow-up study published in 2010 Safren found that 12 weeks of training in organizational techniques relieved the burden of ADHD in 79 adult patients more than relaxation therapy of the same duration did.

Therapy can also curtail impulsive decision making. In our own clinical practices, we ask clients to pick “critical moments” in which they tend to stray from their intended course. Such a moment might be deciding to play one more video game instead of going to bed on time or hitting snooze on the alarm clock, until a person is so rushed that gym clothes are forgotten and the planned exercise never happens. Once patients become aware of the moments they go astray, we help them craft a plan for making a better choice. For example, a patient may decide to read rather than play games before bedtime or set aside a time for gaming as a reward for hard work that does not disrupt their ability to wind down from the day. If someone

surfs the Web or compulsively checks e-mail at work, they might download an app that turns off Internet and e-mail access for hours.

Technology such as computer reminders, distraction blockers or planning tools can serve as “peripheral brains” to support the human brain in completing challenging cognitive tasks. People can play a similar role. An assistant might



Identifying impulsive decisions, such as hitting the snooze on the alarm clock, that derail your day can lead you toward better choices in the future.

keep a calendar for you; a spouse might protect family time; a colleague might remind you of a regular meeting. Professionals, such as mental health therapists, rehabilitation specialists and ADHD “coaches,” can also keep people on track and accountable. Coaches may suggest adaptive strategies, teaching clients to prioritize and set realistic goals, among other skills.

Many adults with ADHD use support groups, such as those organized by Children and Adults with ADHD or the Attention Deficit Disorder Association, to meet and confer with others struggling with similar challenges. In these gatherings, group members can discuss their new habits and own up to their failings, a conversation that may help them stick to the strategies they have learned. In

2010 psychologist Mary V. Solanto of the Mount Sinai School of Medicine and her colleagues found that teaching organizational habits in a group setting is also effective at relieving symptoms of ADHD.

“Why Do I Keep Doing This?”

One critical component of therapy is aimed at an emotional barrier to change: a self-critical internal voice that saps the motivation to learn new skills and adopt better habits. Adults with ADHD often suffer psychologically from a sense of unfulfilled potential, the sting of criticism from others or regrets about the mistakes they have made.

“The default was that I was a bad, out-of-control kid who willfully misbehaved,” Kessler says. “My self-esteem and self-confidence were pummeled as a child.” Before her diagnosis and the hard work that followed, Kessler would often see herself as “screwing up.” “Why do I keep doing this?” she would angrily ask herself.

Cognitive-behavior therapy is based on the idea that thoughts, feelings and actions are interrelated and that changing any one of those elements influences the others. In one cognitive technique, called a thought record, a person describes a situation in which he or she experienced distress and a therapist helps that person identify how much of the distress is rational versus emotional—that is, rooted in his or her own perspective. This process can help people see the mental traps that they tend to fall into when coping with difficult situations. These snares may include catastrophizing (thinking that something is far worse than it is); mind reading (believing you know what others think of you); or taking an all-or-nothing approach toward self-worth (you are either a winner or a loser with no middle ground). Therapists help patients adopt a more rational point of view so that they can focus on problem solving. Individuals with ADHD then have the energy to come up with strategies for getting tasks done or

Could You Have ADHD? Test Yourself

Attention-deficit hyperactivity disorder (ADHD) begins in childhood, but recent work shows that it often continues into adulthood. The latest edition of the American Psychiatric Association's diagnostic manual, the *DSM-5*, has revised its criteria for ADHD to explicitly acknowledge the adult form of the disorder. In one change, symptoms must be present before age 12 instead of age seven, the cutoff in earlier editions, meaning adults only need to recall having troubles by middle school age. In another, the description of symptoms now includes examples more relevant to adults. For instance, one that relates to attention reads, "Often fails to give close attention to details or makes careless mistakes in schoolwork, at work, or with other activities." Another in that category states, "Often does not follow through on instructions and fails to finish schoolwork, chores, or duties in the workplace (e.g., loses focus, side-tracked)." Children require six or more symptoms from each set—attention and hyperactivity/impulsivity—to qualify for a diagnosis, whereas people 17 years and older need five or more.

The World Health Organization has developed a test called the Adult Self-Report Scale Screener that incorporates the most common difficulties in adults with ADHD. Answer its questions (*at right*) to find out whether you could be at risk for the disorder.

Check the box that best describes how you have felt and conducted yourself over the past six months. Please give the completed questionnaire to your health care professional during your next appointment to discuss the results.

