

SCIENTIFIC AMERICAN **MIND**

BEHAVIOR • BRAIN SCIENCE • INSIGHTS

**SEX MAKES
YOU SMARTER**

Lessons from Rats
page 36

September/October 2011

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THE TWO FACES OF **STRESS**

A little
pressure
improves
memory and
learning.
Too much has
the opposite
effect

PLUS
How to ease
stress

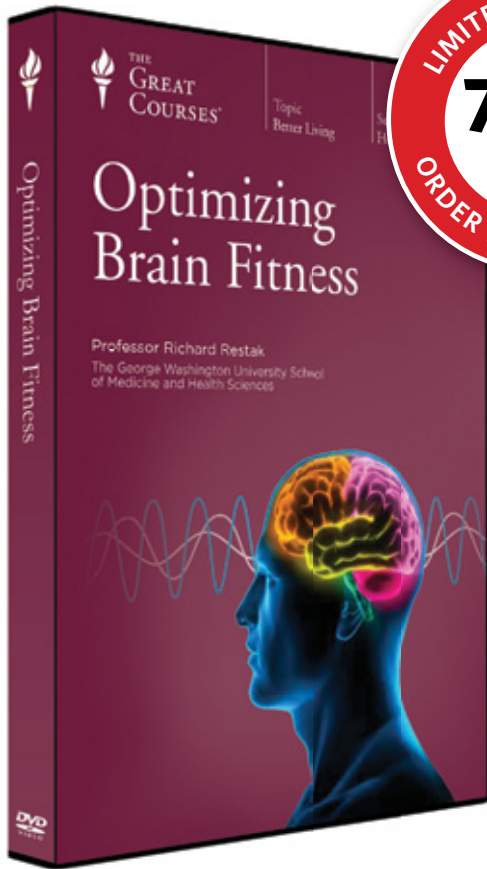
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Stress Less

Time slowed to a crawl as my little Nissan Sentra approached the BMW in front of me. With a pronounced crunch, one bumper smashed into another. The green metal hood scooted back, folding into a sharp crease near the windshield. As freeway traffic blazed by on both sides, my mind went blank. *What do I do now?*

Fortunately, one of my passengers was already on the telephone, dialing 9-1-1 and instructing me to cautiously maneuver the vehicle to the shoulder. What a relief that not everyone in the car had panicked as I did. As Mathias V. Schmidt and Lars Schwabe write in “Splintered by Stress,” on page 22, new research helps us predict when the flood of stress hormones will bolster our brains rather than block thought. Exactly when the brain turns on the chemical spigot makes a world of difference.

Although we cannot control those physiological responses directly, we can take steps to avoid triggering them in the first place, as Robert Epstein advises in “Fight the Frazzled Mind,” on page 30. Many of us get walloped by stress simply because we fail to identify and avoid predictable trouble spots, such as rush-hour traffic.

Such minor adjustments can improve anyone’s quality of life, although not all cultures rate life satisfaction using the same metrics. In “The Many Faces of Happiness,” on page 50, Suzann Pileggi Pawelski explores where we differ and dovetail in the pursuit of pleasure. For example, psychologists have found that feeling materialistic tends to correlate with darker moods.

That fact adds an intriguing dimension to “Passion for Possessions: Mine!” on page 56, in which Bruce Hood explores our quirky love of objects. Although some animals assemble oddities to build nests and others may learn to trade bits of food, we humans are uniquely terrible at recognizing the market value of our beloved things.

But stress not. After feeling a few pangs of sorrow for my crumpled car, I quickly realized that, unlike my vehicle, I was unscathed, as were my companions. At that moment, nothing could have made me happier.

Sandra Upson
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CREATIVE ECCENTRICS

Thank you for the excellent article “The Unleashed Mind,” by Shelley Carson. It’s very refreshing to read that people with eccentric, novel and even schizophrenic ways of thinking are often very high functioning, talented, intelligent individuals who can use their strange perceptual experiences to access beauty, originality and creativity.

Greg Westlake
Norfolk, England

When I telephoned my partner, a highly creative person, and read her the paragraph in Carson’s article in which the question is posed, “Do you often feel like a square peg in a round hole?” her prompt response was “My peg isn’t even on the same plane as the hole.” Another startling affirmation of the complexity of artists’ daily cognitive input.

J. Kruger
Cherry Hill, N.J.

Your May/June 2011 cover illustration may indicate a not too subtle prejudice against highly creative people. It would seem better suited to an article entitled “The Unhinged Mind.” I notice that not one of the nine people shown on page 25, said to be “known for their quirks,” has even a remotely maniacal expression on his or her face, unlike the subject of

your cover art. If a person had never known any creative people, one look at this cover would be enough to make him or her want to avoid them, if at all possible. Hardly an unbiased appraisal.

Leonard Kindler
via e-mail

BRAIN BUGS

“Fatal Attraction,” by Christof Koch [Consciousness Redux], describes how parasites such as *Toxoplasma gondii* can affect their hosts’ behavior to suit their survival needs. I’d like to point out that this effect may not stop at parasites. There are a myriad of bacterial organisms that call our bodies home. To think that over the many millennia none of them could have evolved to influence us to act toward the survival of their species would be naive.

We are not just human, we are an ecosystem, and organisms in an ecosystem—be they humans, beavers or ants—often alter their ecosystems to suit their needs.

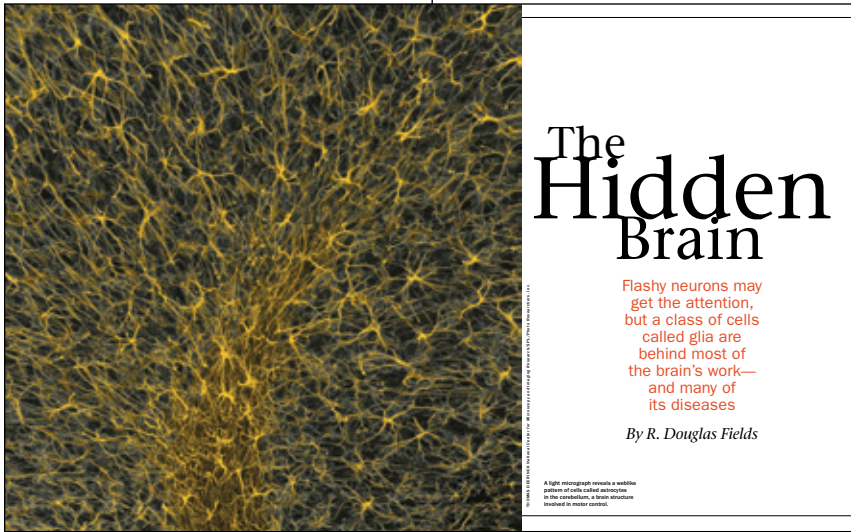
“David N’Gog”
commenting at www.
ScientificAmerican.com/Mind

WHITE MATTER CONSCIOUSNESS

I found “The Hidden Brain,” by R. Douglas Fields, to be exciting reading. This and other research are lending credibility to the conjecture that consciousness is a function of glia, not neurons.

Many who practice meditation are aware that consciousness can be free of the usual verbal chatter of our minds. It may be that what we call our self, or the “I” in our perception of self, is made not of patterns of electrochemical synaptic logic (neurons chattering) but rather the aggregate experience of the mass of glial cells, each one contributing its particle of consciousness to the whole. The mental sensations of self, desire, fear, love and hate seem better understood in the light of Fields’s discoveries about the manner in which glia interact with neural synapses and interact with one another.

Most striking of all is that we may be approaching an understanding of why we feel so strongly that our minds and bodies are split. Functions of the subconscious



Could consciousness arise from the activity of glia rather than neurons?

may be subconscious because they are neural rather than glial. A simple thought experiment: when you first wake up in the morning, your thoughts may be sluggish, but your consciousness is so fully active that you are aware you are thinking sluggishly. It is indeed ironic, as Fields describes, that we have long ignored the glial functions of thought processes, thinking of them as merely support for the nervous system, in a manner similar to the ancient Greeks thinking the brain was simply an organ for cooling the blood.

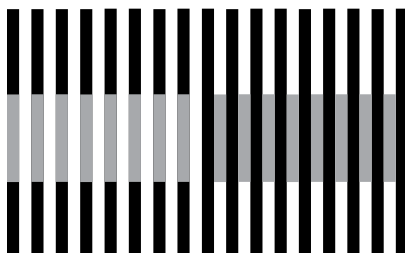
Wayne Schotten
via e-mail

black stripes. I think the effect occurs because of the way our visual system quickly arranges a scene's depth. By interpreting the illusion this way, the left side is composed of solid black columns partially obscured by a translucent rectangle, whereas the right side is composed of the same solid black columns now obscuring a solid gray rectangle that is also presumably in the columns' shade. In this case, our visual system quickly deduces that the translucent object is a lighter color and closer and that the shaded object is a darker color and farther away.

Bobby Standridge
Springfield, Va.

FAULTY DEPTH PERCEPTION

Allow me to take a stab at what might be behind White's Effect, described in "Colors Out of Space," by Stephen L. Macknik



White's Effect

and Susana Martinez-Conde [Illusions]. The mystery is why the gray bars appear brighter when surrounded by white stripes and darker when surrounded by

LEFT BRAINS, RIGHT BRAINS

"What Are You Looking At?" by Nathan Collins [Head Lines], reports a bias. It also nicely falls prey to—or preys on—another. Our level of awareness is not just a function of our sensitivity to social cues, as the study of liberals and conservatives suggests.

We are not simply in the herd (sensitive) or out of the herd (independent). We are also rational and irrational. To rephrase to make the point less politically charged: sensitivity is not always irrational, and independence is not always rational.

Jason Dunn
Houston

As a graduate of the University of Nebraska—Lincoln, I chuckled at the “politically correct” interpretation of the study that liberals would be more sensitive to social cues. Two thoughts occurred to me: first, “liberals” in Lincoln would very likely be “conservatives” in New York or California—neither term was defined. Second, could it be that the “liberals” were of lower intelligence or, because of confusion, took longer to focus?

I recommend Milton Rokeach's classic *The Open and Closed Mind: Investigations into the Nature of Belief Systems and Personality Systems* (first published in 1960), which posited that there are closed individuals on both ends of the political spectrum. His awareness and research is still relevant 50 years later.

Jim Lohr
Ames, Iowa

SAD IN ENGLISH

I was fascinated to learn that personality can vary according to the language one is using, as described in “Speaking with Affect,” by Nathan Collins [Head Lines]. It reminded me of a story I once heard about language and depression.

Over two decades ago a therapist colleague of mine in London was treating an Italian patient for mild depression. His approach was to get the patient to identify the internal dialogue she used to “tell herself” that she was a failure and so trigger a depressive state; he then worked to shift her trigger phrases to more positive ones and so create a more positive outlook.

The work was done in English because that was the therapist's first language and the client was also fluent. But having achieved the treatment goal, my colleague deemed it necessary to repeat the exercise in Italian.

He asked her, “What words do you use in Italian to trigger your depression?” A look of extreme puzzlement came over the client's face as she replied, “But I can't get depressed in Italian!”

Susan Quilliam
Cambridge, England

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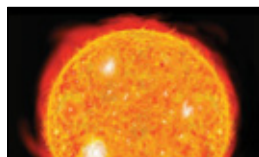
Curious how magic works? Ready to absorb the latest science, without distraction? Join Scientific American for current science and immersion into German culture and scenic beauty, on a river cruise sailing from Amsterdam, The Netherlands to Basel, Switzerland on AMA Waterways's AmaCello, April 12–20, 2012. Particle physics, cognitive neuroscience, solar science, and alpine archaeology are on our itinerary, along with medieval German cities and Strasbourg, France.

Take a close look at sensory perception and visual illusions. Dig into medicine in the ancient world and the interplay of natural and physical sciences in archaeology. Illuminate the profound Sun-Earth connection. Capture evolving thought in subatomic physics. You can lose yourself in the rich intricacies of science while the AmaCello and its English-speaking staff provide gracious service, comfortable quarters, and superb regional cuisine.

Bright Horizons 12 offers distilled cutting edge science and local brews together with long awaited relaxation with good friends. You can add even more Aha! moments to your itinerary with an optional post-cruise excursion to CERN, or find your inner Parisian on an optional 1, 2, or 3-day post-cruise visit to the City of Lights.

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SOLAR SCIENCE

Speaker: Pål Brekke Ph.D.

A Cosmic Voyage Through the Universe

Since the ancients' observations and Galileo's discoveries, humans have been driven to explore the universe. Deep-space finds by sophisticated telescopes and satellites stoke our curiosity. Using imagery from modern space-based telescopes, take a cosmic journey. We'll boldly go where new solar systems are born and visualize black holes, neutron stars, and supernovas.

The Stormy Sun — How Does it Affect our Technology Based Society?

100 years ago, solar storms occurred without humans noticing the damage they caused. Today with satellite systems, GPS, and electrical grids vulnerable to solar weather, it's a different story. Learn about the impact of solar weather activity as well as forecasting, early-warning, and prediction resources. Find out what's hot in sun science!

The Northern Lights: A Message from the Sun

What is more beautiful than the aurora borealis dancing across the sky? Spanning the myths and modern science behind the northern lights, we'll discuss coronal mass ejections, the magnetosphere and solar wind, and the Earth's magnetic field and solar particles. Learn where to see this phenomenon that has fascinated through the ages, and how to predict its appearances.

Does the Sun Contribute to Climate Change?

In the last 150 years the Earth has warmed ~0.7°C. In the same period both concentrations of atmospheric greenhouse gases and the level of solar activity increased. Related phenomena? It's not a trivial task to untangle the two. Dr. Pål Brekke summarizes current understandings and discusses his opinion that the future holds surprising answers on why solar activity varies and the relationship of solar activity and Earth's climate.



ALPINE ARCHAEOLOGY

Speaker: Patrick Hunt, Ph.D.

Medicine in the Ancient Western World

What is the the most profound secret about medicine in the ancient world? Arguably, that while deep superstition and ignorance were elements of medicine in antiquity, logic and rationality entered medical practice early on. Egypt, Mesopotamia, Greece, and Rome have long medical traditions. Hear how significant aspects of ancient medicine are surprisingly familiar.

Science in Archaeology: New Perspectives on Old Problems

Ötzi the Iceman was discovered as a frozen 5300 year-old "ice mummy," high in the Alps in 1991. Through Ötzi's case learn how forensic investigations in microbiology, chemistry, physics, and geology help bring ancient wonders to life.

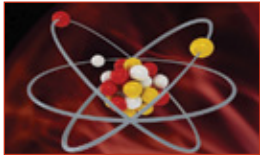
Four Horsemen of the Apocalypse: Climatic Problems, Famine, Disease, War, and Mass Death in History

Human history records apocalyptic cycles of connected catastrophes through environmental or human causation. Through such disasters, humans have always been susceptible to food-supply famine, which brings malnutrition and at times disease. Dr. Hunt discusses history and current work on paleoclimatic environments as a potential model for understanding the multifactorial and interconnected nature of the impact of global warming. Learn why and what big-picture thinking is required.

Tracking Hannibal

Where did Hannibal lead 38,000 infantry, 8,000 cavalry, and 37 war elephants through the Alps in 218 BCE? The mystery of Hannibal's route has consumed archaeologist Patrick Hunt for over a decade. Hear about Dr. Hunt's quest for the route, using scientific, satellite imaging and historical materials, and his own hair-raising explorations of the Alpine passes.





PARTICLE PHYSICS

Speaker: Frank Linde, Ph.D.

Quantum Questions

Welcome to the world of the infinitely small and the weird phenomena that come with it, like slow-running clocks and anti-particles. Dr. Linde leads us through the discoveries, concepts, and studies in the puzzling world of quantum mechanics in a session certain to spark your curiosity about the paradoxes and possibilities quantum physics poses.

Past and Present at CERN

To orient us to the Large Hadron Collider (LHC)'s significance, Dr. Linde recaps the highlights of CERN's "low energy" LEP accelerator which studied the Standard Model of particle physics. Learn how physicists think the LHC experiment will address current challenges in particle physics: the origin of particle masses; the mystery of dark matter and the apparent absence of antimatter in our everyday life.

Particle Physics Matters

What has particle physics done for you today? Dr. Linde discusses the societal benefits of his research. Learn how the particle physics field leads to the development of novel technologies and applications in medicine, information technology, energy, finance and commerce, and more. Find out how basic particle research, whose significance might not be obvious, touches on all our lives.

Astroparticle Physics

Parked at the intersection of particle physics, astronomy, and cosmology, astroparticle physics is evolving rapidly. Dr. Linde guides you through the strange terrain of astroparticle physics research rooted at CERN. Hear how deep-sea neutrino telescopes search for ripples in the space-time fabric itself and how huge cosmic-ray observatories are seeking answers to the big questions.



COGNITIVE NEUROSCIENCE

Speakers: Stephen Macknik, Ph.D. & Susana Martinez-Conde, Ph.D.

How the Brain Constructs the World We See

All our understandings of our life experiences are derived from brain processes, and are not necessarily the result of an event in the real world. Neuroscientists are researching the cerebral processes underlying perception to understand our experience of the universe. Discover how our brain constructs, not reconstructs, the world we see.

Windows on the Mind

What's the connection behind eye movements and subliminal thought? Join Drs. Macknik and Martinez-Conde in a look at the latest neurobiology behind microsaccades: involuntary eye movements that relate to perception and cognition. Learn how microsaccades suggest your bias toward certain objects, their relationship to visual illusions, and the pressing questions spurring visual neurophysiologists onward.

Champions of Illusion

The study of visual illusions is critical to understanding the basic mechanisms of sensory perception, and helps with cures for visual and neurological diseases. Connoisseurs of illusion, Drs. Macknik and Martinez-Conde produce the annual "Best Illusion of the Year Contest". Study the most exciting novel illusions with them, and learn what makes these illusions work.

Sleights of Mind

Magic fools us because humans have hardwired processes of attention and awareness that are hackable. A good magician uses your mind's own intrinsic properties against you. Magicians' insights, gained over centuries of informal experimentation, have led to new discoveries in the cognitive sciences, and also reveal how our brains work in everyday situations. Get a front-row seat as the key connections between magic and the mind are unveiled!