1. How often do you have trouble wrapping up the final details of a project once the challenging parts have been done?
2. How often do you have difficulty getting things in order when you have to do a task that requires organization?
3. How often do you have problems remembering appointments or obligations?
4. When you have a task that requires a lot of thought, how often do you avoid or delay getting started?
5. How often do you fidget or squirm with your hands or feet when you have to sit down for a long time?
6. How often do you feel overly active and compelled to do things, as if you were driven by a motor?

Never	Rarely	Sometimes	Often	Very Often
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

Add the number of checkmarks that appear in the darkly shaded areas. Four or more checkmarks indicate that your symptoms may be consistent with adult ADHD. It may be beneficial for you to talk with your health care provider about an evaluation.

SOURCE: "ADULT ADHD SELF-REPORT SCALE -V1.1 (ASRS-V1.1) SCREENER," FROM WHO COMPOSITE INTERNATIONAL DIAGNOSTIC INTERVIEW, © WORLD HEALTH ORGANIZATION

even caring for themselves—important tasks such as eating, exercising and sleeping on a regular schedule. The behavioral interventions, such as instruction in organizational techniques and decision making at critical moments, represent another key part of this type of therapy.

For Kessler, medication, along with cognitive approaches, has transformed the way she lives. "Before, I was just too overwhelmed and couldn't really bring anything to term," Kessler recalls. Today she uses a pen-and-paper system to keep track of appointments and the great ideas that bubble up at random times. She also does meditation to lessen her mood swings and improve her focus and time management. Being in nature similarly quiets her mind, stabilizes her mood and helps her manage her hyperactivity. She channels her drive to talk into standup comedy, public speaking and writing. Cultivating friends who are supportive helps her feel better about herself.

Her organization and stamina have improved dramatically through these efforts. Kessler's second book, part memoir, part self-help, entitled *ADHD According to Zoë*, was published in September, and her freelance writing and speaking careers are thriving. Emotionally, she also now understands that when she does say something inappropriate

it is not necessarily a catastrophe. If she needs to apologize to someone, she does, without beating herself up about it. That way she can focus on other aspects of her life. And Kessler's improved mental and organizational discipline has reinforced her sense of self-worth. "I actually get a kick out of myself," she says. **M**

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 - **How to pick an ADHD coach: www.adhdcoaches.org/how-to-pick-an-adhd-coach**
- From Our Archives*
- **Are Doctors Diagnosing Too Many Kids with ADHD?** Scott O. Lilienfeld and Hal Arkowitz; May/June 2013.



Just Say No?

A popular program for preventing teen drug use does not help. Here's what does

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ

"JUST SAY NO." In 1982 First Lady Nancy Reagan uttered those three words in response to a schoolgirl who wanted to know what she should say if someone offered her drugs. The first lady's suggestion soon became the clarion call for the adolescent drug prevention movement in the 1980s and beyond. Since then, schools around the country have instituted programs designed to discourage alcohol and drug use among youth—most of them targeting older elementary schoolchildren and a few addressing adolescents.

There is good reason for concern about youth substance abuse. A large U.S. survey conducted in 2012 by psychologist Lloyd D. Johnston and his colleagues at the University of Michigan revealed that fully 24 percent of 12th graders had engaged in binge drinking (defined as five or more drinks on one occasion) in the past two weeks. Moreover, 42 percent had consumed at least some alcohol in the past month, as had 11 percent of eighth graders and 28 percent of high school sophomores. In addition, 1 percent of 12th graders had tried methamphetamine, and almost 3 percent had used cocaine in the past year.

In an attempt to reduce these figures, substance abuse prevention programs often educate pupils regarding the perils of drug use, teach students social skills to resist peer pressure to experiment, and help young people feel that saying no is socially acceptable. All the approaches seem sensible on the surface, so policy makers, teachers and parents typically assume they work. Yet it turns out



that approaches involving social interaction work better than the ones emphasizing education. That finding may explain why the most popular prevention program has been found to be ineffective—and may even heighten the use of some substances among teens.

Rehearsing Refusal

The most widely publicized teen substance abuse prevention program is Drug Abuse Resistance Education, better known by the acronym D.A.R.E. Created in 1983 by the Los Angeles Police Department, D.A.R.E. asks uniformed police officers to go into schools to warn students about the dangers of drug use and underscore the pluses of a drug-free way of life. In most cases, the

officers do so once a week, typically for 45 to 60 minutes, for several months. D.A.R.E. is immensely popular; according to the program Web site, it has been put in place in 75 percent of U.S. school districts and 43 countries. D.A.R.E. bumper stickers, D.A.R.E. T-shirts, and police cars emblazoned with the word D.A.R.E. are familiar fixtures in many U.S. communities.

Despite this fanfare, data indicate that the program does little or nothing to combat substance use in youth. A meta-analysis (mathematical review) in 2009 of 20 controlled studies by statisticians Wei Pan, then at the University of Cincinnati, and Haiyan Bai of the University of Central Florida revealed that teens enrolled in the program were just

(A large survey revealed that 24 percent of 12th graders had **engaged in binge drinking** in the past two weeks.)

COURTESY OF SCOTT O. LILIENFELD (Lilienfeld); COURTESY OF HAL ARKOWITZ (Arkowitz); AURORA PHOTOS (teenagers)

as likely to use drugs as were those who received no intervention.

A few clues to D.A.R.E.'s deficiencies come from psychologist Pim Cuijpers of the Netherlands Institute of Mental Health and Addiction in Utrecht. In a review of 30 studies published in 2002, she attempted to pinpoint the common

rect social interaction with other students are usually ineffective. Merely telling participants to "just say no" to drugs is unlikely to produce lasting effects because many may lack the needed interpersonal skills. Programs led exclusively by adults, with little or no involvement of students as peer leaders—another

scores of schoolteachers and parents, that D.A.R.E. works. One reason for this discrepancy, clinical psychologist Donald R. Lynam, now at Purdue University, and his colleagues wrote in a 1999 article, is that teachers and parents may overestimate the prevalence of substance use among children. As a

In effective programs, **students learn the social skills** they need to refuse drugs and get chances to practice those skills.

elements of successful programs. Cuijpers reported that the most effective ones involve substantial amounts of interaction between instructors and students. They teach students the social skills they need to refuse drugs and give them opportunities to practice these skills with other students—for example, by asking students to play roles on both sides of a conversation about drugs, while instructors coach them about what to say and do. In addition, programs that work take into account the importance of behavioral norms: they emphasize to students that substance use is not especially common and thereby attempt to counteract the misconception that abstaining from drugs makes a person an oddball.

In a 2011 review of various substance abuse prevention programs, epidemiologist Melissa Stigler of the University of Texas School of Public Health and her colleagues buttressed these conclusions. They further observed that programs that unfold during many sessions—ideally, over several years—garner especially strong results, probably because they provide students with lessons that are reinforced over time, as children mature and encounter different environments.

D.A.R.E. lacks some of these key elements. It typically lasts only months rather than years. Moreover, it affords students few opportunities to practice how to refuse offers of drugs. Indeed, Cuijpers noted that purely educational programs that involve minimal or no di-

rect social interaction with other students are usually ineffective. Merely telling participants to "just say no" to drugs is unlikely to produce lasting effects because many may lack the needed interpersonal skills. Programs led exclusively by adults, with little or no involvement of students as peer leaders—another

Good Intentions That Backfire

Worse, D.A.R.E. programs might occasionally backfire when it comes to the use of milder substances, such as alcohol and cigarettes. In a 2002 review psychologist Chudley Werch, now president of PreventionPLUSWellness in Jacksonville, Fla., and health educator Deborah Owen of the University of North Florida reported a slight tendency for teens who went through D.A.R.E. to be more likely to drink and smoke than adolescents not exposed to the program. Small negative effects for D.A.R.E.-like programs on drinking and smoking were also reported in a 2009 study by public health professor Zili Sloboda of the University of Akron and her colleagues. The reasons for these potential boomerang effects are unclear. Yet by emphasizing the hazards of severe drug abuse, D.A.R.E. may inadvertently convey the impression that alcohol and tobacco are innocuous by comparison.

These scientific findings stand in stark contrast to the belief, held by

consequence, they may assume a decline in use when students of D.A.R.E. abstain from alcohol and drugs. But that conclusion is erroneous if children who did not receive drug prevention education display levels of drug use that are just as low, if not lower. In addition, as Lynam and his colleagues observe, D.A.R.E. makes intuitive sense: it seems plausible that most children exposed to authority figures who warn that drug use is dangerous would hesitate to disobey those admonitions.

The good news is that some proponents of D.A.R.E. are now heeding the negative research findings and incorporating potentially effective elements, such as role playing with peers, into the intervention. Research on these revised programs should soon tell us whether they will make a dent in the considerable problem of substance abuse among vulnerable youth. **M**

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

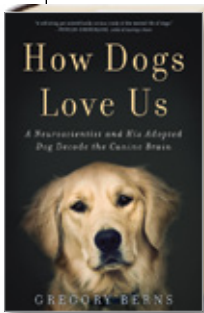
Send suggestions for column topics to editors@SciAmMind.com.