SCIENTIFIC AMERICAN Travel HIGHLIGHTS



PRIVATE, INSIDER'S TOUR OF CERN

April 20, 2012 — From the tiniest constituents of matter to the immensity of the cosmos, discover the wonders of science and technology at CERN. Join Bright Horizons for a private post-cruise, custom, full-day tour of this iconic facility.

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

Our full day will be led by a CERN physicist. We'll have an orientation; visit an accelerator and experiment; get a sense of the mechanics of the large hadron collider (LHC); make a refueling stop for lunch; and have time to peruse exhibits and media on the history of CERN and the nature of its work.

This tour includes: • transfer from Basel (end of cruise) to our Geneva hotel (April 19) • hotel (3 nights) — the nights of April 19, April 20, and April 21 • full breakfasts (3) — April 20, 21, and 22 • transfer from hotel to CERN and back to the hotel on April 20 • lunch at CERN • cocktail party the evening after our visit to CERN (April 20) • free day in Geneva; transfers to/from downtown provided (April 21) • transfer to airport for return home (April 22)

The price is \$799 per person (based on double occupancy). This trip is limited to 50 people. NOTE: CERN charges no entrance fee to visitors

INSIDER'S TOUR OF THE MPIA

Private tours of Max Planck Institute for Astronomy (MPIA) and the newly opened Center for Astronomy Education and Outreach on April 16, 2012 (mid-cruise) (\$275 pp, includes elegant lunch)

We'll board a bus to Heidelberg right after breakfast. Our tour will include a visit to the Max

Planck Institute for Astronomy, a presentation at the Center for Astronomy Education and Outreach including a planetarium show about the latest astronomical research done in Heidelberg, followed by a brief visit to the historical instruments of the Landessternwarte founded by Max Wolf in 1898. We'll conclude our excursion with a memorable lunch in downtown Heidelberg.



A FULL DAY IN AMSTERDAM

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>> **GROUPTHINK**

Following the Crowd

Changing your mind to fit in may not be a conscious choice

Beauty is not just in the eye of the beholder—it is also in the eyes of the beholder's friends. A study published in April in *Psychological Science* found that men judge a woman as more attractive when they believe their peers find that woman attractive—supporting a budding theory that groupthink is not as simple as once thought.

Researchers at Harvard University asked 14 college-age men to rate the attractiveness of 180 female faces on a scale of 1 to 10. Thirty minutes later the psychologists asked the men to rate the faces again, but this time the faces were paired with a random rating that the scientists told the men were averages of their peers' scores. The men were strongly influenced by their peers' supposed judgments—they rated the women with higher scores as more attractive than they did the first time. Functional MRI scans

showed that the men were not simply lying to fit in. Activity in their brain's pleasure centers indicated that their opinions of the women's beauty really did change.

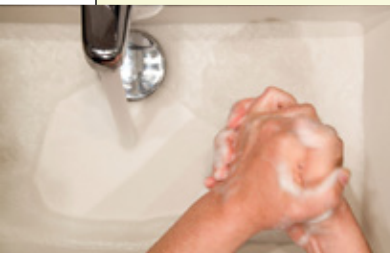
The results fit in with a new theory of conformity, says the study's lead author Jamil Zaki. When people conform to group expectations, Zaki says, they are not concealing their own preferences; they actually have aligned their minds. In addition, the likelihood of someone conforming depends on his or her place within the group, according to a study in the December 2010 issue of the *British Journal of Sociology*. Members who are central are more likely to dissent because their identities are more secure. Those at the edges, who feel only partially involved or are new to the group, may have more malleable opinions. —Carrie Arnold

MARIO WAGNER

Of Tics and Compulsions

Brain imaging teases apart Tourette's syndrome and obsessive-compulsive disorder

On the surface, Tourette's syndrome and obsessive-compulsive disorder (OCD) seem to have little in common. Tourette's is characterized by repetitive involuntary facial or vocal tics, whereas OCD sufferers have all-consuming thoughts and overwhelming urges to perform certain actions. But 50 to 70 percent of people with Tourette's also have OCD, and recent studies suggest that the same genetic roots may underlie both conditions [see "Obsessions Revisited," by Melinda Wenner Moyer; SCIENTIFIC AMERICAN MIND, May/June 2011]. Now a new study published in *Neurology* may help scientists further understand how the disorders overlap and differ by revealing several key differences in the brain activity of Tourette's patients with and without OCD.



Repetitive handwashing may be a sign of OCD.

Andrew Feigin and his colleagues at North Shore LIJ Health System in Manhasset, N.Y., scanned the brains of 12 unmedicated Tourette's patients—some of whom also had OCD—and 12 healthy subjects using positron-emission tomography, which reveals patterns of brain activity. Compared with healthy controls, those who had Tourette's exhibited more activity in the premotor cortex and cerebellum, regions that handle motor control, and less activity in the striatum and orbitofrontal cortex, areas involved in decision making and learning. These findings support the idea that the symptoms of the disorder may arise from the brain's inability to suppress abnormal actions using decision-making skills.

When the researchers compared the Tourette's patients who had OCD with those who did not, they found that the patients who had both disorders exhibited greater activity in the primary motor cortex and precuneus, an area that plays a role in self-awareness. Previous research has suggested that in patients who suffer from both disorders, OCD might show up more in the form of compulsions than obsessions, and these findings support that idea: the increased activity of the precuneus may reflect individuals' efforts and ability to resist obsessive thought, and the motor cortex may be more active because OCD is manifesting itself more physically than mentally.

Although the neural networks that seem to be affected in Tourette's and OCD are distinct, they nonetheless involve brain regions with similar functions—in particular, motor activity and decision making. The discovery isn't all that surprising, Feigin says, given that tics are actually quite similar to compulsions—both, after all, involve extra involuntary movements.

—Melinda Wenner Moyer

ALAMY (washing); MIKE KEMP/Alamy (Judge)

Lunchtime Leniency

Judges' rulings are harsher when they are hungrier

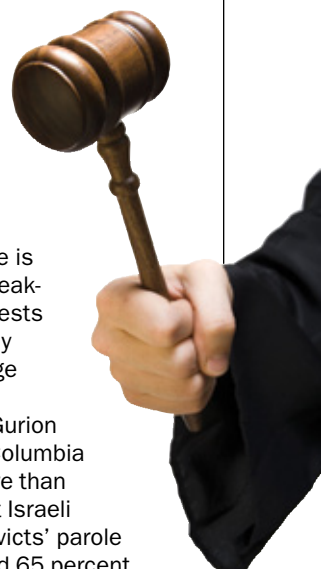
Lawyers quip that justice is what the judge ate for breakfast. New research suggests that justice might actually depend on when the judge ate breakfast.

Researchers at Ben Gurion University in Israel and Columbia University examined more than 1,000 decisions by eight Israeli judges who ruled on convicts' parole requests. Judges granted 65 percent of requests they heard at the beginning of the day's session and almost none at the end. Right after a snack break, approvals jumped back to 65 percent again.

Jonathan Levav, associate professor of business at Columbia, said that the judges could just be grumpy from hunger. But they probably also suffer from mental fatigue. Previous studies have shown that repeated decisions make people tired, and they start looking for simple answers. For instance, after making a slew of choices, car buyers will start accepting the standard options rather than continuing to customize. As sessions drag on, judges may find it easier to deny requests and let things stand as they are.

Levav says he suspects a similar effect occurs in hospitals, university admissions offices or anywhere people make repeated decisions. So if you're thinking about asking the boss for something special, you might want to do it right after a nice lunch.

—Kurt Kleiner



Musicians Stay Sharp

Playing an instrument as a kid leads to a sharper mind in old age, according to a new study. Emory University neuropsychologist Brenda Hanna-Pladdy and her colleagues gave 70 people between the ages of 60 and 83 a battery of tests to measure memory and other cognitive abilities. The researchers found that those who had played an instrument for a decade or longer scored significantly higher on the tests than those with no musical background. Hanna-Pladdy says that music lessons, as with learning a second language, might stave off age-related cognitive decline.

—Carrie Arnold

HOLLY WILMETH/Aurora Photos (music notes)

>> MEDICINE

Catching Concussions Early

A new test could help coaches identify head injuries on the sidelines



Evidence is mounting that repeated concussions can do long-term harm to the brain. Athletes who play contact sports are particularly at risk. But a concussion can be difficult to diagnose, and many sports teams, especially those at the youth level, lack medical personnel. Neurology researchers at the University of Pennsylvania think they may have found a solution—an easy-to-use two-minute reading test that can assess the likelihood that a concussion has occurred.

The test was originally designed to evaluate reading skills in children, but it also catches problems with vision and eye movements, which makes it useful for studying concussions. The test consists of a series of numbers arranged in zig-zagging patterns on cards, which subjects read from left to right as quickly as possible. The Pennsylvania researchers tried out the test on boxers and mixed martial arts fighters in a study published in *Neurology* earlier this year and found it worked well as a predictor of head injury.

The researchers gave the fighters the test before and after a match. Typically people can complete the test faster the more times they take it, says Laura Balcer, a neurologist and a lead author of the study. But the athletes who had experienced head trauma during their fights read the cards more than 11 seconds slower when they took the test a second time. Fighters who had lost consciousness fared especially poorly, worsening by 18 seconds on average.

Now Balcer and her collaborators are studying the test's ability to predict concussions in athletes who play football and other contact sports. Their goal is to create an evaluation tool that could serve as an early warning sign for coaches, who would need only the cards and their stopwatch to determine whether a player needs to be sent to a doctor. —Erica Westly

ERIK ISAKSON Getty Images (football); LEANDER BAERENZ Getty Images (speech bubble)

>> LANGUAGE

Hesitant Speech Helps Kids, Um, Learn

Filled pauses direct toddlers' attention to new words

Parents never want their tots to learn to fumble over words, but they need not worry about their own “uhs” and “ums”—such filled pauses may actually improve kids' ability to pick up language.

Such vocal hesitations, called disfluencies, tend to occur before we use a word that is infrequent or unfamiliar in our speech. They also precede words

used for the first time in a conversation. Disfluencies keep adults tuned in and help them process the real words that come next.

Even infants can distinguish between fluent and disfluent speech, research at Brown University has shown. New experiments at the University of Rochester suggest that around the age of two, children make



an association between the disfluencies they hear and the likelihood that new words will follow them.

In the study, kids aged 16 to 32

>> MIND-BODY CONNECTION

Mindful Medicine

How meditation relieves the subjective experience of pain



Meditation can relieve pain, and it does so by activating multiple brain areas, according to an April study in the *Journal of Neuroscience*. Fadel Zeidan of Wake Forest University and his colleagues scanned people's brains as they received uncomfortably hot touches to the leg. When subjects practiced a mindful meditation technique that

encourages detachment from experience while focusing on breathing, they reported less pain than when they simply paid attention to their breathing. Likewise, different patterns of brain activity emerged under the two conditions, with mindful meditating resulting in more activity not only in executive centers that evaluate experiences and regulate emotions but also in lower regions that control the signals coming from the body. The volunteers learned the meditation technique in only four 20-minute sessions, which means this pill-free analgesia could be a feasible way to help real patients suffering from pain. "People can reap some of the benefits of meditation without extensive training," Zeidan says.

—Michele Solis

GETTY IMAGES (woman with cast); CORBIS (sleepy man)



>> EXHAUSTION

Half Asleep

Deprived of rest, parts of the brain start to snooze

Ever stay up so late you feel like parts of your brain are falling asleep? They might be. In the April 28 issue of *Nature*, researchers used too-fun-to-resist toys to keep rats up for hours longer than usual, measuring electrical activity in the rodents' brains with tiny implanted wires. Although the animals remained active, with most brain cells firing as erratically as they normally do in alert animals, small groups of neurons began flipping over to a sleep-like state, becoming electrically silent before firing in unison. Trained rats lost the knack for food-nabbing tricks as neurons in learning-related brain regions dozed off, perhaps explaining some of the deteriorating dexterity, flagging attention and questionable judgment seen in humans who are sleep-deprived.

—Andrea Anderson

months sat on their parent's lap in front of a computer monitor that showed images of paired objects, one recognizable (such as a ball) and one imaginary but equally colorful.

The first time a pair appeared, a voice from the computer said, "I see the ball." The second time it said, "Ooh, what a nice ball." The third time it instructed the children to look at one of the objects in the pair, using a made-up word for the invented object such as "gorp."

During this third step, sometimes the voice said simply, "Look! Look at the

ball," or "Look! Look at the gorp." In other trials, the sentence included a disfluency: "Look! Look at the, uh, ball," or "Look! Look at the, uh, gorp."

When kids heard the disfluency, they paid significantly more attention to the unfamiliar object for the next two seconds—before the computer finished the sentence with either "ball" or "gorp." During the "fluent" trials, when the computer did not say "the, uh," the children were no more likely to fixate on one object over the other.

The results suggest that disfluencies help kids follow a conversation, says

Celeste Kidd, a graduate student who co-authored the study (published online in April in the journal *Developmental Science*). "We don't know whether they're reasoning about the speaker's intentions, which is a pretty sophisticated understanding, or whether they just notice an association between 'uh' and 'um' and objects they don't know the name of," she says.

Either way, parents can relax and speak normally, ums and all—what seem like verbal stumbles are actually useful signals that tell youngsters to tune in.

—Jordan Lite

>> SOCIAL BEHAVIOR

Pull Up a Chair

We tend to move closer to those who share our physical traits

The next time you find yourself seated in a roomful of strangers, take a close look at your nearest neighbor. Does he or she resemble you in subtle ways? The answer is most likely yes, according to a recent study published in the July issue of *Personality and Social Psychology Bulletin*.

Although psychologists have long known that humans tend to associate by race, sex and other broad-brush categories, the latest work is the first to suggest that the impulse runs even to the picayune. “Sometimes we either gravitate toward people or away from them not because of a large prejudice but just because there’s something a little bit more—or less—familiar about them,” says Anne Wilson, a social psychologist at Wilfrid Laurier University in Waterloo, Ontario, and a co-

author of the study. “Most of these processes are not really conscious.”

Wilson and her colleagues performed four consecutive experiments using university students in a variety of settings, including a classroom on the first day of a course and tightly controlled laboratory environments in which subjects waited on couches or completed surveys while sitting at large tables. In every case, people tended to sit closer to someone with a trait they shared—for example, the wearing of glasses, hair length or color. The effect held even after the researchers ruled out the influence of race and sex.

Wilson says the findings help to explain why pairings and groupings of similar-looking individuals seem so common: they are no accident.



“People tend to think that someone who looks a little more like them is more likely to think like them,” she says. “If you expect someone to be more like you, you might behave toward them in a more open and likable way.” And that kind of “social lubrication” is a key ingredient in the foundation of a lasting relationship.

—Adam Marcus



>> EMOTIONS

How Embarrassing

Research pinpoints self-consciousness in the brain

Feeling embarrassed? You can probably thank your pregenual anterior cingulate cortex (pACC), a boomerang-shaped region of the brain nestled behind the eyes. Cognitive scientists at the University of California, San Francisco, and U.C. Berkeley probed the neuroanatomy of embarrassment by asking healthy people and those with neurodegenerative diseases to sing along to the Temptations’ “My Girl.” Horns blared, strings flowed and the subject’s voice soared—and then the music and professional vocals were stripped away. The subjects had to watch a video of their own solitary singing while researchers measured their racing hearts, sweaty palms, squirms and grimaces. Those with damage in the right pACC were least likely to cringe at their own performance.

The study, presented in April at the American Academy of Neurology conference in Hawaii, adds further evidence that this brain region has a role in many emotions, says U.C.S.F. postdoctoral fellow Virginia Sturm. Among them are the self-conscious emotions, including embarrassment, pride and guilt, which are felt in the context of others’ imagined reactions. Embarrassment, Sturm says, may have evolved to motivate us to repair social bonds that become strained when we fall short of expectations. —Carrie Peyton Dahlberg

The pregenual anterior cingulate cortex (purple) may be the seat of self-consciousness in the brain.

PAUL VOZDIC/Getty Images (businesswomen); ALAMY (woman in red); COURTESY OF W. IRWIN University of California, San Francisco (fMRI)

Autism in Another Ape

An extraordinary baby bonobo is a rare case study for autism researchers

Rambunctious one-year-old Teco, a third-generation captive-born bonobo at the Great Ape Trust in Des Moines, Iowa, has an ape's usual fondness for games and grapes. But perhaps because of trauma from a difficult birth (his mother was in labor for 60 hours) or a genetic predisposition, Teco is different from his bonobo peers in ways that resemble autism in young children. He could not cling to his mother or nurse the way healthy young apes do instinctively, mimicking the aversion to physical contact seen in children with autism. Teco also tends to fixate on shiny objects and avoids eye contact, and he has trouble coordinating his four limbs. A genetic analysis of bonobos, already under way, may shed light on Teco's condition and offer new perspectives on autism's genetic roots in humans.

—Nina Bai



Teco (above) shows more interest in objects than in his family—much as autistic children do.

Painkillers Thwart Prozac

Over-the-counter pain relievers may block some antidepressants

People with depression encounter a lot of pharmaceutical frustration. For largely unknown reasons, roughly one in three patients receive no benefit from any antidepressant. A recent study, however, suggests that something as simple as over-the-counter painkillers could play a role. Ibuprofen, aspirin and other anti-inflammatory drugs may disrupt the action of selective serotonin reuptake inhibitors (SSRIs), the most commonly prescribed type of antidepressant.

Antidepressants alter brain chemistry. SSRIs increase the amount of the neurotransmitter serotonin in the space between brain cells. Neuroscientist Jennifer L. Warner-Schmidt of the Rockefeller University and her colleagues noticed that certain proteins in the brain that interact with SSRIs had the potential to be influenced by anti-inflammatory drugs such as pain relievers.

The team embarked on a series of experiments in rodents to explore this idea. In one test, researchers measured how long it takes a mouse to overcome its fear of a new, open space and move toward food placed in the center. Mice that had been given the SSRI citalopram for two weeks



approached the food more than twice as quickly as unmedicated mice. But mice given ibuprofen with the SSRI for two weeks headed for the food nearly as slowly as unmedicated mice, Warner-Schmidt and her colleagues report in the *Proceedings of the National Academy of Sciences USA*.

The researchers also examined information from a previous study of patients with treatment-resistant depression. The study evaluated how

the participants responded to a 12-week course of citalopram and noted other medication use. Patients who had taken an anti-inflammatory drug or acetaminophen during their SSRI treatment were significantly less likely to experience relief from their symptoms than patients who had not.

The researchers are planning studies to figure out how exactly the pain medications interfere with the SSRIs and to determine how big a dose of painkillers is detrimental. But the evidence so far “is clinically important,” Warner-Schmidt says. “It’s a piece of information that doctors should keep in mind when looking at an individual who is not responding to an SSRI.”

—Aimee Cunningham

COURTESY OF ELIZABETH RUBERT-PUGH Great Ape Trust (bonobo); ANDY KROPA Redux Pictures (painkillers)

>> SENSES

The Reading Region

A growing body of research calls into question the idea that most brain areas are tied to specific sensory inputs

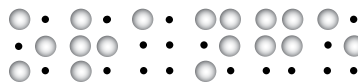
Does a blind person reading Braille process words in the brain differently than a person who reads by sight? Mainstream neuroscience thinking implies that the answer is yes because different senses take in the information. But a recent study in *Current Biology* finds that the processing is the same, adding to mounting evidence that using sensory inputs as the basis for understanding the brain may paint an incomplete picture.

Researchers in Israel, Canada and France used brain imaging to observe the neural activity of eight blind subjects as they read Braille. They found that although the blind subjects were using their sense of touch, their brains showed activity in the same so-called visual region that sighted people use when they read.

The finding runs counter to the long-held belief that the functions of areas of the brain are determined by the senses that feed them information. Instead it suggests that at least some areas developed primarily to perform a specific job. "The brain will use any information it can get to achieve this task," says lead author Amir Amedi of the Hebrew University of Jerusalem. Although his study only dealt with reading, Amedi thinks many areas of the brain are similarly task-oriented. He points to a 2005 study in which researchers found that participants who inspected an object with either their hands or their eyes used the same brain region to ultimately identify it. "When we look at a dog or a hammer

and we recognize it, we have a very specific center that is activated," he says. "It's the exact same for touching it."

According to Mary Helen Immordino-Yang, a neuroscientist at the University of Southern California not associated with the reading or touch studies, this task-based view of the brain is becoming widely accepted by cognitive neuroscientists but almost completely ignored by their hard-neuroscience colleagues. Neuroscientists who work on the biology of the brain tend to believe that humans are driven "by how the world pokes us," she says—in other words, sensory stimuli. They fail to see that "the hallmark of humanity is the ability to move beyond sensory inputs."



"orange"

Whether reading the word "orange" in Braille or in English, the same brain area identifies it. The idea that different sensory inputs are necessarily processed in disparate regions may be obsolete.

One criticism hard neuroscientists have of this task-based view is that certain cognitive processes are simply too new for humans to have evolved a specific brain area to process them. Reading, for example, has been around for only about 5,000 years. Its invention is much too recent to have had an effect on the evolution of the human brain. So how, then, could there be a part of the brain designated for reading?

Both Immordino-Yang and Amedi agree this is an important question. Immordino-Yang sees the evidence as a testament to the brain's ability to accommodate human inventions in the modern world. "It's amazing how plastic our brain is," she says. Parts of the brain are constantly being co-opted to process technological innovations. Amedi concurs: "We use the best networks that already did something most similar to this task. This is what allows us to evolve." —Joe Kloc



I Love You, Shoes

A warm, fuzzy feeling toward your bobblehead dolls or a shoe collection, say, may reveal a lack of secure relationships, according to a study in the *Journal of Experimental Social Psychology*. "Valuing possessions can be a way in which people substitute for interpersonal security," says Edward P. Lemay, a study author and assistant professor of psychology at the University of New Hampshire. The logic also applies to hoarding. Being reminded of the supportive relationships in your life might make it easier to let go of unneeded stuff, Lemay says. [For more on the psychology of ownership, see "Passion for Possessions: Mine!" by Bruce Hood, on page 56.] —Winnie Yu

AURORA PHOTOS (orange); MICHAEL BLANN Getty Images (shoes)

Heal Thyself

Internet-based self-help for social phobia shows promise



Treating social phobia without personal contact between patient and therapist—or without any therapist involvement at all—could be viewed as ironic, but two recent studies suggest that it works. Self-guided online therapy may offer relief for a wide range of disorders.

The first study, published in the October 2010 issue of the *Australian and New Zealand Journal of Psychiatry*, found that self-guided, Internet-based cognitive-behavior therapy (CBT) reduced social phobia symptoms in most of the participants. The Internet CBT program consisted of eight online lessons with components similar to those used in face-to-face CBT: education about symptoms and treatment, instruction on how to challenge the negative thoughts and core beliefs that maintain social phobia, preparation for dealing with physical symptoms of panic, graded exposure to social situations, and techniques for relapse prevention.

A more recent study examined whether adding therapist support via e-mail or telephone would affect the outcome of online treatment for social phobia. The paper, published in the March 2011 issue of *Behaviour Research and Therapy*, found that programs are equally effective regardless of therapist involvement.

The October experiment was the latest of eight studies on Internet-based self-help for social phobia led by Nickolai Titov, director of the eCenter Clinic (www.ecentreclinic.net) at Macquarie University in Sydney, Australia. The team has also conducted 20 trials on conditions such as depression and generalized anxiety disorder. “A similar formula seems to work for all conditions,” Titov says.

With such programs sprouting across the Internet, Titov advises consumers to verify the credentials of the people running them and to confirm that the regimens are evidence-based. He recommends AnxietyOnline (www.anxietyonline.org.au) as a great resource offering free and low-cost Web-based treatments for various anxiety disorders.

—Tori Rodriguez



Seeds of Destruction

Mating opportunities may be one motivation for war

Men may wage wars in part to spread their seed. In a recent report in *Personality and Social Psychology Bulletin*, Chinese researchers argue that alongside revenge and resource acquisition, mating is a key motivator for taking up arms. Exposing heterosexual men to images of attractive women increased their professed support for international aggression. Pictures of flags did not have the same effect, and men did not associate attractive women with aggression against males in general or with peaceful resolution to trade conflicts.

An evolved war-mating association makes sense: the authors' analysis of 20th-century records suggests warriors gain an estimated 10 times as many sexual opportunities as civilians, whether through raping the enemy or showing off their battle scars.

—Matthew Hutson

At Risk for Psychosis?

Psychiatrists propose a new diagnosis for people who show early signs of a break with reality

BY CARRIE ARNOLD

MIKE (not his real name) had always been an unusual child. Even as a toddler, he had difficulties relating to others and making friends, and he seemed strikingly suspicious of other people. After he entered high school, Mike became increasingly angry, paranoid and detached. He worried that people were searching his room and his locker when he was not around. His grades plummeted as he turned inward during class, sketching outlandish scenes in his notebooks and muttering to himself rather than listening to the instructor.

Paranoia and difficulties connecting with others are signs of psychosis, a mental illness in which people lose touch with reality. Psychotic individuals usually have problems forming rational, coherent thoughts. They also may hear voices or hallucinate while believing that what they perceive is real. Often such delusions result in bizarre behavior and, in severe cases, an inability to manage everyday life. But a psychiatrist deemed Mike's symptoms too mild to qualify him as psychotic. Mike obviously needed some kind of professional intervention, so he bounced among psychiatrists who could not figure out how to help him.

Cases such as Mike's have prompted some practitioners to propose the inclusion of a new psychosis risk diagnosis to the forthcoming fifth edition of the *Diagnostic and Statistical Manual of Mental Disorders (DSM)*, the "bible" of mental health diagnoses. To receive this diagnosis, a patient would first need to report, for example, having delusions or hallucina-



The earlier that people with psychosis symptoms receive treatment, the better their recovery is likely to be.

tions about once a week (as opposed to most of the time for at least one month for clinical psychosis). In addition, either the patient or a loved one must be significantly distressed by those symptoms. The idea of including such a diagnosis in the *DSM* is highly controversial, but supporters argue that patients such as Mike not only need immediate help, they are at increased risk for developing full-blown psychosis, an outcome doctors might be able to prevent with early intervention.

An Ounce of Prevention

Currently patients diagnosed with full-blown psychosis find relief from so-called atypical antipsychotic medications such as risperidone and olanzapine, which help to reduce hallucinations and delusions. Patients may also benefit from some forms of psychotherapy. And data suggest that the earlier such patients re-

ceive help by either method, the better they fare. In a study published in 2005 psychiatrist David L. Penn of the University of North Carolina at Chapel Hill and his colleagues analyzed 30 studies evaluating treatments for first-episode psychosis. The researchers found that early, aggressive treatment with medication and psychotherapy, as compared with no treatment, showed promise in reducing both psychotic symptoms and their impact on patients' lives. Thus, intervening with patients earlier, at the "risk" stage, could conceivably be even more beneficial, some argue.

In addition, several recent studies have found that two forms of psychotherapy alone—without medication—can help control psychotic symptoms even before a person can be officially diagnosed as psychotic. Using cognitive-behavior therapy, practitioners encourage patients to look

LAURI ROTHKO/Getty Images

(In one type of therapy, practitioners encourage patients to **look for evidence** supporting their delusions.)

for evidence supporting their hallucinations and delusions. And so-called acceptance and commitment therapy alleviates psychotic symptoms by teaching patients mindfulness—the ability to focus on the moment in a nonjudgmental way. What is more, in a study published in 2010 psychiatrist G. Paul Amminger of the Medical University of Vienna in Austria and his colleagues found that over-the-counter omega-3 fatty acid supplements reduced the onset of full-blown psychosis by 23 percent in young people with subclinical psychosis.

As a result of such data, psychiatrists such as William T. Carpenter, Jr., of the University of Maryland, who chairs the Psychotic Disorders Work Group for *DSM-5*, believe that intervening at a pre-psychotic stage could ameliorate and even thwart this serious mental illness in a large number of people. Preliminary studies, he says, show that individuals who fit the putative criteria for the psychosis risk syndrome—now officially dubbed attenuated psychosis syndrome—are tens to hundreds of times more likely to develop schizophrenia and psychosis than the average person. Preventing some of these cases would be a huge boon to the individuals affected and would lift the burden on their families, communities and the mental health system as a whole.

Dangerous Doses

Nevertheless, critics contend that accurately identifying a person at risk for psychosis is very difficult and far from foolproof. Although severe cases of psychosis are generally easy to recognize, early warning signs can be subtle. Is Mike's increasing paranoia a harbinger of an imminent psychotic episode, or does it reflect a slightly more extreme version of teenage difficulties? Symptoms of drug addiction, depression or other medical conditions can also be mistaken for those of psychosis.

Perhaps because of such ambiguities,

most people who receive the psychosis-risk label will never actually become psychotic, according to Allen Francis, a psychiatrist emeritus at Duke University and chair of the group that created the *DSM-IV*. In a 2003 study, for example, a team led by psychiatrist Patrick McGorry of the University of Melbourne in Australia found that six out of every 10 people deemed at high risk of psychosis did not end up developing it.

False diagnoses are problematic, Francis says, because of the perils of unnecessary treatment. People recognized as having mental health disorders are often prescribed antipsychotic drugs, which can be dangerous, he notes. Side effects can include significant weight gain, increases in blood glucose and cholesterol levels, and movement problems. If a patient is falsely labeled, he or she can end up enduring those side effects unnecessarily.

To improve the accuracy of such verdicts, researchers are trying to identify better warning signs of psychosis, such as finding genetic signatures that may foretell the illness and anatomical patterns that doctors might see in brain scans. (Some scientists are working on parallel projects geared toward finding biological markers that can help them predict other mental disorders, such as bipolar disorder and major depression.)

At the moment, treating people such as Mike with nondrug remedies can minimize the hazards of misdiagnoses. For Mike, a course of cognitive-behavior therapy and, eventually, a low dose of antidepressants controlled the worst of his symptoms. No one knows for sure



A checklist of proposed diagnostic criteria for attenuated psychosis syndrome:

- You have had delusions or hallucinations about once a week for the past month.
- You or a loved one is bothered by your behavior.
- Symptoms have appeared or worsened in the past year.
- No other mental disorders (such as bipolar disorder or substance abuse) explain the problem.

whether Mike was in danger of becoming psychotic, but he is slowly improving. Such cases will warrant consideration as the *DSM-5* Psychotic Disorders Work Group decides whether to adopt attenuated psychosis syndrome as a valid diagnosis, reject it entirely, or include it as a provisional diagnosis and request more research. The final decision will be made public by May 2013. **M**

CARRIE ARNOLD is a freelance science writer who lives outside Norfolk, Va. She is currently at work on her third book.

(Further Reading)

- ◆ **Head to Head: Is Early Intervention in the Major Psychiatric Disorders Justified?** Patrick McGorry and Anthony Pelosi in *British Medical Journal*, Vol. 337, pages a695 and a710; August 2008.
- ◆ **Early Intervention in Psychosis: Concepts, Evidence and Future Directions.** Patrick McGorry, Eóin Killackey and Alison Yung in *World Psychiatry*, Vol. 7, No. 3, pages 148–156; October 2008.

Testing for Consciousness in Machines



Asking people and computers what's wrong with manipulated photos may tell if there is "anybody home"

BY CHRISTOF KOCH AND GIULIO TONONI

HOW WOULD WE KNOW

if a machine is conscious? As computers inch closer to human-level performance—witness IBM's Watson victory over the all-time champs of the television quiz show *Jeopardy*—this question is becoming more pressing. So far, though, despite their ability to crunch data at superhuman speed, we suspect that unlike us, computers do not truly "see" a visual scene full of shapes and colors in front of their cameras; they don't "hear" a question through their microphones; they don't feel anything. Why do we think so, and how could we test if they do or do not experience a scene the way we do?

Consciousness, we have suggested, has two fundamental properties [see the July/August 2009 column by Christof Koch, "A Theory of Consciousness"]. First, every experience is highly informative. Any particular conscious state rules out an immense number of other possible states, from which it differs in its own particular way. Even the simple percept of pitch-blackness implies you do not see a well-lit living room, the intricate canopy of the jungle or any of countless other scenes that could present themselves to the mind: think of all the frames from all the movies you have ever seen.

Second, conscious information is integrated. No matter how hard you try,



Any person can tell what is wrong with this picture. Once computers can routinely do the same, they may truly "see."

you cannot separate the left half of your field of view from the right or switch to seeing things in black and white. Whatever scene enters your consciousness remains whole and complete: it cannot be subdivided into unrelated components that can be experienced on their own. Each experience, then, is a whole that

acquires its meaning by how it can be distinguished from countless others, based on a lot of knowledge about the world. Our brain, with its multitude of specialized but interacting parts, seems optimally adapted to achieving this feat of information integration. Indeed, if the relevant parts of our cerebral cortex

CHRISTOF KOCH (Koch); DAN BURN-FORTI. Getty Images (bike)

become disconnected, as occurs in anesthesia or in deep sleep—consciousness wanes and perhaps disappears.

What's Wrong?

If consciousness requires this ability to generate an integrated picture that incorporates a lot of knowledge about the

know whether, amid the usual clutter on your desk, your iMac computer on the left and your iPad on the right make sense together. It would not know that while the iMac and the iPad go together well, a potted plant instead of the keyboard is simply weird; or that it is impossible for the iPad to float above the

level features, such as whether a face rests on a neck and so on, might manage to defeat one of these tests. But presenting many different image tests, not unlike asking many arbitrary questions about the image, would defeat today's machines.

Yet a different kind of machine can

(Our visual system enables us to instantly know whether all the components fit together properly.)

world, how could we know whether a computer is sentient? What is a practical test?

As we propose in the June 2011 issue of *Scientific American*, one way to probe for information integration would be to ask the computer to perform a task that any six-year-old child can ace: “What’s wrong with this picture?” Solving that simple problem requires having lots of contextual knowledge, vastly more than can be supplied with the algorithms that advanced computers depend on to identify a face or detect credit-card fraud.

Views of objects or natural scenes consist of massively intricate relations among pixels and objects—hence the adage “a picture is worth a thousand words.” Analyzing an image to see that something does not make sense requires far more processing than do linguistic queries of a computer database. Computers may have beaten humans at sophisticated games, but they still lack an ability to answer arbitrary questions about what is going on in a photograph. In contrast, our visual system, thanks to its evolutionary history, its development during childhood and a lifetime of experience, enables us to instantly know whether all the components fit together properly: Do the textures, depths, colors, spatial relations among the parts, and so on, make sense?

Take just one example, a photograph of your workspace. Unless it is specifically programmed for that purpose, a computer analyzing the scene would not

table; or that the right side of the photograph fits well with the left side, whereas the right side of a multitude of other photographs would be wrong. But you would know right away: to you an image is meaningful because it is chock-full of relations that make it what it is and different from countless others.

Therein lies the secret of determining whether a computer is conscious. To do so, pick some images at random from the Web. Black out a strip running vertically down the central third of every one, then shuffle the remaining left and right sides of the pictures. The parts of the composites will not match, except in one case where the left side is evidently from the same picture as the right side. The computer would be challenged to select the one picture that is correct. The black strip in the middle thwarts the simple image-analysis strategies that computers use today—say, matching lines of texture or color across the separated, partial images. Another test inserts objects into several images so that these objects make sense in all images except one, and the computer must detect the odd one out. A keyboard placed in front of an iMac is the right choice, not a potted plant. A variety of dedicated modules looking for specific high-

be envisioned, too—one in which knowledge of the innumerable relations among the things in our world is embodied in a single, highly integrated system. In such a machine, the answer to the question “What’s wrong with this picture?” would pop out because whatever is awry would fail to match some of the intrinsic constraints imposed by the way data are integrated within a given system. Such a machine would be good at dealing with things not easily separable into independent tasks. Based on its ability to integrate information, it would consciously perceive a scene.

In the next Consciousness Redux column, we’ll tell you about the surprising results of a near-identical test that psychologists devised to probe the extent to which the unconscious can solve such problems. **M**

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(Further Reading)

- ◆ **Consciousness as Integrated Information: A Provisional Manifesto.** Giulio Tononi in *Biological Bulletin*, Vol. 215, No. 3, pages 216–242; December 2008.
- ◆ **A Test for Consciousness.** Christof Koch and Giulio Tononi in *Scientific American*, Vol. 304, No. 6, pages 44–47; June 2011.