FURTHER READING

- **Project DARE: No Effects at 10-Year Follow-Up.** Donald R. Lynam et al. in *Journal of Consulting and Clinical Psychology*, Vol. 67, No. 4, pages 590–593; August 1999.
- **Interventions for Reducing Adolescent Alcohol Abuse: A Meta-Analytic Review.** Stephen J. Tripodi, Kimberly Bender, Christy Litschge and Michael G. Vaughn in *Archives of Pediatric and Adolescent Medicine*, Vol. 164, No. 1, pages 85–91; January 2010.

> CANINE CONNECTION

How Dogs Love Us: A Neuroscientist and His Adopted Dog Decode the Canine Brain



by Gregory Berns. New Harvest, 2013 (\$25)

In *How Dogs Love Us*, Emory University neuroscientist Berns recounts the death of Newton, his pet pug of 15 years. With age, Newton's spinal cord deteriorated, and the dog lost control of his hind legs, bowel and bladder. Berns recalls

Newton's look of shame after his first accident inside the house and how he interpreted this look as Newton's plea to die. Berns laid him down and watched him snort one last time as he passed. It was then Berns realized he had never known what Newton was thinking or whether his pet loved him back.

That realization marked the beginning of the Dog Project, a research program to decode doggie thoughts and emotions with functional MRI. Scientists already employ fMRI, which uses changes in blood flow as a proxy for brain activity, to scan the brains of restrained monkeys, but Berns wanted to train dogs to willingly enter the machine and learn simple things, such as associating a hand signal with a reward of a hot dog, all the while staying still enough to collect interpretable brain scans.

The first half of the book details how Berns, his lab mates and two pooches worked together to accomplish this feat. It is an entertaining and inspiring inside look at the do-it-yourself aspect of science and a testament to Berns's passion. The latter half is a highly speculative analysis of brain scans collected from Berns's beloved terrier mix, Callie, and a border collie named McKenzie. He exposes Callie and McKenzie to the smells of familiar as well as unknown dogs and humans.

In Callie's scans, Berns observes activation in the caudate, a brain region involved in processing rewards, after exposing her to the smell of his daughter. He interprets this singular finding as evidence that dogs love their owners. In his excitement to describe Callie's brain activity as love, he sometimes forgets that fMRI is not a tool for mind reading and leaps to conclusions about dogs' abilities to mentalize human intentions.

What Berns lacks in hard data, he more than makes up for with scientific curiosity. He hopes his initial foray will spur

future investigations into the mysteries of the canine brain, such as whether dogs have empathy. The book is as much a scientific exploration of how the canine brain might function as it is a deeply personal story about Berns's relationship with dogs as pets and colleagues. Ultimately that connection is what makes the book compelling. —Daniela Hernandez

> NO PAIN, NO BRAIN

Smarter: The New Science of Building Brain Power

by Dan Hurley. Penguin Group/Hudson Street Press, 2013 (\$25.95)

Psychologists have long believed that fluid intelligence, or the ability to learn and solve problems, is essentially immutable. That is why in 2008, when Swiss psychologists Susanne M. Jaeggi and Martin Buschkuhl suggested that they could improve this form of intelligence with a simple working memory task, their findings sent ripples of disbelief among cognitive scientists.

As journalist Hurley explains in *Smarter*, the work of Jaeggi, Buschkuhl and others has sparked a revolution in how we think about intelligence. In recent years evidence has mounted that certain interventions could benefit people of average or high ability or prevent cognitive decline associated with aging and disease. [For more on this work, see "Building Better Brains," by John Jonides, Susanne M. Jaeggi, Martin Buschkuhl and Priti Shah; *SCIENTIFIC AMERICAN MIND*, September/October 2012.]

Hurley investigates the validity of these claims, exploring empirical evidence and implementing some of the better-supported approaches in a weekly routine. For three months he takes countless tests, plays numerous games, learns a new musical instrument, engages in intense physical exercise, receives transcranial direct-current stimulation and wears a nicotine patch—all in pursuit of a nimbler noggin.

Although the precise mechanisms underlying many of these techniques remain unknown, Hurley suggests that electrical brain stimulation may increase intelligence by promoting new neural connections.

Other interventions appear to have fewer direct effects. Nicotine, for example, encourages the flow of dopamine, which

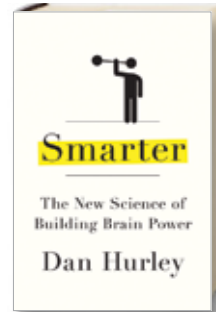
might in turn modulate attention and movement (hence use of the patch). And cardiovascular exercise increases the flow of oxygen to the brain, which could aid cognition.