The Eyes Have It

Eye gaze is critically important to social primates such as humans. Maybe that is why illusions involving eyes are so compelling

By Susana Martinez-Conde and Stephen L. Macknik

The eyes are the window to the soul. That is why we ask people to look us in the eye and tell us the truth. Or why we get worried when someone gives us the evil eye or has a wandering eye. Our language is full of expressions that refer to where people are looking—particularly if they happen to be looking in our direction.

As social primates, humans are keenly interested in determining the direction of gaze of other humans. It is important for evaluating their intentions and critical for forming bonds and negotiating relationships. Lovers stare for long stretches into each other's eyes, and infants focus intently on the eyes of their parents. Even very young babies look at simple representations of

faces for longer than they look at similar cartoonish faces in which the eyes and other features have been scrambled.

In this article, we investigate a series of illusions that take advantage of the way the brain processes eyes and gaze. It turns out that it is fairly easy to trick us into thinking that someone is looking somewhere else.

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



GHOSTLY GAZES

Not knowing where a person is looking makes us uneasy. For this reason, it can be awkward to converse with somebody who is wearing dark sunglasses. And it is why someone might wear dark sunglasses to look “mysterious.”

A recently identified visual illusion takes advantage of the unsettling effect of uncertainty in gaze direction. The “ghostly gaze” illusion, created by Rob Jenkins of the University of Glasgow in Scotland, was awarded second prize in the 2008 Best Illusion of the



Year Contest, held in Naples, Fla. In this illusion (*left and center*), twin sisters appear to look at each other when seen from afar. But as you approach them, you realize that the sisters are looking directly at you!

The illusion is a hybrid image that combines two pictures of the same woman. The overlapping photos differ in two important ways: their spatial detail (fine or coarse) and their direction of gaze (sideways or straight ahead). The images that look toward each other contain only coarse features, while the ones that look straight ahead are made up



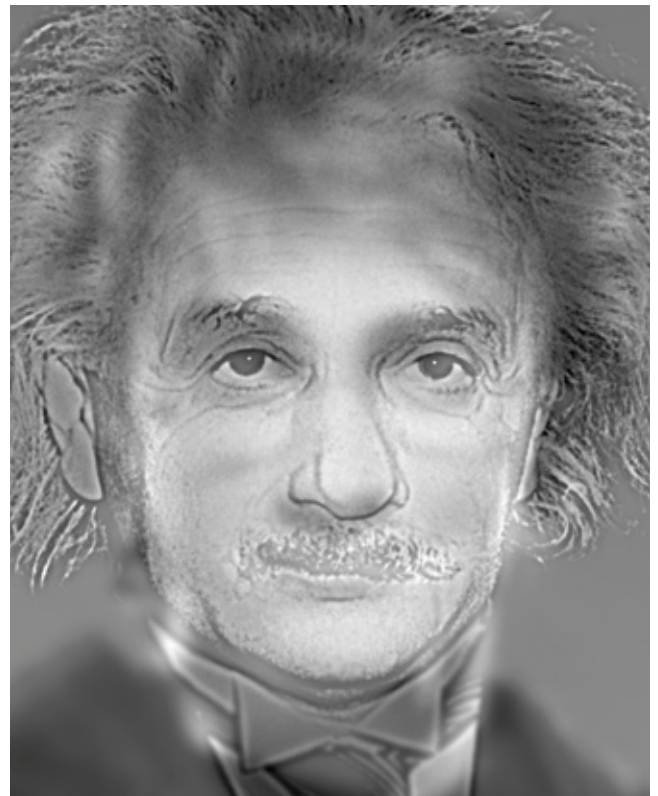
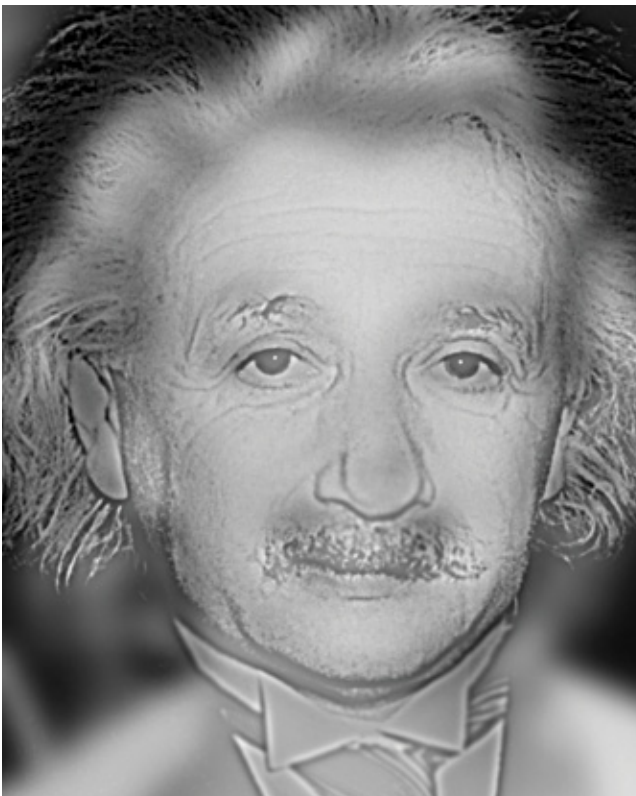
of sharp details. When you approach the pictures, you are able to see all the fine detail, and so the sisters seem to look straight ahead. But when you move away, the gross detail dominates, and the sisters appear to look into each other's eyes. See an interactive demo at <http://illusioncontest.neuralcorrelate.com/2008/ghostly-gaze>.

In another example of a hybrid image (*right*), a ghostly face appears to look to the left when you hold the page at normal reading distance. Step back a few meters, however, and she will look to the right.

COURTESY OF ROB JENKINS University of Glasgow

CONTEXTUAL CUES

Contextual cues, such as the position of the face and the head, also influence the perceived direction of gaze. In this illusion created by Akiyoshi Kitaoka, a professor of psychology at Ritsumeikan University in Japan, the girl on the left appears to gaze directly at you, while the girl on the right appears to be looking to her left. In reality, the eyes of both girls are identical. This illusion was first described in 1824 by British chemist and natural philosopher William Hyde Wollaston, who also discovered the elements palladium and rhodium.



EINSTEIN'S ALTER EGOS

The ghostly gaze illusion is based on a hybrid-image technique created by Aude Oliva and Philippe G. Schyns of the Massachusetts Institute of Technology. In a shocking example of how perceptual interpretation of hybrid images varies with viewing distance, Albert Einstein, seen from up close, becomes Marilyn Monroe (*left*) or Harry Potter (*right*), when seen from a few meters away. For more hybrid images created by the Oliva laboratory, visit the hybrid image gallery at http://cvcl.mit.edu/hybrid_gallery/gallery.html.

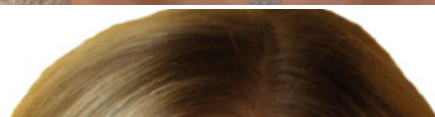
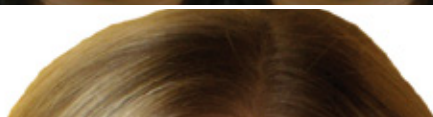
COURTESY OF AKIYOSHI KITAOKA, Ritsumeikan University (top);
COURTESY OF AUDE OLIVA, M.I.T. (bottom)



SEEING DOUBLE?

What if you duplicate some of the features of a portrait without overlapping them completely? It is relatively easy to create images in Photoshop in which the eyes and the mouth, but no other facial features, have been doubled. The results are little short of mind-bending: as the brain struggles (and fails) to fuse the doubled-up features, the photograph appears unstable and wobbly, and observers experience something akin to double vision.

The neural mechanisms for this illusion may lie within our visual system's specialized circuits for face perception. If you double up the eyes and mouths in a portrait, the neurons in the face-recognition areas of the brain may not be able to process this visual information correctly. Such failure could make the faces unsteady and difficult to perceive.



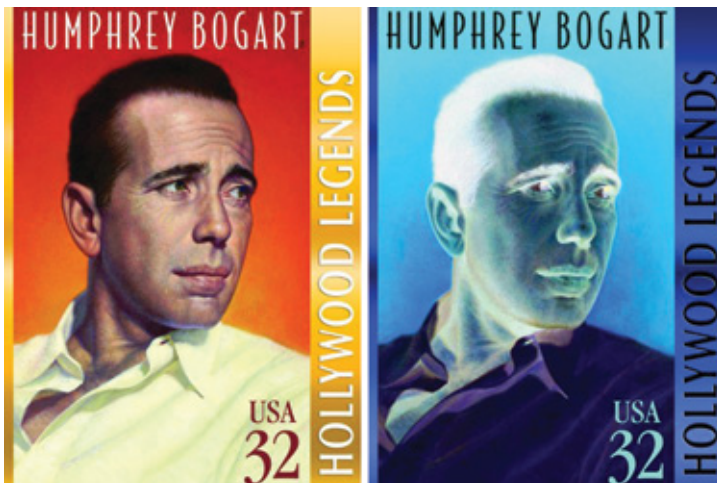
THE IRIS ILLUSION

This illusion, by vision scientists Jisien Yang and Adrian Schwaninger of the Visual Cognition Research Group at the University of Zurich, was one of the top 10 finalists in the 2008 Best Illusion of the Year Contest. It shows that context, such as the shape of the eyelids and face, affects the apparent distance between the irises. Consider the pair of Asian faces

shown here: the distance between the left eye of the left face and the right eye of the left face seems short. In the Caucasian faces, the separation looks wider. Notice the reconstructions of the eyes and irises below each face: without the context of the face and eyelid shapes, it is clear that the irises are equally spaced. Visit <http://illusioncontest.neuralcorrelate.com/2008/yangs-iris-illusion> for more details.

HERE'S LOOKIN' AT YOU, KID

Vision researcher Pawan Sinha of the Massachusetts Institute of Technology shows us with this illusion that our brains have specialized mechanisms for determining gaze direction. In the normal photograph of Humphrey Bogart (left), the actor appears to be looking to his left, but in the photo negative (right) he appears to be looking in the opposite direction. Yet Bogart's face does not look backward; only the eyes are reversed. Why? The answer is that we have specialized modules in our brain that determine gaze direction by comparing the dark parts of the eyes (the irises and pupils) with the whites. When the face is negative, the whites and irises appear to swap position. Our knowledge that irises are light rather than dark in a negative does not change our perception of this illusion.



COURTESY OF WALDEMAR JUNQUEIRA (top); COURTESY OF JISIEN YANG, University of Zurich, AND ADRIAN SCHWANINGER, University of Applied Sciences Northwestern Switzerland and University of Zurich (middle); COURTESY OF PAWAN SINHA AND TOMASO POGGIO M.I.T. (bottom)

(calendar)

September



7–10 Neuroimaging techniques have revolutionized our understanding of how the brain works. A recent study, for instance, used functional MRI to show that physical and emotional pain, such as feelings of rejection after a breakup, activate the same pathways in the brain. At the four-day **International Society for Neuroimaging in Psychiatry conference**, researchers will focus on how to use imaging techniques to visualize both normal changes that occur during a person's life and the effect of age-related diseases, such as schizophrenia or dementia, on brains over time.
Heidelberg, Germany
<http://isnip.org/meetings>.

html
24 Ever wish you could see what was going on inside your head? At the Technology Museum of the Federal Electricity Commission's **Brain: The World Inside Your Head**, you can. The exhibit, sponsored by pharmaceutical company Pfizer, takes visitors into a shimmering tunnel displaying a human brain in action. Special effects, 3-D and virtual reality enable museum-goers to explore what happens when we dream, how we experience pain and what the future of medicine holds for the brain.
Mexico City
www.evergreenexhibitions.com/exhibits/brain/index.asp

25–29 A dolphin's sonar message to another dolphin and the ominous footsteps a human hears on a deserted street have at least one thing in common—both patterns of sounds can contain information crucial for survival. At the five-day **11th International Conference on Cognitive Neuroscience**, Carles Escera, a neuroscientist from the University of Barcelona, will explore the similarities in how humans and animals detect novel sounds. Other speakers will discuss topics such as the neural basis of aging and memory, models of cognition in animals and techniques for imaging the brain.
Mallorca, Spain

www.icon11mallorca.org

Ongoing

Understanding the brain's complexity can be overwhelming, especially for children. The Web site **Brain Power: It's All in Your Head**, created by faculty members at the University of Washington, may make this learning process easier. For children aged



10 to 14, the site presents 30 exhibits that investigate how the brain works. One exhibit simulates how alcohol or other drugs can disrupt our sense of balance and our reaction times, and another models the process of addiction.



ROUNDUP: Navigating Mental Illness

September 25

Is it possible to empathize with a serial killer, even root for him to succeed? Surprisingly, it is—at least in the Showtime television series **Dexter**. Premiering its sixth season this month, the show centers on serial killer Dexter Morgan (played by Michael C. Hall), who works as a forensic bloodstain-pattern analyst for the Miami Metro Police Department. Like many people with antisocial personality disorder, Dexter expresses little to no remorse or empathy for others, lies pathologically, and needs to exert control and maintain order in his life. What helps make Dexter a likable killer, however, is his desire to live by a moral code, one that mandates he can kill only other murderers.
www.sho.com/site/dexter/home.do

October 2

Mental illness is more common than one might expect. According to a government survey in 2009, approximately one in five Americans (about 45 million people) experienced a mental disorder, such as depression, bipolar disorder or anxiety, that year. Learn more about what causes these diseases and what treatments exist dur-

ing **Mental Illness Awareness Week** by participating in outreach and educational programs across the country. Throughout the week PBS television stations will also air the documentary *Unlisted: A Story of Schizophrenia*, which follows a man afflicted with paranoid schizophrenia as his condition progresses and his daughter as she struggles to accept his illness.

Nationwide
www.nami.org

October 21

Schizophrenia affects about 1 percent of the world's population, but currently researchers do not know what causes the disease or how to cure it. Lorna Role, professor and chair of the department of neurobiology and behavior at Stony Brook University, is hoping to uncover this mystery. During the **Washington University Neuroscience Colloquium**, Role will describe her work on *neuregulin-1*, a key gene implicated in the disease's progression.

St. Louis, Mo.
<http://neuroscienceresearch.wustl.edu/Pages/NeuroscienceColloquium.aspx>

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

PHILIPPE PSAILA Photo Researchers, Inc. (brain); CORBIS (girl); VALERIE LOISELUX iStockphoto (green ribbon)

Psychological pressure can make you more attentive, improving your memory and ability to learn. But too much stress can have the opposite effect

SPLINTERED *BY* STRESS

By Mathias V. Schmidt and Lars Schwabe

A needling twinge in the torso or a tense interaction with a boss is all you need to get your nerves on edge. The bills are piling up and—of course—your spouse is on your case about them. You feel as if an extra weight is pressing down on your mind.

The all too familiar sensation of stress can preoccupy your thoughts, narrowing attention to the sphere of your concerns. But its effects do not end there—stress also causes physical changes in the body. In a stressful situation, alarm systems in the brain trigger the release of hormones that prepare you to fight back or flee the scene. Among other results, these chemicals may boost blood pressure, speed up heart rate and make you breathe faster [see box on page 26]. They may also affect your ability to learn and remember things.

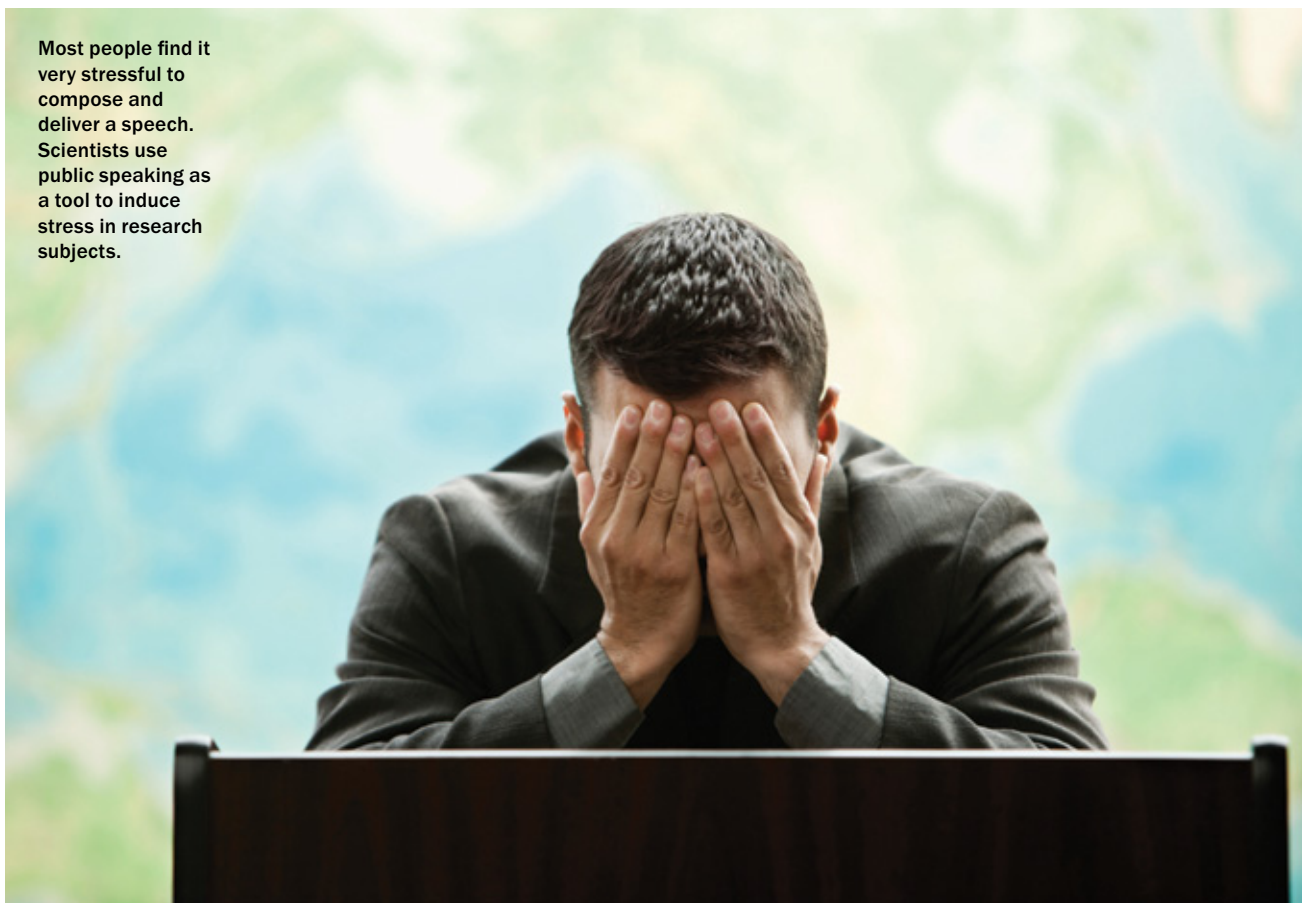
Think back on the tests you took in school.