Hurley measures his intelligence before and after this experiment through a number of IQ tests. Although the results show little or no improvement on many measures, his score on the Raven's matrices, a test of general intelligence, climbs about 16 percent. Notably, Hurley reports feeling more focused, alert and invigorated throughout his training—yet for all we know he may be experiencing a placebo effect.

Despite the limited scientific value of one man's self-experimentation, Hurley's research suggests that his combined approach may be best for achieving real change. At this early stage, though, the field of cognitive enhancement offers more questions than answers. For example, it is unclear whether training in one memory task

truly alters general intelligence as opposed to merely improving skills related to the specific activity. Yet some scientists are optimistic, likening the results to strength training that may target one set of muscles but still improves overall balance and stability.

Smarter presents a clear-eyed but encouraging view of cognitive enhancement, making the science come to life through engaging anecdotes. Although efforts to boost our brainpower are still in their infancy, Hurley convincingly argues that we have the ability to keep our mind razor-sharp by continuously challenging the brain and body. —Daisy Yuhas



> VISUAL PLEASURES

The Aesthetic Brain: How We Evolved to Desire Beauty and Enjoy Art



by Anjan Chatterjee. Oxford University Press, 2013 (\$34.95)

Why do we covet beauty? Why does art, which seems to serve little practical purpose, feel fundamental to our lives? Such questions have long fascinated philosophers and artists. Now neuroscientists are weighing in as well.

The Aesthetic Brain explores the field of neuroaesthetics, the science of how our brain experiences and responds to art, music and objects of beauty. Chatterjee, a neurosci-

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(3) Free or nominal rate copies mailed at other classes mailed through the USPS: average number of copies each issue during preceding 12 months, 0; number of copies of single issue published nearest to filing date, 0. (4) Free or nominal rate distribution outside the mail: average number of copies each issue during preceding 12 months, 90; number of copies of single issue published nearest to filing date, 93. e. Total free or nominal rate distribution (sum of 15d (1), (2), (3) and (4)): average number of copies each issue during preceding 12 months, 1,047; number of copies of single issue published nearest to filing date, 1,047. f. Total distribution (sum of 15c and 15e): average number of copies each issue during preceding 12 months, 134,293; number of copies of single issue published nearest to filing date, 130,631. g. Copies not distributed: average number of copies each issue during preceding 12 months, 125,753; number of copies of single issue published nearest to filing date, 130,071. h. Total (sum of 15f and 15g): average number of copies each issue during preceding 12 months, 260,029; number of copies of single issue published nearest to filing date, 260,702. i. Percent paid (15c/15f × 100): average number of each issue during preceding 12 months, 99.2%; number of single issue published nearest to filing date, 99.2%. 16. Publication of statement of ownership will be printed in the January/February 2014 issue of this publication. 17. I certify that all information furnished on this form is true and complete. I understand that anyone who furnishes false or misleading information on this form or who omits material or information requested on the form may be subject to criminal sanctions (including fines and imprisonment) and/or civil sanctions (including civil penalties). 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entist, argues that an instinct for beauty has helped our species endure. Art is a product of our quest for beauty and knowledge.

The author first walks through the complex neural mechanics of aesthetic experience. When we look at something, whether it is the *Mona Lisa* or a city skyline, information from nerve cells in the eye's retina travels to the brain's occipital lobes to process what we have seen. If we find these sights beautiful, the brain is flooded with pleasure-inducing neurotransmitters. Beauty is inextricably linked with pleasure.

Chatterjee turns to evolutionary psychology to explain why we are drawn to things of beauty, positing that this urge may have improved our ancestors' chances of survival. Facial symmetry often signaled a better mating partner, and landscapes replete with rolling hills, waterways and blooming plants may have appealed to primitive humans because they provided safe refuge and sustenance.

Of course, our relation with art is more complex than such simplistic theories may suggest. Art is not always beautiful, at least

not in a straightforward way. It can be vulgar, bizarre or abstract; it can tell a story, incite emotions or depict a given moment. Take the sculpture *Piss Christ*, which depicts a crucifix soaked in urine. Chatterjee explains that people viewing this artwork out of context often react with disgust, but those who know that the artist intended to show the horrors of the crucifixion tend to find a deeper meaning in it. Our response to art can be richer and more nuanced than to a pleasing vista or tableau.

Overall, *The Aesthetic Brain* offers an intriguing overview of the neural and historical underpinnings of beauty and art. Chatterjee, however, may tackle too much in his 244-page book. He attempts to capture the immense topics of aesthetics, pleasure and art while weaving in anecdotes about science, history and even math, which can at times cause him to lose track of his main thesis. Nevertheless, he makes a compelling case that although art and beauty may seem nonessential, they epitomize our search for pleasure and meaning in life.

—Daisy Yuhas

ROUNDUP

UNEARTHING INNER RESOURCES

Three books help us nurture our strengths and achieve our dreams



Sitting through an entire lecture or even a movie without furtively glancing at a cell phone can be surprisingly difficult for some of us. In **Focus: The Hidden Driver of Excellence** (HarperCollins, 2013), psychologist and journalist Daniel Goleman explores the significance of attention, revealing the deleterious effects of distractions on work and relationships. Investing more fully in the moment can spur creativity when wrestling with a problem or even spark a new

romantic connection. Attention, Goleman suggests, is like a muscle, and learning to strengthen it through simple exercises, such as 10 minutes of deep breathing every morning, can help the brain gain focus.

Enhancing attention is not the only thing that can improve our prospects. In **Compelling People: The Hidden Qualities That Make Us Influential** (Penguin Group/Hudson Street Press, 2013), communications consultants John Neffinger and Matthew Kohut illuminate what makes certain people particularly likable and magnetic. Neffinger and Kohut home in on two especially important characteristics: strength and warmth. They argue that strength reflects a person's competence and that warmth indicates someone's capacity for empathy. The authors also offer tips on how to increase these qualities.

Despite a desire to aim high, insecurity often holds us back. In **The 5 Essentials: Using Your Inborn Resources to Create a Fulfilling Life** (Penguin Group/Hudson Street Press, 2013), cognitive neuroscientist Bob Deutsch, with writer Lou Aronica, contends that we can overcome this impediment by developing certain innate abilities, such as curiosity and openness. Deutsch provides inspiration by describing the personal trials of artists and scientists who have overcome self-doubt or other setbacks to ultimately achieve success.

—Victoria Stern

THINKSTOCK

asktheBrains

An unwarranted, persistent fear of a certain situation or object can cause overwhelming distress.

Why do we develop certain irrational phobias?

—Andrew Watts, via e-mail



Katherina K. Hauner, a post-doctoral fellow at the Northwestern University Feinberg School of Medicine, answers:

UNDER NORMAL circumstances, fear triggers a natural fight-or-flight response that allows animals to react quickly to threats in their environment. Irrational and excessive fear, however, is typically a maladaptive response. In humans, an unwarranted, persistent fear of a certain situation or object, known as specific phobia, can cause overwhelming distress and interfere with daily life. Specific phobia is among the more prevalent anxiety disorders, affecting an estimated 9 percent of Americans within their lifetime. Common subtypes include fear of small animals, insects, flying, enclosed spaces, blood and needles.

For fear to escalate to irrational levels, a combination of genetic and environ-

mental factors is very likely at play. Estimates of genetic contributions to specific phobia range from roughly 25 to 65 percent, although we do not know which genes have a leading part. No specific phobia gene has been identified, and it is highly unlikely that a single gene is responsible. Rather variants in several genes may predispose an individual to developing a number of psychological symptoms and disorders, including specific phobia.

As for the environmental component, a person may develop a phobia after a particularly frightening event, especially if he or she feels out of control. Even witnessing or hearing about a traumatic occurrence can contribute to its development. For instance, watching a devastating airplane crash on the news may trigger a fear of flying. That said, discerning the origin of the disorder can be difficult because people tend to do a poor

job of identifying the source of their fears.

Our understanding of how and why phobias crop up remains limited, but we have made great strides in abating them. Exposure therapy, a form of cognitive-behavior therapy, is widely accepted as the most effective treatment for anxieties and phobias, and the vast majority of patients complete treatment within 10 sessions. During exposure therapy, a person engages with the particular fear to help diminish and ultimately overcome it over time. An individual might, for example, look at a photograph of the dreaded object or become immersed in the situation he or she loathes. Fortunately for those plagued by irrational fears, we can treat a phobia rapidly and successfully without necessarily knowing its origin.

What brain activity can explain suspension of disbelief?

—Michael Mueller, Ohio



Norman N. Holland, author of *Literature and the Brain*, replies:

ALTHOUGH WE KNOW a fair amount about the brain activity linked with reading, no one has isolated the mechanisms tied specifically to suspension of disbelief. Yet we can extrapolate how the brain behaves on a more general level.