Even when you crammed like crazy, your performance on exams may have left something to be desired. Maybe key pieces of knowledge simply escaped you—until they came to mind, unbidden, several hours too late. One possible explanation for this phenomenon is stress: your anxiety may have impaired your recall.

That reasoning sounds simple enough, but it turns out that the effect of stress on memory is surprisingly nuanced. Studies have shown that under certain circumstances, psychological pressure may actually improve recall—but not necessarily of the facts you were



Most people find it very stressful to compose and deliver a speech. Scientists use public speaking as a tool to induce stress in research subjects.



hoping to summon to pass the class. People who have trouble remembering information during a test often have strong recollections of the frustration and embarrassment they felt at the time. Emotionally charged experiences—whether positive or negative—remain extraordinarily well anchored in memory. Recall your most vivid experiences from last year. Most likely they were accompanied by particular joy, pain or stress.

FAST FACTS

Stress and Memory

- 1**» Stress hormones such as adrenaline and cortisol can either facilitate or impair memory, depending on when these hormones are released.
- 2**» Stress hormones may affect memory by strengthening or weakening the connections between nerve cells in the brain.
- 3**» Drugs that mimic cell-adhesion molecules, which bridge the gaps between nerve cells, may help restore memory in people with stress-induced cognitive disorders.

Researchers have long struggled to untangle the role of emotions and other factors in the encoding of stressful memories. In the past few years we and other researchers have come to the conclusion that the effects of stress depend on its timing and duration: the details of the moment make a big difference as to whether the stressor enhances recall or impedes it. And the memory boost happens for only a relatively short period—beyond a certain window, all stress becomes deleterious. Understanding the distinctions between different physiological responses may lead to new treatments that can reduce or even reverse the debilitating impacts of stress on memory.

Muddled Memories

In 2005 Sabrina Kuhlmann of the University of Düsseldorf in Germany and two colleagues conducted an experiment to test the effects of stress on memory. They wanted to know whether stress affects recall of either emotionally charged or neutral material. The three researchers had 19 young men memorize a list of 30 words that had either positive, negative or neutral associations. The next day the psychologists subjected some of the men to the Trier social stress test, a procedure that puts participants through a series of stressful experiences, including making a job-application speech to a panel of three people playing the role of company managers and then performing some mental arithmetic for the panel. A short time af-

GETTY IMAGES

terward, the men were asked to remember the words they had learned the day before. The result: stress reduced the number of emotionally charged words that the men were able to recall, although it did not affect their memory of neutral words.

Earlier experiments had found that administering the stress hormone cortisol can impair our ability to retrieve memories, but the Düsseldorf study was the first to show that stress itself can have this effect on humans, presumably by triggering the release of cortisol and other hormones. The finding may help explain

the event to be remembered. Immersing your hand in ice water right after studying a series of images, for example, seems to make those images more memorable later. But stress hormones have the opposite effect when they are released before the event or a considerable time afterward—as in the study where the young men took a stress test 24 hours after studying a word list.

The other requirement proposed by Joëls's team—convergence in space—occurs when the hormones released in response to stress activate the same neuronal circuits as does the

Mice subjected to chronic stress in early life do not perform well on memory tests in later life.

why people who are feeling stressed—during an exam or a job interview, for example—sometimes have trouble remembering important information. The results also suggest that emotionally arousing material may be especially sensitive to the memory-altering effects of stress hormones, perhaps because these hormones activate the amygdala—a brain structure that plays a critical part in processing emotions.

Initially that experiment seemed at odds with earlier studies that had reported *improved* recall of emotionally arousing material after receiving cortisol or undergoing a stressful experience. In one study, published in 2003, Larry Cahill and his colleagues at the University of California, Irvine, asked 48 men and women to look at a series of emotionally charged or neutral images. Immediately afterward, some of the participants were asked to immerse a hand in ice water—a test that causes discomfort and elevated cortisol levels in most people. The control group got a painless lukewarm hand dunk instead. A week later both groups took a memory test, and the people who had experienced the cold water treatment were able to recall more images than the control group. In both studies, stress had an effect only on the emotionally charged material—but in opposite ways.

Convergence in Time and Space

How can stress facilitate memory in some experiments but impair it in others? In 2006 a research team led by Marian Joëls of the University of Amsterdam in the Netherlands came up with a “unifying theory” to resolve the conflicting reports. Joëls and her colleagues proposed that stress facilitates memory only when it is experienced at about the same time as the event that needs to be remembered and when stress hormones activate the same biological systems as those activated by the event. In brief, they theorized that stress only aids memory “when convergence in time and space takes place.”

Convergence in time, as the researchers explained, is when the stress hormones are released during or immediately after



information to be processed and stored. These conditions only enhance memory, however, if the stress is short-lived. The beneficial effect disappears if the stress is chronic or repetitive.

Joëls and her colleagues also proposed a mechanism for how stress exerts these opposing effects on memory. The body's response to stress comes in two phases. At first, stress launches hormones and neurotransmitters that promote attention and help form new memories by strengthening the connections between brain cells. But just as a rocket fires a second stage once it is high in the sky, the hormone cortisol initiates a second process within an hour or so of the stressful event, and instead of promoting attention, cortisol now works to consolidate memories. The hormone suppresses the processing of any information not associated with the stressful event.

These two distinct stages of the stress response explain why stress can have such contrary effects on memory. Initially stress enhances perception and learning, but later, stress obstructs the processing of new information. According to this model, recalling an event such as being late to an exam should be easy because the stress occurs during the experience. But remembering information during the test is more difficult because the stress of taking the exam occurs hours or days after learning the information.

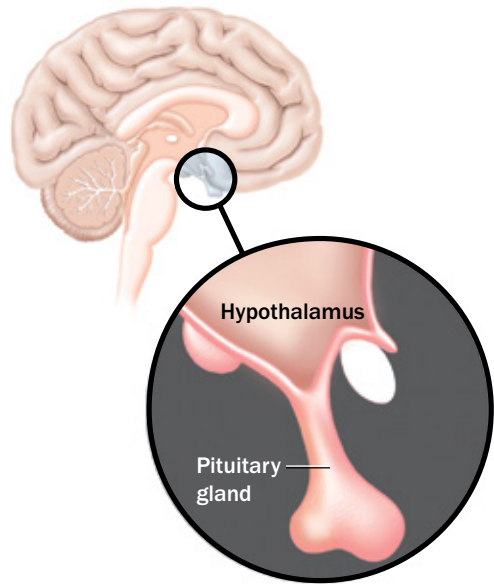
Stress not only affects how much information we retain in memory but also what type. Our memory is not like one big drawer into which we toss everything that we experience and

(The Authors)

MATHIAS V. SCHMIDT is a biologist and researcher at the Max Planck Institute for Psychiatry in Munich. **LARS SCHWABE** is a psychologist who recently graduated from the University of Trier in Germany and is doing postdoctoral research at the Ruhr University in Bochum.

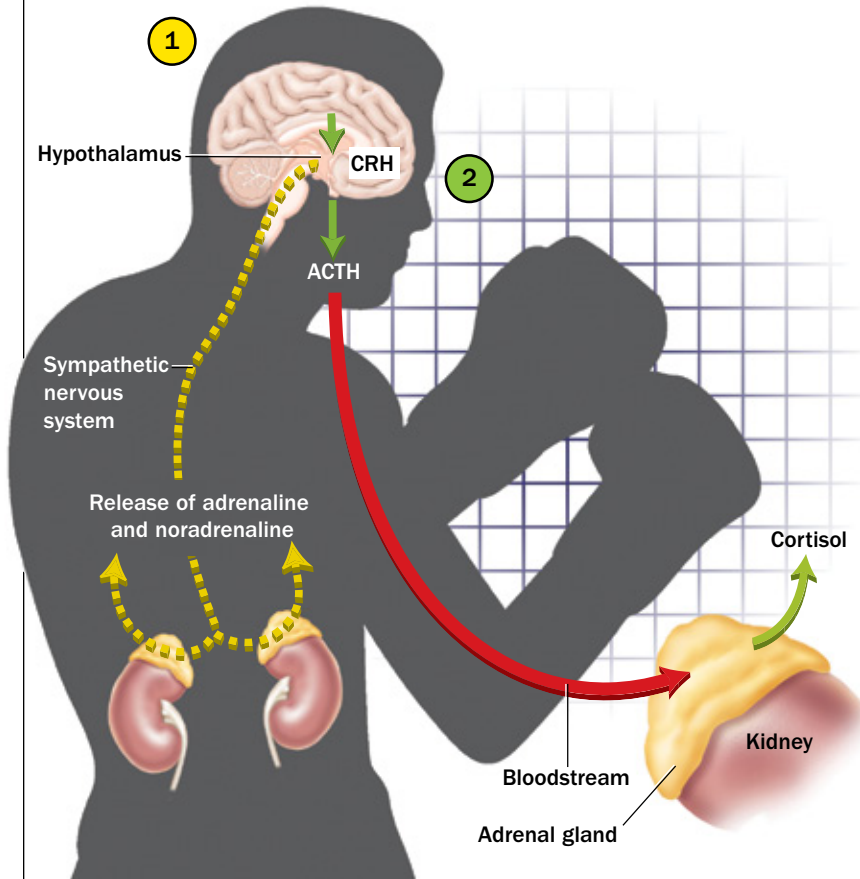
Defense Mechanisms

When we find ourselves in situations that seem threatening, the hypothalamus—a structure that lies deep in the brain—sends out an alarm. This triggers two cascades of activity: a rapid response that releases one set of hormones and a more delayed one that releases a different set of hormones. Together these two lines of defense not only enable us to cope with acutely stressful situations but also prepare us for similar future situations by strengthening our memory of what we have just been through. —M.V.S. and L.S.



1 Rapid Response

The hypothalamus sends a signal along fibers of the sympathetic nervous system to the adrenal medulla, located in the core of the adrenal gland just above the kidney. The adrenal medulla then releases the stress hormones adrenaline and noradrenaline, which prepare the body for a rapid fight-or-flight response. Energy reserves are mobilized; blood pressure and heart rate increase to better supply nutrients to the muscles; respiration increases so that more oxygen reaches the brain; natural painkillers are released preventively; and platelets are activated to minimize blood loss in case of injury.



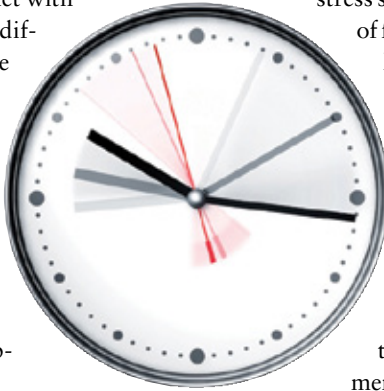
2 Delayed Reaction

Later the body releases another set of hormones from the hypothalamus, pituitary gland and adrenal cortex in sequence. First, corticotropin-releasing hormone (CRH), which is produced in the hypothalamus, travels along a special network of capillaries to the pituitary gland, an almond-size structure located near the base of the skull. There CRH triggers the release of another hormone, adrenocorticotropic hormone (ACTH), which travels to the adrenal cortex via the bloodstream and triggers the release of cortisol—the most important human stress hormone.

Cortisol boosts the action of adrenaline and noradrenaline while at the same time preparing the body for a return to normal. It puts a damper on the body's inflammatory and immune responses and promotes the transformation of nutrients into fats and glycogen, thereby replenishing spent stores of energy.

THERESA SAKNO

learn. Rather it resembles a giant filing cabinet with many drawers and folders, each containing different types of information. Some of these files—including the episodic memory that gives us access to life experiences—are extremely sensitive to stress. Memories of practical skills such as bicycling and typing, on the other hand, are barely affected by stress. These different memory systems work in parallel and may even compete with one another, and stress plays a role in determining which memory system has the upper hand at any given moment.



stress simplifies our learning behavior at the expense of flexibility, making it harder for us to apply our knowledge to new situations. If a fire alarm goes off in a building, for example, you might find that you can remember only that you usually follow the first hallway on the left to reach the main entrance. But that knowledge is of little use if the main entrance is blocked and you need to find your way out through a side entrance.

In 2009 we confirmed the hypothesis that under stress, the brain favors rigid “habit” memory over more flexible “cognitive” memory.

Under stress, the brain favors rigid “habit” memory over more flexible “cognitive” memory.

Simpleminded Learning

To test the effect of stress on various learning strategies, we conducted an experiment in 2007 at the University of Trier in Germany. We showed the participants a three-dimensional model of a room containing a chair, a potted plant and a table with four cards lying face down on it [see illustration below]. The object of the game, which every participant played 13 times, was to win 50 cents by selecting the “winning” card from among the four cards. Half the players were subjected to the Trier social stress test before playing the card game.

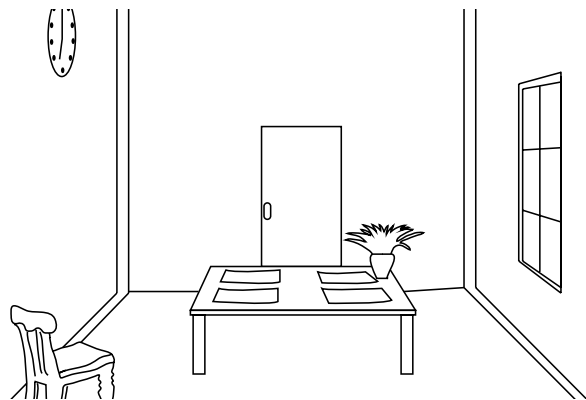
What none of the players was told was that the winning card was always located in the same place—in the corner next to the potted plant. At first, players picked the winning card only by chance. But as the game went on, the participants used one of two strategies. Some players oriented themselves spatially, using the relation between various objects in the room—such as the door, a window and a clock hanging on the wall—as clues to where the winning card might be located. Other players used a “stimulus response” strategy: they looked for a simple association between the winning card and another object in the room. We were easily able to test which strategy a subject was using simply by moving the plant and placing winning cards in two of the four positions—next to the plant’s new location and in the corner where the winning card had previously been located. If a player selected the card that had always been in the winning corner, we concluded that he was using a spatial learning strategy. On the other hand, a player who selected the card next to the now repositioned plant was probably using a stimulus-response learning strategy.

The results revealed that participants who had not taken the stress test were much more likely to use the more flexible—but more mentally taxing—spatial learning strategy. Under stress, almost all the participants fell back on the simpler stimulus-response strategy.

These results and data from other studies suggest that

We subjected half our subjects to the ice-water stress treatment for several minutes, whereas participants in the control group immersed their hand in lukewarm water. Afterward everyone was asked to choose between chocolate milk and orange juice by clicking on symbols on a computer screen. The participants quickly learned which symbols would deliver the drink of their choice, but then we spoiled their appetites by feeding them chocolate pudding or oranges.

When they resumed choosing drinks, the participants in the control group who had eaten chocolate pudding avoided the now devalued chocolate milk, and participants who had eaten oranges avoided orange juice. But their stressed counterparts responded differently: even though the participants reported no further interest in the food they had just eaten, they continued to click on the symbol associated with it. They



STRATEGY FOR STRESS

In this test, subjects try to pick the “winning” card from among four cards lying face down on a table. Under stress, participants fall back on a simple strategy: they look for a single clue, such as a potted plant placed next to the winning card. Unstressed participants are more likely to orient themselves in relation to features seen in the room—a more difficult but more accurate spatial learning strategy.

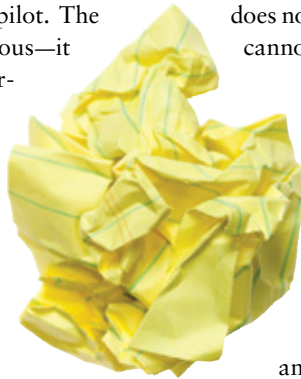
It may even be possible to develop drugs that enhance the positive effects of stress on memory and recall.

had become victims of habit, operating on autopilot. The evolutionary advantage of this strategy is obvious—it enables the brain to concentrate on more important things in a stressful situation.

Life in the Rat Race

Tests on human volunteers can help reveal the effects of stress on learning and memory, but animal experiments also provide clues. Rats, mice, chicks and other vertebrates release hormones and neurotransmitters in response to stress, just as we do. And as with people, animals must remember places and events: Where did I find food yesterday? Where is my nest? Which places are dangerous and must be avoided? Reliable memories of stressful events are essential for survival.

Scientists have devised a number of methods for measuring learning and memory in animals. One frequently used approach, developed in 1984 by Richard Morris of the University of St. Andrews in Scotland, is a water maze—a large basin filled with cold water. (Unlike a conventional maze, the water “maze”

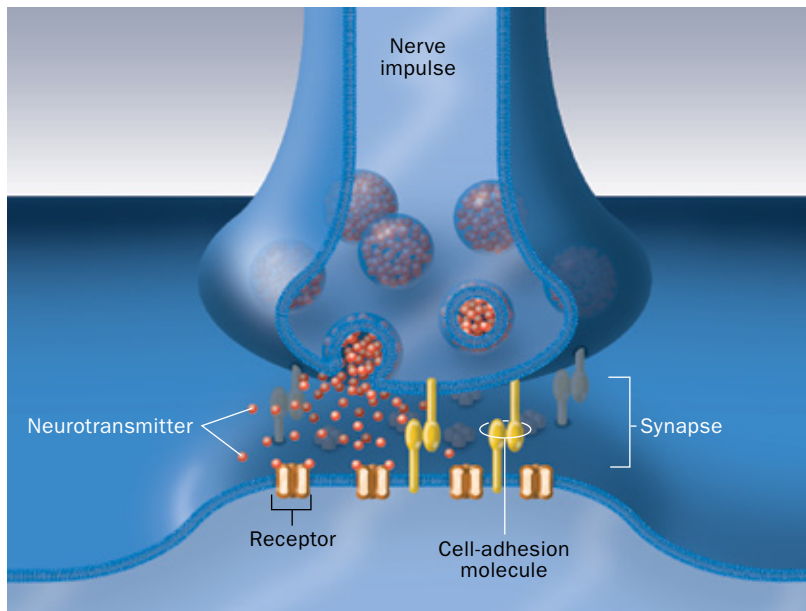


does not have branching passages.) Rats placed in the basin cannot see a small platform hidden just below the water’s surface, but they are highly motivated to find it: the faster they do so, the sooner they can get out of the cold water. At first, a rat placed in the water finds the platform only by chance. After repeated tests, though, the rat learns to use conspicuous markings on the walls to quickly find the platform.