Poet Samuel Taylor Coleridge coined the term “suspension of disbelief” in 1817, but almost two centuries would lapse before we could infer how the brain might support this puzzling phenomenon. Coleridge asked readers of his fantastical poems, including *The Rime of the Ancient Mariner*, to give him “that willing suspension of disbelief for the moment, which constitutes poetic faith.” That phrase, “poetic faith,” encapsulates what our brain is doing. It isn’t that we stop disbelieving—it’s that we believe two inconsistent things. We accept that we are sitting and reading or watching a movie. We also believe or, more accurately, feel that what we are reading or viewing is happening.

Action is the key. When we are reading a story or watching a movie, we know that we cannot or will not act to change what is occurring, a phenomenon philosopher Immanuel Kant

called disinterestedness. Yet because we are not going to act, the brain economizes. We turn off the neural processes that tell us we might need to do something about what we are seeing. The prefrontal cortex does not try to assess the reality of what we are seeing, nor does it trigger motor impulses. That is why when we are sitting in a theater, we do not jump out of our seats to save the blond starlet even though we know she is about to get chopped up by a chainsaw-wielding fiend.

Losing ourselves refers to another element of poetic faith, when the audience is, in the psychologists’ term, “transported.” We cease to be aware of our body, our posture or our environment. No longer are we in our living room or able to see the cinema’s glowing exit sign. Perhaps most important, our limbic system causes us to feel emotions—anger, disgust, jealousy, desire, fear—about the stories we are watching or reading.

Being transported emotionally into an alternative reality helps us to invest more completely in a piece of fiction, no matter how unbelievable. Thus, we are able to believe in the supernatural occurrences in Coleridge’s *Ancient Mariner*, the inhuman strength and speed of Superman, or the harrowing journey of a Hobbit in his quest to destroy an evil ring. **M**

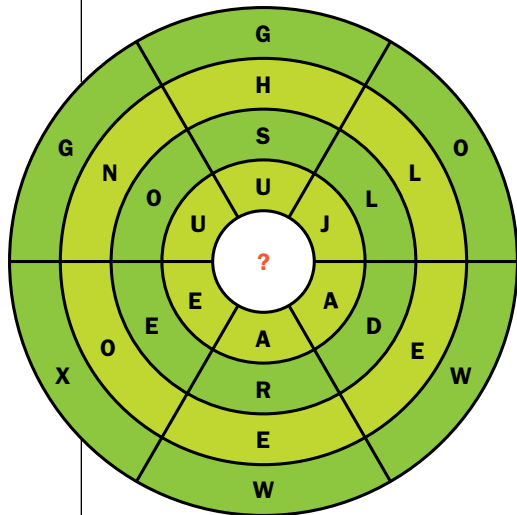
Have a question? Send it to editors@SciAmMind.com

Head Games

Match wits with the Mensa puzzlers

1 COMMON GOAL

The scrambled words in each pie-shaped section share a common missing letter. Provide the missing letter and unscramble the words.



2 SPELL IT OUT

One letter can replace the first letter of each word pair below so that two new English words are formed. Place the letter on the line between the words. (Example: RAIN ___ DARK = MAIN M MARK.) When you find the right set of letters, they will spell a word vertically.

- MAIL ___ PINK
- CART ___ SAID
- GRID ___ RIMLESS
- LINK ___ BOUND
- ROWED ___ RIPPLE

3 PROVERBIAL MYSTERY

All the vowels have been removed from the following proverb, and the remaining letters are arranged into groups of three letters each. Replace the vowels and restore the correct word breaks to discover the proverb.

- BRD SFF THR
- FLC KTG THR

4 MULTIGRAMS

Each of the following groups of letters can be anagrammed into two to four words. Unscramble the letters into all possible words.

- EFIRSSU EEMPRSU EENPRST

5 MAGIC SQUARE

Use only the numbers 0, 4, 8 and 12 to complete this square so that all the vertical, horizontal and long diagonal rows add up to 24.

0		12	0
4			
			12

6 HIDDEN PATTERN

What term should most logically come next in this sequence?

- S30 031 N30 ?

7 FILL IN THE BLANKS

Each of the following words contains the letters JAN in order. (They may also contain other Js, As or Ns.) Using the definitions, find the words.

A variety of semiprecious stone that can be either blue or orange:

J A _ _ N _ _

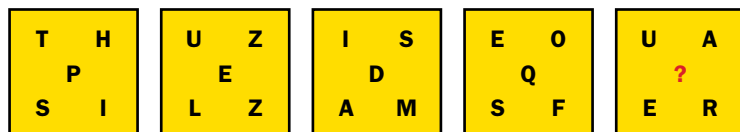
A type of soldier: J A N _ _ _ _ _

Pertaining now to the Democratic party of the U.S., but originally with a slightly different meaning. Adjectival form of politician's name:

J _ _ _ _ _ A N

8 LETTERS IN A BOX

What letter belongs in the center of the last box?