Studies using the water maze have shown that stress hormones play an important part in the learning process in rats as well as humans. For example, in 1992 Melly S. Oitzl and E. Ronald de Kloet of Leiden University in the Netherlands demonstrated that in the absence of stress hormones, rats perform poorly in a water maze. After Oitzl and de Kloet removed the rats’ adrenal glands, which are responsible for releasing the stress hormone corticosterone (similar to human cortisol), the animals needed much more time to locate the underwater platform. The researchers observed the same effect after they blocked corticosterone receptors in the rats’ brain.

But as with humans, timing is everything. Stress that is independent of the learning situation can impair memory, as David M. Diamond, then at the University of Colorado Health Sciences Center, and three colleagues showed in an experiment in 1996. First they trained rats to forage for food hidden in seven arms of a 14-arm radial maze. After about a month, the rats rarely visited the arms without food. Then the experiment began. As soon as the rats had eaten four of the seven treats, the rodents were removed from the maze and placed in either a familiar or a stressful environment for up to four hours. After the unstressed rats returned to the maze, they had not forgotten where to find the three remaining treats, but the stressed rats made many more errors while searching for the treats.

Persistent or intense stress may even decrease cognitive capacities over the long term. In 2009 our research team at the Max Planck Institute for Psychiatry in Munich showed that mice that were subjected to chronic stress in early life do not perform well on memory tests in later life, compared with their unstressed littermates. The reasons for the difference are buried deep in the brain.



CLOSE CONNECTION

Nerve impulses travel through the brain by jumping from one nerve cell to the next across a gap called the synapse. At every synapse, the upstream nerve cell releases a puff of neurotransmitters, chemical messengers that travel across the gap and bind to receptors on the downstream cell. Specialized cell-adhesion molecules connect the two cells across the gap, stabilizing the synapse. Recent research indicates that stress affects the production of cell-adhesion molecules, which may in turn affect long-term memory by strengthening or weakening synapses.



Animal studies suggest that stress in early life can impair memory in adulthood. The same may be true for humans.

Stronger Synapses

Memories depend on the structural connections between the brain's nerve cells—the synapses where nerve impulses jump from one cell to the next. A particular stimulus, such as a green traffic light, triggers a cascade of signals that activate what we have already learned: green means go. Step on the accelerator.

Learning strengthens these cellular connections. As a result, signals are more easily transmitted from one nerve cell to its neighbors—a process known as long-term potentiation. This process is what allows the brain to store and recall information. Synapses can grow stronger or weaker over time, depending on their level of stimulation, and memories in turn can be reinforced or forgotten.

If stress hormones are brought to bear on the nerve cells during the right window of opportunity, they can produce a long-lasting improvement in signal transmission and with it memories of that particular event or place. If the hormones are not present at the right time, however, the connections between the nerve cells are comparatively weaker—and memories of that moment are harder to access.

Specialized cell-adhesion molecules may be a key to the learning process at the cellular level. These proteins connect two nerve cells, stabilizing the synapse between them and enabling the transmission of signals from cell to cell. Cell-adhesion molecules have an important role in reestablishing contact between nerve cells. They also assist in enabling the synapses to change strength in response to increased or decreased signal transmissions.

Recent research suggests that stress affects the production of cell-adhesion molecules, thereby affecting long-term

memory. A team led by Carmen Sandi of the Brain-Mind Institute of the Swiss Federal Institute of Technology in Lausanne has found that stress activates neural cell-adhesion molecules (NCAMs) in the hippocampus—a region of the brain that is essential for learning new information and consolidating it in long-term memory. Mice in which NCAM activation has been suppressed by genetic manipulation have impaired learning and memory.

With a better understanding of how stress affects memory at the cellular level, we may be able to develop new drugs to treat stress-induced cognitive disorders, perhaps even Alzheimer's disease. One example of such work is a research project sponsored by the European Union, called MemStick, which is studying the effect of cell adhesion. The project's hypothesis is simple: if cell-adhesion molecules are responsible for forming or stabilizing synapses, we should in theory be able to develop analogous substances that restore memory by simulating the function of these molecules. And in fact, researchers have already developed a mimetic peptide for NCAM—a small protein that is similar to a portion of the molecule. If rats under chronic stress are treated with this peptide, they show reduced loss of cognitive performance.

This success offers hope that someday new drugs will be able to reduce—and perhaps even reverse—the negative effects of stress on memory processes. It may even be possible to develop drugs that are able to enhance the positive effects of stress on memory and recall: imagine a pill that could help you ace an exam or job interview. That glimmer of hope is something to think about the next time you feel the pressures of life, work and love closing in on you. **M**

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Fight the

FRAZ

A new study suggests that preventive, proactive approaches are the most helpful—and that our stress management IQ is painfully low

By Robert Epstein

ZILED Mind

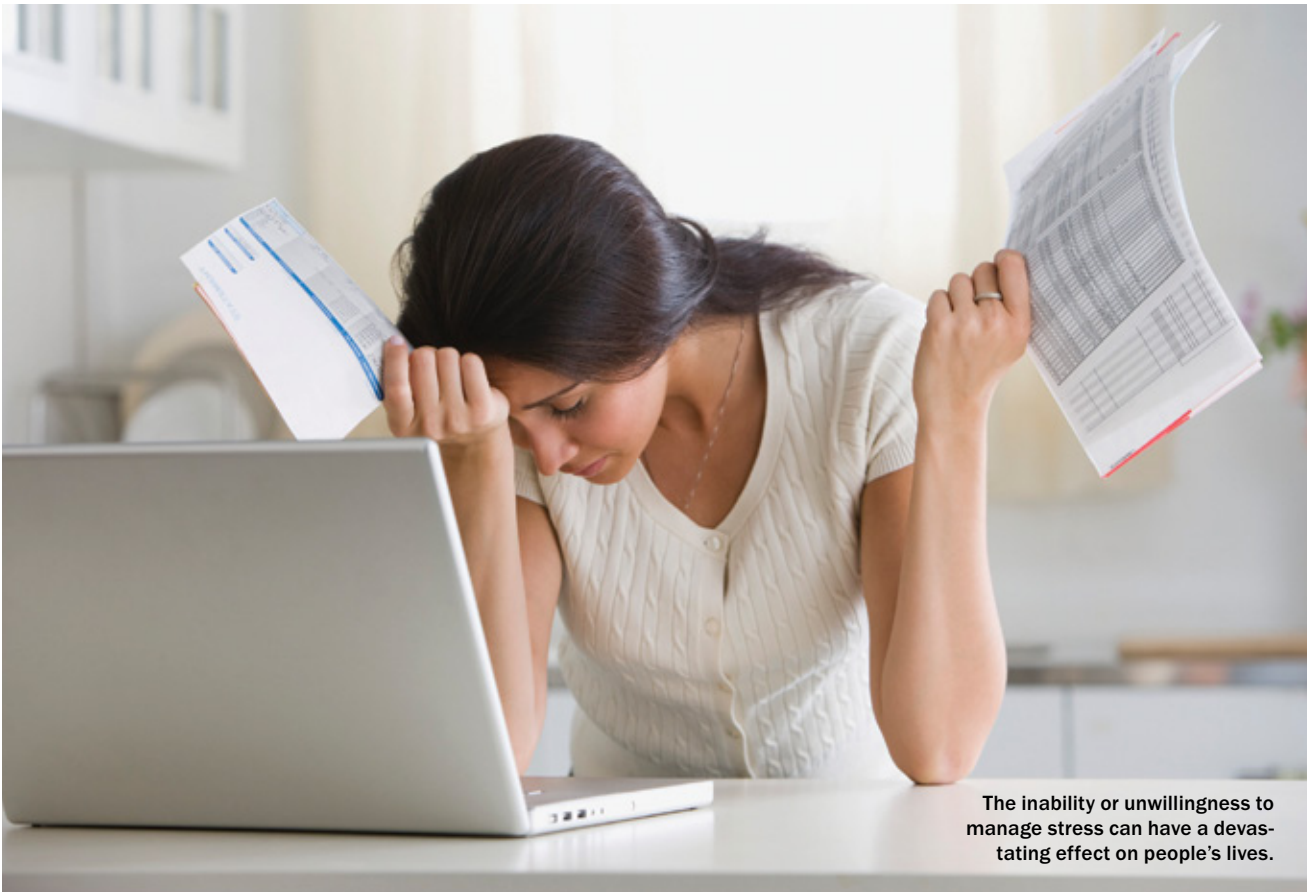
“Desserts” spelled backward is “stressed.”

Isn't life like that? Even the good things in life—fine wine, rich food, sex—can stress you out.

There is just no escaping stress, and some experts even suggest that a little stress is good for you. In my view, that idea is flawed—the misleading result of averaging data across many individuals. Yes, high levels of stress are harmful to most people, adversely affecting health, mood and productivity. And yes, most people perform and feel better when faced with moderate levels of stress. And sure, very few people know how to be productive when they are not being pushed by stressors—but it can be done. Just as some people are able to perform well under highly stressful

conditions (think Olympic athletes), it is also possible to perform well when relaxed (think masters of kung fu). That should be the goal, in my opinion: a life that is productive but also virtually stress-free.

Bear in mind that there is only an approximate relationship between stress—our internal, adverse reaction to stimuli we perceive as threatening—and stressors—the threatening stimuli that actually surround us. A traffic jam might make us feel stressed one day but not the next. This is good news because it suggests that with the right training and preparation, we might be able to face *any* stressor with equanimity.



The inability or unwillingness to manage stress can have a devastating effect on people's lives.

I have been investigating this issue for nearly two decades now, and in a study I presented recently at the annual meeting of the Western Psychological Association in Los Angeles, I compared different stress-management techniques to see which are the most helpful.

In real life, unfortunately, although we receive intensive formal training in writing and math, learning how to manage

stress is left entirely to chance. Many people, overwhelmed by bills, flat tires and abusive bosses, resort to destructive ways of coping, drugs and alcohol being the most common. But research conducted over the past few decades suggests that there are at least four broad, trainable skill sets or “competencies” people can use to manage stress nondestructively: source management (reducing or eliminating the sources of stress), relaxation (practicing techniques such as breathing exercises or meditation), thought management (correcting irrational thinking and interpreting events in ways that don’t hurt you), and prevention (planning and conducting your life so that you avoid stressors).

My new study looked at how an ethnically and racially diverse group of 3,304 people managed stress. The subjects ranged from 10 to 86 years old (mean 34.9), and about 85 percent of them were from the U.S. or Canada, with the remainder from 28 other countries. They participated in the study by completing an online test accessible at <http://MyStressManagementSkills.com>.

Participants were asked to answer various demographic questions and then to rate, on 10-point scales, how stressed they were, how generally happy they were, and how much success they had had in both their personal and professional lives. I conjectured that people with good stress-management skills would be not only less stressed but also happier and more successful both personally and professionally. Stress can really wear you down, after all, and it is brutal on relationships, even affecting the quality

JOSE LUIS PELAEZ, INC. Corbis

FAST FACTS
Stress Test

- 1» Few people receive formal training on how to manage stress, which may explain why many of us turn to destructive ways of coping.
- 2» Although commonly practiced relaxation techniques such as yoga and meditation help, they may not be as effective as learning to sidestep potential stressors before they happen.
- 3» Receiving training in stress management will make us better at handling the ups and downs of daily life.

Test Your Stress-Management Competence

Here is a selection of items from the Epstein Stress-Management Inventory (ESMI-i). To get a rough measure of your competence in the four areas measured by the test, check off items that apply to you. If you are able to check off three or four items in a category, you are probably

COMPETENCY I

Manages Sources of Stress

- I have adequate shelf, file and drawer space to serve my needs.
- I consistently put important tasks ahead of unimportant tasks.
- I try to schedule appointments and meetings so that they won't overlap.
- I have no trouble keeping my work area organized.

COMPETENCY II

Practices Relaxation Techniques

- I schedule some relaxation time every day.
- I sometimes visualize soothing scenes to relax.
- I sometimes use special breathing techniques to help me relax.
- I sometimes tense and relax my muscles as a way of fighting stress.

reasonably competent in that category. To compute your overall score, add up the number of check marks you made. If you scored under 12, you might want to consider taking a stress-management course. To take the full version of the test, visit <http://MyStressManagementSkills.com>.

COMPETENCY III

Manages Thoughts

- I regularly examine and try to correct any irrational beliefs I might have.
- I'm aware that my thinking is sometimes unclear or irrational.
- I keep myself calm by being selective about what I pay attention to in my environment.
- I often reinterpret events to reduce the stress I'm feeling.

COMPETENCY IV

Prevents Stress from Occurring

- I try to fight stress before it starts.
- I keep an up-to-date list of things I'm supposed to do.
- I spend a few minutes each morning planning my day.
- I have a clear picture of how I'd like my life to proceed over the next few years.

GRAND TOTAL _____

Although we receive formal training in writing and math, learning how to manage stress is left entirely to chance.

of parenting ["What Makes a Good Parent?" by Robert Epstein; *SCIENTIFIC AMERICAN MIND*, November/December 2010].

The main body of the test consisted of 28 questions about different practices that fall into the four broad competency areas I mentioned earlier, with the questions asked in a random order. "I often reinterpret events to reduce the stress I'm feeling" is an example of a test item that fits into the thought-management category. (To take an abridged version of the test, see the box above.) For each test item, people indicated on a five-point scale how much they agreed or disagreed with the statement. On completion of the test, participants were immediately given a total score, along with results in each of the four competency areas and information about what the scores meant.

A Surprise, a Lesson and a Dire Need

I thought I could predict the outcomes of this study fairly well (a presumptuous attitude in science), but in one respect—an outcome that has important practical implications—my predic-

tion was way off. If anyone had asked me which of the four competencies were most important, I would have said relaxation, followed by thought management. After all, a number of studies confirm what common sense tells you about relaxation: people who learn and practice techniques such as breathing exercises, muscle-relaxation exercises, yoga, meditation, and so on benefit in multiple ways. Meditating regularly, for example, has been shown to lower blood pressure and also to help people feel

(The Author)

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“immunized” against stressors. As for thought management, it is perhaps the main thing that therapists and counselors teach their clients: how to reinterpret events in your life so that they stop bothering you. It is empowering to learn how to do that.

But the new study showed clearly that prevention is by far the most helpful competency when it comes to managing stress. I determined this using a statistical technique called regression

and thought management—the competencies that people who are concerned about stress are most likely to try to improve through counseling or training. Relaxation, which can be practiced both proactively and reactively, fared better than thought management, which is almost always reactive. (My favorite example comes from Aesop’s Fables. Frustrated that he can’t reach the bunch of grapes, the fox reframes his thinking

On average, people get a grade of F when it comes to managing the inevitable stress they face in their lives.

analysis, in which scores in the different competency areas (known as subscales on a test of this kind) are used to predict various outcomes, in this case the answers to those questions about happiness and success. Prevention—doing things such as planning your day or year and trying to avoid stressors before they can affect you—was by far the most powerful predictor of all four of the outcome questions.

Also suggestive, the second most powerful predictor was source management, which is sometimes reactive but usually proactive. This broad category includes practices such as delegating tasks, organizing your space and scheduling your time well, all of which can be considered preventive measures.

Least predictive were those other two competencies, relax-

ation and concludes, “They are probably sour anyway.” Problem solved! Stress relieved!

The lesson here is to manage stress proactively. Taking a deep breath or counting to 10 when you are stressed is all well and good, but you will be much happier in the long run if you can find ways to avoid the situations that make you feel stressed in the first place [see box on opposite page].

Can we actually learn to fight stress more effectively? Fortunately, my study shows that (1) people who have had training in stress management are better at it than people who have not and that (2) the greater the number of training hours, the better the skills. This suggests that no matter what our natural reactions are to stress, learning stress-management skills is likely



Preventing sources of stress before they strike is an important skill that many of us lack. Small scheduling changes could eliminate traffic jams and other teeth-grinding situations we experience.

AURORA PHOTOS

An Ounce of Prevention

Here are six strategies for fighting stress before it starts, which are suggested by the new study:

- 1. Seek and kill.** Take a few minutes every day to identify stressors in your life and find ways to reduce or eliminate them. Does that old cell phone of yours make you swear because the battery keeps dying? Get a new phone!
- 2. Commit to the positive.** In our culture, people often try to cope with stress in self-destructive ways, mainly by drinking, taking drugs or overeating. Commit to avoiding the self-destructive solutions—for a day, a week or whatever you can handle—and replacing them with positive, healthful ways of managing stress. Yoga class, anyone?
- 3. Be your own personal secretary.** People who keep lists of things to do really do more things. So use your smartphone or, in a pinch, a pen and paper (remember those?) to keep a list of things you need to do. You'll never walk out of a supermarket again having purchased everything except what you went there to buy.
- 4. Immunize yourself.** Through exercise, thought management and the daily practice of relaxation techniques, you will be in a better position to face stressors without feeling stress. Lion tamers manage to remain calm when working with lions, after all. With the right preparation, you can face almost any situation calmly.



- 5. Make a little plan.** Spend a few minutes every morning planning your day. You will waste less time, get more done and feel less stressed.
- 6. And make a big plan.** The famous behavioral psychologist B. F. Skinner not only planned his day and year, he even maintained a 10-year planner. You don't need to go that far, but planning your future is a great way of exercising more control over your life. The more control you have, the less stressed you will feel.

to be beneficial. That said, only 17 percent of the subjects in this study had had any stress-management training—a figure that is probably much lower in the general population. Even more disturbing, the new data show that people are poor at prevention; it ranked third out of the four competencies in our test scores.

The worst news, though, has to do with the overall scores I found. On a 100-point scale, people scored 55.3 on average on a test of simple, basic stress-management techniques. If you think of that as a score on an exam at school, that means that on average, people get a grade of F when it comes to managing the inevitable stress they face in their lives.

The Importance of Stress Management

A few years ago I conducted a seminar on stress management at a mental health facility in Massachusetts. Before we started, I asked the attendees—administrators and staff members at the clinic—to take a test of stress-management competence similar to the one I used in the present study. One disturbing result: the director of the clinic—a personal friend—had the lowest score in the room. He also had the most stressful job, and he had suffered some significant health problems in recent years, very likely brought about or at least made worse by stress. The physiological mechanisms by which stress damages health have now been well established.

The inability or unwillingness to manage stress can have a

devastating effect on people's lives. One of the most dramatic results of the new study was a high positive correlation between test scores and the overall level of happiness people reported. To put this another way, the study suggests that nearly 25 percent of the happiness we experience in life is related to—and perhaps even the result of—our ability to manage stress. I also found a strong negative correlation between the test scores and the level of stress people were feeling, as well as strong positive correlations between test scores and both the personal and professional success people had experienced.

The bottom line is that stress management is both trainable and beneficial, and individuals reap the greatest benefits by fighting stress before it starts. That insight leaves us with a great challenge: to teach techniques for managing stress to a public that knows little about them and, especially, to educate our children before the big stressors hit. **M**

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♥ A Tale of Two Rodents ♥



Rats teach a neuroscientist lessons of love—
or at least sex

By Kelly Lambert

In the reality television shows *The Bachelor* and *The Bachelorette*, 25 potential mates vie for a desirable male or female during a series of artificial encounters and interactions. The most attractive candidates are given a rose each week, a gesture indicating their special standing among the others. These shows are saturated with cultural icons representing romance and desire: physically beautiful people, bikinis, hot tubs, gourmet meals, adventure dates, champagne.

All of this drama and glamour leads to the Final Rose Ceremony, during which a rose is given to the favorite mate. This moment is often accompanied by a marriage proposal, although the entire relationship has been staged for a TV audience. To no one's surprise, out of 22 shows and final rose ceremonies, only two marriages actually emerged from this confusing, uninformed, maladaptive mating game.

In stark contrast to this glitzy display, rats—yes, rats—can inform us of the essen-

Reprinted from The Lab Rat Chronicles: A Neuroscientist Reveals Life Lessons from the Planet's Most Successful Mammals, by Kelly Lambert, Ph.D., by arrangement with Perigee, a member of Penguin Group (USA) Inc., Copyright © 2011 by Kelly Lambert.

Illustrations by Kate Francis

ALAMY (left); OLEG KOZLOV Alamy (above)



SERENADING IN THE BUFF: Male rats make music during the act, uttering a special song for each phase of the intimate tango.

tial elements of romance, which are definitely missing from this reality-show version of a relationship train wreck. The information revealed by rats, mice and monogamous prairie voles illuminates some of the dark mysteries of love affairs. These rodents remind us of the importance of a few basic ingredients that are critical for successful relationships, regardless of your species.

The Joys of Rat Sex

Rats have been studied intensely, enabling us to use them as a model to discern the influence of hormones, drugs, age and a host of other variables on

sexual behavior. From decades of research, we know that rats follow a rather predictable sequence of events in the bedroom.

It goes something like this: The male rat greets the female rat by sniffing her. If the male seems distracted, the female may get his attention by darting around the cage and engaging in the ultimate rat flirtation response: ear wiggling. I still feel as if I am watching a cartoon when I see this behavior, the ears look like little helicopter propellers as the female entices the male to approach her. There is also a lot of sniffing. The female is sexually receptive, or in a behavioral state known as estrus, only 12 to 20 hours of her four- to five-day estrous cycle. It is only during this time, after ovulation, that the female will mate. In fact, if a male approaches when she is not in estrus, she is likely to give him a swift kick. Not having access to text messages, the males rely on their olfactory system to determine if the female is in the mood for love.

Only if the female is in estrus and has attracted the male's attention will the copulatory sequence begin. As the male mounts the female's back and grasps her sides, she reciprocates by assuming a posture known as lordosis characterized by an arched back and lifted tail.

During a series of initial mounts, the male attempts to achieve penetration. If and when he does, that mount with accompanying penetration, lasting all of 200 milliseconds, is known as an intromission. Then the male mounts the female again. In an extended version of foreplay, this sequence will continue until the male has achieved from eight to 12 intromissions. On the last mount and penetration, the male finally ejaculates. To enhance the romantic ambiance, the male likes to sing during this process—he has a special ultrasonic vocalization announcing every phase of his sexual performance.

After this intense sequence—which lasts about 10 minutes—the male will take about a five-minute break and, yes, begin the entire ritual again. If left undisturbed, the two mice will repeat this reproductive dance five or more times. (I enjoy watching the sometimes sleepy male students in my animal behavior lectures suddenly wake up from their slumber as they hear about these rat sex studs.) As the males continue this marathon date, however, the time between the ejaculation and the next intromission, known as the postejaculatory interval, gets longer and longer, as if the male were getting tired over the course of the date night.

If a new female is placed in the cage, even when the male is displaying his “I’m exhausted” act, the rules suddenly change. With a new female in the

FAST FACTS

Rat Romance

- 1** >> Female rats are not passive sex partners: they pace the encounters and will run across an electrified grid to gain access to a male.
- 2** >> Sex fortifies the brain (in rats, at least), stimulating the growth of new neurons and neuronal connections.
- 3** >> Rodent females are choosy, traveling up to seven city blocks—a long way for a rat—to find a male who meets her standards. She sniffs out his biological germ-fighting arsenal.

area, an entirely new sequence begins, providing evidence that, for the rats, a little variety tends to spice things up.

Legend has it that this so-called Coolidge effect has a rather unique namesake. According to the story, President Calvin Coolidge was touring a chicken farm with his wife, Grace, during the 1924 reelec-

the world have benefited from basic reproductive endocrinology work first contributed by rodents.

Hot Heads

Screenwriter Woody Allen has famously called the brain his “second favorite” organ. The truth is that the brain is just as essential to sexual behavior

This brain structure is responsible for the four F's: feeding, fleeing, fighting ... and mating.

tion campaign. When Mrs. Coolidge noticed the sexual vigor of a prize rooster, she asked the tour guide about the number of sexual encounters the rooster averaged in a day. After learning that the number was rather high—up to 20 encounters a day—she was visibly impressed and asked the guide to mention this interesting bit of information to the president. When President Coolidge heard this statistic, he asked if the encounters were with the same hen every time. The guide commented that, to the contrary, it was with a different hen every time. The president then asked the guide to convey *that* bit of information to Mrs. Coolidge.

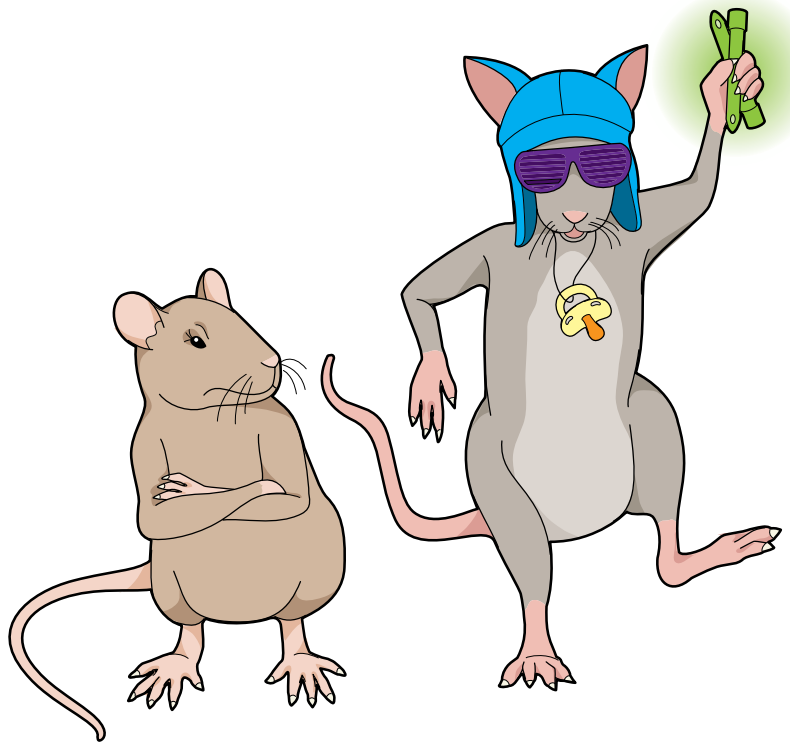
When tested under the right conditions, we now know that females actually pace the timing of the males' mounts and intromissions. Even though the males prefer fast-paced intromissions and ejaculations, females require longer intervals to ensure fertilization and pregnancy. If males are tethered in a cage and the copulation depends on the advances of the female, her optimal pacing schedule becomes apparent.

We can also use the rat sex model to learn about the potential disruptions or enhancements of certain drugs or environmental conditions on sexual responses. In a recent study, for example, a group of Italian neuroscientists wondered about the effects of rave parties on sexual behavior in humans. The researchers administered MDMA (Ecstasy) to rats and played very loud music for a specified period. They found that MDMA suppressed the sexual vigor of the male rats, but surprisingly the loud music mitigated the negative effects of the drug somewhat, though not to baseline levels. So the data from the rat raves suggest that such all-night parties have a negative impact on sexual responses.

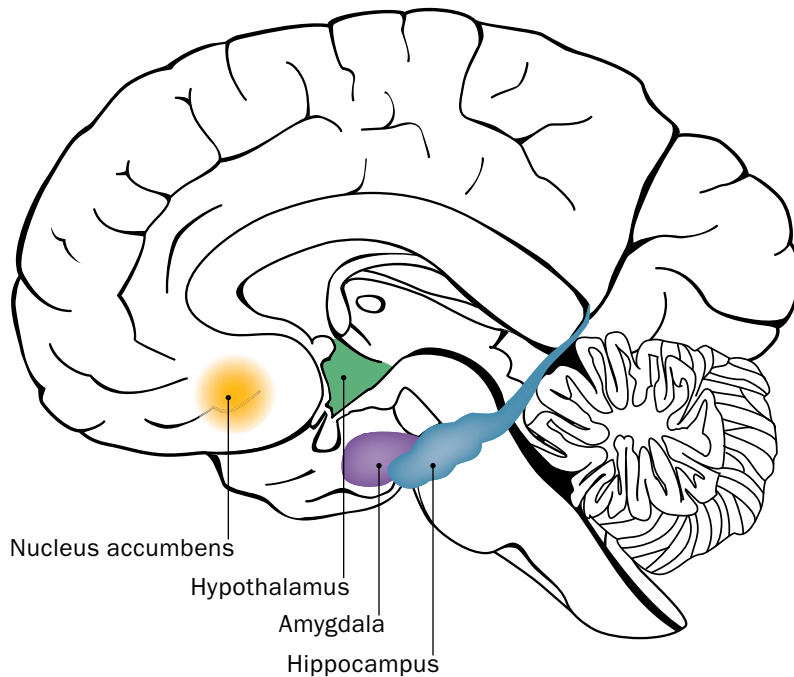
All of this rat-sex reporting over the years has enlightened the medical community about the effects of different hormones on every aspect of the reproduction process. Fertility patients across

as the reproductive organs. The cadre of reproductive hormones—such as estrogen, testosterone, progesterone and prolactin—pulls the appropriate neural triggers for reproductive responses. In rodents, if the hormones are removed, the behavior is removed; thus, their sexual responses are considered hormone-dependent. These hormones exert their effects by entering the brain through its security system, the blood-brain barrier, and activating certain areas responsible for reproductive behaviors.

In the female, the focus has been on the small structure called the hypothalamus [*see top illustration on next page*]. Generally this pinhead-size re-



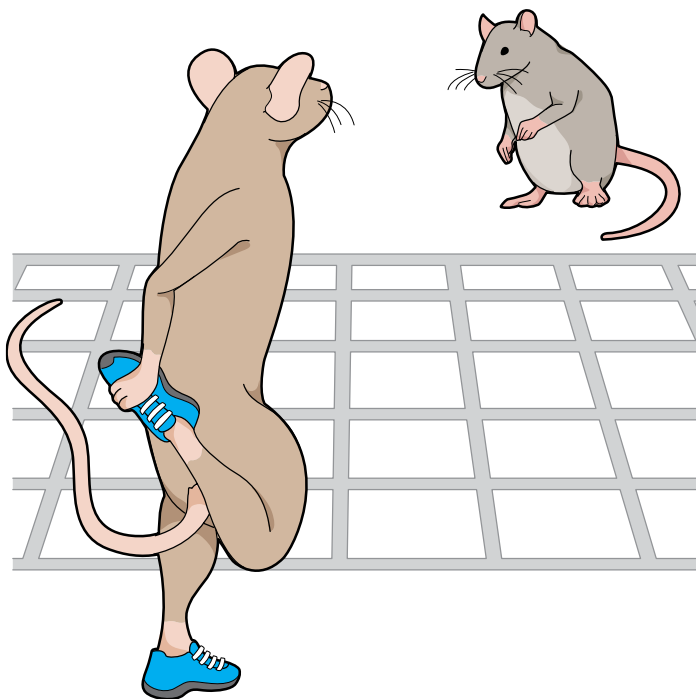
RAT CHANCE: If rats are any guide, all-night raves imperil the potency of partying lover boys.



The brain (the human version, at left) is just as vital for sex as the reproductive organs. If what we know about rats is true of us, females need a hypothalamus to flirt. That organ also puts a female rat in the position required for a male to mount her. Rats (and people) feel pleasure through the nucleus accumbens, providing the motivation to engage in the act. The amygdala, an emotion hub, is the seat of desire. And sex may make you—or at least rats—smarter by spurring cell growth in the hippocampus, a memory center.

gion is involved with motivational behaviors, such as eating, drinking, copulating, escaping and fighting. I frequently tell my students that this structure is responsible for the four F's: feeding, fleeing, fighting and ... mating. Within this structure are clusters

of similarly functioning nerve cells. The so-called ventromedial hypothalamic nucleus is intimately involved with lordosis in the female rat. If this brain area is destroyed, the female will no longer display the posture required for the male to mount her. In addition, if the reproductive hormone progesterone is delivered to this area, it elicits flirting in the female—hopping, darting and ear wiggling. Along with other brain areas, the ventromedial hypothalamus also influences eating, informing us when we are full. Perhaps the female brain sees little difference between food and sex, explaining why chocolate is such a best seller on the supposedly most romantic day of the year, Valentine's Day.



SHE WANTS ME: Not even the threat of an electric shock will keep a rodent Juliet from her Romeo.

The reward neurochemical for the brain, dopamine, and a hub of its reward circuit, the nucleus accumbens, are also involved in the copulatory response. If the nucleus accumbens is damaged, female rats reject males more often than when they have an intact reward circuit. An interesting study in the 1970s provided strong evidence of the intensity of the female's motivation for sexual encounters. Researchers found that female rats will run across an electrified grid to gain access to a male, a finding that runs contrary to beliefs that the female plays a passive role in copulation.

Another part of the hypothalamus, the medial preoptic area, contributes to sexual responses in male rats, as does the amygdala, which governs emotional processing. In an experiment that seemed to re-create Amsterdam's red-light district, University of Cam-

MELISSA THOMAS (brain)

This study suggests that sex builds more complex brains. There, I said it.

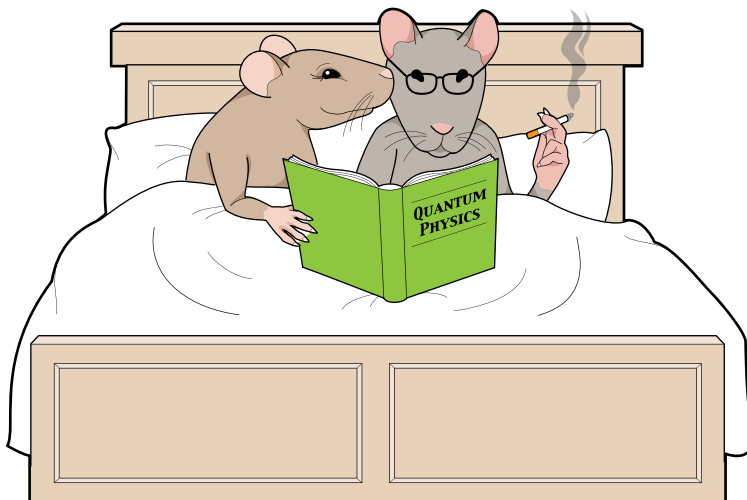
bridge neuroscientist Barry Everitt and his colleagues trained male rats to press a bar for a sexually receptive female. After the males learned this task, the scientists damaged the medial preoptic area and placed the animals in the sex chamber. The brain-damaged rats continued to bar-press for females, suggesting they still wanted them, but once a female was delivered, the male rats failed to copulate with her. After the amygdala was damaged, the opposite occurred: these males did not bar-press for females—their desire was gone—but if a female was presented, they copulated with her. In this way, Everitt and his team dissociated sexual desire and sexual performance.

The brain's reward circuit is also involved in male sexual behavior. If researchers infused amphetamine—a drug that enhances dopamine—into the brain's pleasure center in male rats with amygdala lesions, the males resumed pressing a bar for females, indicating that the jolt from the reward center compensated for the lack of the amygdala function. Dopamine in the brain's pleasure center also increases naturally after a receptive female is placed behind a screen.

Smarter for Stamina?

Thus, it is clear that the brain initiates and enhances sexual behavior. A fascinating study conducted by Elizabeth Gould and her colleagues at Princeton University, including one of my former students, Erica R. Glasper, suggests that the converse is also true; that's right, sexual behavior enhances the brain. Gould is widely regarded for her work confirming that mammalian brains produce new neurons throughout the life span. This process, called neurogenesis, has been well documented in rats. Conditions associated with stress and high-stress hormones are typically linked to low levels of neurogenesis. Gould wondered if a behavior that could be described as both stressful and rewarding—namely, sex—would lead to increased neurogenesis.