Answers

- 6. D31. (The sequence is made up of the first initial of a month and the number of days in that month.)
- 7. JACINTH, JANISSARY, JEFFERSONIAN.
- 8. S. (Spiral clockwise around each square into the center to spell out THIS PUZZLE IS MADE OF SQUARES.)


12	0	0	12
4	8	8	4
8	4	4	8
0	12	12	0

- 1. The missing letter is "Y." (GUSHY, JOLLY, YAWED, WEARY, OXEYE and YOUNG.)
- 2. SMART.
- 3. BIRDS OF A FEATHER FLOCK TOGETHER.
- 4. FISSURE and FUSSIER; SUPREME and PRESURE; PRESIDENT, REPENTS, SERPENT and PENSNER.


BRAINSTORM

BY DWAYNE GODWIN
& JORGE CHAM

EPILEPSY, A SERIOUS BRAIN DISORDER THAT AFFECTS MILLIONS, WAS ONCE THOUGHT TO BE AN AFFLICTION FROM THE GODS.



AROUND 400 B.C., HIPPOCRATES WAS AMONG THE FIRST TO PINPOINT THE BRAIN AS THE SOURCE OF SEIZURES.

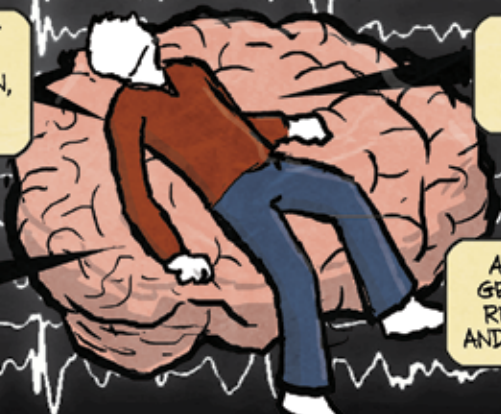


NORMALLY, THE NEURONS IN YOUR BRAIN COMMUNICATE WITH GENTLE SPARKS AND RHYTHMS AMONG WELL-ESTABLISHED NETWORKS.



BUT WITH EPILEPSY, A STORM OF ACTIVITY CAUSES MANY CELLS IN THE NETWORK TO FIRE UNCONTROLLABLY.

THERE ARE DIFFERENT TYPES OF SEIZURES, DEPENDING ON THE SYMPTOMS AND THE BRAIN AREA AFFECTED:



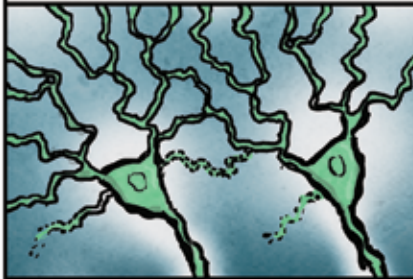
PARTIAL SEIZURES MAY AFFECT LIMITED AREAS OF THE BRAIN, CAUSING CHANGES IN PERCEPTION, MOTOR MOVEMENT AND EVEN LOSS OF CONSCIOUSNESS.

GENERALIZED SEIZURES AFFECT THE ENTIRE BRAIN OR LARGE AREAS OF IT.

SEIZURES THAT AFFECT THE TEMPORAL LOBE CAN RESULT IN WHOLE-BODY CONVULSIONS.

ABSENCES ARE A TYPE OF GENERALIZED SEIZURE THAT RESULT IN STARING SPELLS AND LOSS OF CONSCIOUSNESS.

EPILEPSY CAN BE CAUSED BY CHANGES IN HOW THE NEURONS ARE WIRED TO ONE ANOTHER ...



... OR BY GENETIC MUTATIONS IN THE ION CHANNELS OF NEURONS, WHICH AFFECT HOW NEURONS SYNCHRONIZE WITH ONE ANOTHER.

PEOPLE AFFLICTED WITH SEIZURES CAN DO MOST THINGS YOU AND I CAN DO, AND MORE.



EPILEPSY IS A PHYSIOLOGICAL PROBLEM, NOT A MENTAL DISORDER.

HIPPOCRATES SAID, "IF MEN CALLED EVERYTHING WHICH THEY DO NOT UNDERSTAND DIVINE, WHY, THERE WOULD BE NO END TO DIVINE THINGS."



NOW THAT'S A BRAINSTORM OF AN IDEA.

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

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