To test her hypothesis, Gould exposed the Princeton male rats to either one receptive female (acute sexual experience) or 14 days of sexual experience (chronic sexual experience). The animals in both groups were injected with bromodeoxyuridine, a substance that is incorporated into DNA during cell division, leaving a physiological tag on recently generated brain cells; this technique is handy for discerning when new brain cells are born. The scien-



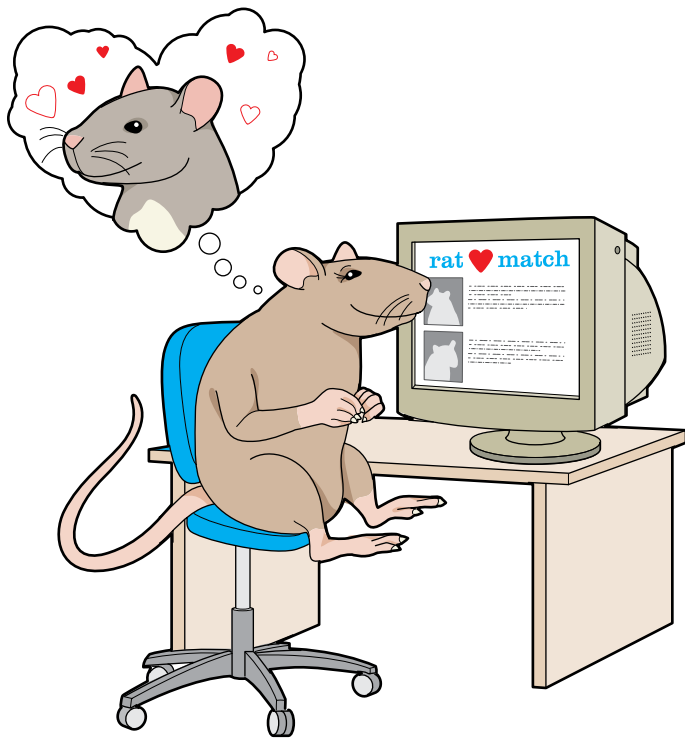
SEX EDUCATION: Hanky-panky produces new brain cells—all the better to study with.

tists also measured stress hormones and assessed anxiety behavior in the rats receiving sex therapy. They found that the brains of the rats given opportunities for sex showed a higher rate of neurogenesis in the hippocampus, a brain area involved in learning, memory and emotional processing.

Only the acute sexual experience was determined to be stressful for the animals. The chronic sex group no longer had high-stress hormones and exhibited decreased anxiety in a behavioral anxiety test. As an added benefit, when the researchers took a look at nerve cells in the chronic sex group, they found enhanced growth of connecting structures, or dendrites. Thus, even though sexual behavior is stressful, at least in the beginning, the rewarding aspects of the behavior appear to lead to both new nerve cells and more sophisticated connections among existing neurons in a brain area critical for learning and memory. This study suggests that sex builds more complex brains. There, I said it.

(The Author)

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FINDING MR. RIGHT: Rodent ladies carefully check credentials of potential mates. She'll travel to meet him, but he must smell healthy and fit.

Ratmatch.com

I cannot confidently say that rats are not attracted to large muscles, dreamy eyes or a big bank account. I can only confirm that the scientific literature suggests that the rats use a more sophisticated compatibility screening technique. If a female rat could write a singles ad, it might read something like this:

Female rat from City Block 8 searching for healthy young male living at least seven blocks away who isn't afraid of letting the female pace the timing of romantic encounters. Coat color doesn't matter, but a diverse immune system does—a major histocompatibility complex that is very different from my own is essential to ensure the health of our offspring. I have my heart set on a family, but I don't expect the father to hang around. I know male rat brains aren't necessarily wired for the sophisticated social interactions required for parenthood. If

interested, meet me in the local alley. I only have five hours left in this estrous cycle!

I realize that most people think very little screening occurs before rats consummate their relationships, but the truth is, at least for the females, romance is serious. For example, Gregory Glass, an infectious diseases expert at the Johns Hopkins School of Public Health, has been tracking the distance Baltimore city rats traverse to find their mates. His DNA testing suggests that jet-setting females are traveling a long distance—up to seven city blocks—when there are plenty of available males living in the female's local neighborhood. Why go so far? Researchers have yet to find the answers, but one possibility may be related to a little genetic screening. Female rats do this beautifully with their impressive olfactory system.

It appears that the proteins produced by a component of the genetic immunological blueprint have a distinct odor. This part of the immune system—the major histocompatibility complex (MHC)—is made up of a cluster of genes that encode proteins that provide information about the ability of the immune system to combat pathogens. The more diverse an animal's MHC, the better equipped it is to respond to the diverse array of immunological challenges it meets over its lifetime. In simpler terms, there are a lot of different germs in an animal's environment; rats with a more diverse immunological tool kit have an advantage.

Accordingly, a female rat is more likely to select a mate whose MHC is different from her own so that her offspring will be well armed against immunological attack. Thus, the odors of the MHC-different males are indeed sexy for the females and likely lure them far from their homes. When female mice are allowed to choose their own mates in seminatural habitats, the MHCs of their offspring are more diverse than those of offspring that result from laboratory matings with assigned males. Thus, without the help of genetic counselors, the mice verified the immune profiles of their mates, leading to increased chances of survival for their offspring.

You may be thinking that there is no way humans are using this genetic screening strategy. But a series of "smelly T-shirt" studies suggests that human females prefer T-shirt odors from men who are less closely related to them and who have more di-

Wanted: Healthy young male rat that isn't afraid of letting the female set the pace of romance.

verse MHC profiles. And when researchers at the University of Oxford recently compared the MHCs of couples with randomly selected pairs of individuals, they found that the couples were more MHC-dissimilar than were the random pairs. This study tells us that human couples were indeed using MHC in their mate selection, even though this behavior certainly was not conscious.

The general health of an individual may also influence his or her desirability. One of my former students, Sabra L. Klein, an integrative biologist at Johns Hopkins, has done extensive research on just what rodents find sexy in potential mates. In an interesting study she conducted with Ohio State University neuroscientist Randy J. Nelson, these researchers manipulated the health status of males from two different vole species—one monogamous (voles in a committed type of relationship) and the other polygamous (voles that liked to play the field). They designed a kind of a bachelorette-style investigation in which a female of either species was given a choice between two males, one that was made sick with a bacterial endotoxin known as LPS and one that received a harmless saline injection. The scientists hypothesized that a monogamous female vole would pay closer attention to the health status of a male. After all, she was looking at a long future with this guy. Sure enough, monogamous female voles spent more time with the healthy, saline-injected male, whereas the male's health status did not influence the romantic choices of the polygamous voles.

A Prairie Vole Companion

In his radio show *A Prairie Home Companion*, Garrison Keillor brags that in the (fictitious) town of Lake Wobegon, “all the women are strong, all the men are good-looking and all the children are above average.” In their communities, prairie voles distinguish themselves in another way: once two of them bond, the couple stays together for the rest of their lives; even after one dies, the partner rarely establishes a new pair bond. Talk about ‘til death do us part!

University of Illinois at Urbana-Champaign neuroscientist C. Sue Carter has investigated the neurochemical basis of long-term pair bonds in prairie voles. In one study, she and her colleagues administered two neuropeptides, oxytocin and vasopressin, to male and female voles. Known for its role in lactation and childbirth, oxytocin is also involved in positive social responses; vasopressin mediates physiological functions such as fluid retention as well as social responses. Carter and her colleagues found that these neuropeptides facilitated the formation of pair bonds in males and females. That is,



SPREAD THE LOVE: Prairie voles bond in pairs for life, but rats are more promiscuous.

if given a choice between a familiar partner and a strange animal, these neuropeptides led the prairie vole to spend more time with the familiar partner. When these neuropeptides were chemically blocked, no preferences for prior partners formed.

Larry J. Young's group at the Emory University School of Medicine has also tracked the pattern of oxytocin receptors in female voles. The team has identified rich populations of these receptors around the nucleus accumbens and the prefrontal cortex, an area responsible for cognitive functions. In addition, dopamine facilitates pair bonding in both male and female prairie voles. Thus, research on these rodent Romeos and Juliets reveals a recipe for a romantic cocktail: oxytocin and vasopressin, combined with a dash of dopamine. Of course, the studies suggest that this is a delicate and complex process, so it is not likely the love potion will be ready for mass marketing any time soon. **M**

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Primal Brain

in the

Modern Classroom

Evolution biased the human mind to attend to some types of information over others—often the exact opposite of what teachers wish children would learn

By David C. Geary

MICHAEL HITOSHI Getty Images (forest background); DORI O'CONNELL Getty Images (child)

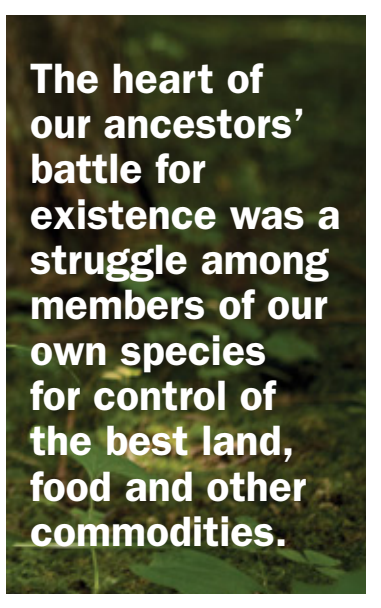
As children settle into their classrooms for the beginning of a new school year, parents steel themselves for the pending battle. Mothers and fathers know well that their youngsters would rather pay attention to one another than to the blackboard. But parents may not realize that the reasons children struggle with education lie deep in our evolutionary past.

Charles Darwin's theory of natural selection provides a framework for organizing and understanding all living things. How we learn—and what we are interested in learning about—is also shaped by natural selection. Most demands of life are relatively mundane and change little across the millennia. Our minds have evolved to handle these predictable bits of information with ease. Dramatic variation, such as an outbreak of disease or war, brings unexpected challenges and can have a disproportionate influence on our survival. Those who can deftly solve problems to survive such fluctuating circumstances gain an edge.

In essence, we have two modes for dealing with information—autopilot and conscious engagement. Whereas automated processing handles the universal features of the social and ecological worlds, our conscious problem-solving abilities let us register nuances in our environments.

By understanding both mechanisms for learning, we achieve deep insight into how children think. We can begin

to see why children pick up some skills effortlessly and others with substantial struggle. An evolutionary approach to teaching could help educators bridge the divide between children's innate cognitive biases and the goals of contemporary schooling, potentially revealing more effective ways to educate future generations.



The heart of our ancestors' battle for existence was a struggle among members of our own species for control of the best land, food and other commodities.

Anchors in a Sea of Sensations

Some of our learning biases are revealed early in life. From birth, babies attend longer to stimuli with the structure of a human face—two eyes above a nose—than to other equally complex stimuli. These critical features draw infants' attention, facilitating the development of parent-child attachment. Such elements of human survival that stay basically the same across thousands of lifetimes become hardwired as anchors of human cognition. They direct our attention to predictable aspects of life and allow us to automatically process information related to them. The bias for faces helps newborns anchor

themselves in an otherwise overwhelmingly stimulating environment.

Infants must also differentiate their parents from other people, however, so these cognitive anchors are imbued with a certain amount of flexibility. But what makes humans unique is another level of plasticity that allows us to consciously solve problems. When conditions change rapidly, threatening our survival or reproductive prospects, our automatic systems can hold us back. Instead we need creative ways to address new situations. The combination of hardwired predilections and plastic problem solving

determines how we handle new information—and, by extension, how we learn.

Theorists suggest that our ability to consciously solve problems very likely emerged from fluctuating climates, complex social dynamics or ecological demands such as hunting. Richard D. Alexander, an evolutionary biologist now retired from the University of Michigan at Ann Arbor, has proposed one possible model for the evolution of the human mind. When our ancestors began building shelters, creating tools for hunting and using fire for cooking, they became better at extracting resources from their environments and fending off starvation and predation. With these threats reduced, early populations likely expanded, spurring competition over the best land, food and other desirable commodities.

The heart of this battle for existence then becomes a struggle among members of our own species for control of those key resources. Social competition is not unique to humans, but it becomes an especially potent selection pressure for species that dominate their ecosystems, as we do. Both our ecological supremacy and the accompanying social competition are undergirded by “folk knowledge”—the indigenous patterns of thought that help us process the psychology, biology and physics of life.

Folk psychology refers to implicit knowledge organized around ourselves, other people and group dynamics, whereas folk biology and folk physics involve our grasp of living things and the physical world, respectively. These abilities evolved because they allowed our ancestors to not waste their mental energies on mundane day-to-day tasks and to focus instead on mastering ever changing social and environmental challenges.

Our built-in psychological competencies set us apart from all other species most dramatically. Humans possess an innate, perhaps unique, self-awareness. This ability is tightly connected to the important skill of mental time travel—being able to project oneself both backward in time to relive the past as well as forward to create a mental simulation of a potential future. Underpinning our self-awareness is a long-term network of memories and knowledge about ourselves, called a self-schema. Self-schemas can regulate goal-related behaviors, allowing us to plan where to focus effort and when to persist in the face of failure.

We also develop schemas for other people. Certain human relationships, including the ones between a parent and a child or between two friends, are universal. These bonds are supported by built-in skills that let us read nonverbal communication sig-

FAST FACTS

How Humans Learn

1>>> Understanding how the brain evolved can help us comprehend why children may struggle to learn in school.

2>>> Natural selection biased human minds over thousands of generations to attend automatically to some features of the social and ecological environment before others.

3>>> Only with effort can we override our automatic learning systems to tackle new challenges, such as those we face in school.

nals, decipher facial expressions, share a language and possess a theory of mind—that is, the ability to make inferences about the intentions, beliefs, emotional states and likely future behavior of others. When we form a new relationship, we adopt a schema of the other person that encapsulates our lasting memories of physical attributes, personality traits and the specific incidents that involved him or her.

cross-species evidence suggests that we have an intuitive sense of number and time, although the complexity of how humans mentally represent time vastly outstrips that documented in other species.

Evolution of Consciousness

What these folk competencies tell us is that most information encountered in day-to-day living during



Children are born with cognitive biases that help them attend to the features of the world that are key to survival. They seek out information about their social, biological, and physical environments.

This knowledge enables people to better understand and predict the actions of their acquaintances.

In addition to forming one-on-one relationships, individuals divide the social world into groups. We tend to have more positive attitudes and beliefs about members of our own group than about outsiders, especially when the groups are competing. We are also capable of forming affiliations by nationality and religion, organizing ourselves into larger social units than would be possible based only on personal relationships. A preoccupation with social matters is deeply ingrained in how we think.

Similarly, we have evolved shortcuts for managing information about the biological world. For instance, we possess a universal ability to develop taxonomies of other species and to arrange knowledge about the behavior, growth patterns, and recurring characteristics of a familiar type of plant or animal. This knowledge helped humans in traditional cultures acquire the skills needed to secure food and medicine.

To safely find our way to fruitful hunting grounds, we rely on innate systems for navigating in three-dimensional space and remembering key features of those environments, as do many other species. Humans go at least one step further, though, and form bird's-eye-view maps as well as images of physical space when we are not in it. Our ability to construct and use tools also far exceeds the competencies found in other species and is almost certainly a component of humans' dominance on the earth. Finally, strong

our evolutionary history is processed automatically and with little cognitive effort. But life is not always routine—living with other people always has its surprises. The ability to block those built-in systems and engage in controlled—that is, conscious—problem solving is a defining feature of the human mind.

Building on the work of others, I proposed in 2005 that humans, perhaps uniquely, can generate mental models of our circumstances that enable us to anticipate future changes and concoct coping strategies. We use our working memory to hold mental representations of situations. We can envision a fantasized scenario and compare this image with a model of our current state. By doing so, we can simulate strategies to reduce the difference between where we are and where we want to wind up in the future, giving us a key evolutionary advantage. We might mentally rehearse ways to outcompete others, for instance, for a mate or a job promotion. The combination of consciousness, self-awareness and explic-

(The Author)

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STEFAN KIEFER (left); GETTY IMAGES (center); KRIS TIMKEN/Getty Images (right)

it problem solving is what enables us to learn things not relevant to our evolutionary past.

Consider modern physics, one of humanity's most significant intellectual accomplishments and yet a domain that most of us understand poorly.

Part of the challenge with learning physics is that the inferences that emerge from our folk physics often clash with the scientific explanations of the same phenomena. When asked about the motion of a thrown baseball, for example, most people believe two forces create this motion: one propels it forward, akin to an invisible engine, and another drives it downward. The downward force is gravity, but in fact no force propels it forward once the ball leaves the player's hand. Although adults and even preschool children often describe the correct trajectory for a thrown or moving object, reflecting their implicit folk physics, their *explicit* explanations can reveal a naive understanding of the forces acting on the object.

In his masterwork, the *Principia*, Isaac Newton neatly summed up the situation: "I do not define time, space, place and motion, as being well known to all. Only I must observe, that the vulgar conceive those quantities under no other notions but from the relation they bear to sensible objects." In other words, the "vulgar" only comprehend physical phenomena in terms of folk knowledge. Newton brought humanity beyond these coarse explanations by using the conscious problem-solving systems that we evolved to cope with new situations. Unlike most people, he was ob-

essed with understanding the physical nature of the world rather than its social complexities. He devoted many years purely to thinking about physics and conducted experiments to test his hypotheses.

Newton's efforts transformed the sciences and generated a substantial gap between the technical understanding of gravity and motion and folk beliefs about them. Brain-imaging studies and other experiments indicate that giving up our intuitions and grasping Newton's insights does not come easily, even for college students.

And so it is with many realms of modern life: the chasm separating our folk knowledge and the vast store of humankind's cultural, scientific and technological legacy is widening at an accelerated pace. Because some of this expertise is now critical to thriving in contemporary life, we rely on schools to ensure that all members of society possess core skills and information. But unlike the fast implicit learning that adapts folk systems to local conditions—such as learning to identify one's parents—learning in school requires the same effortful engagement of working memory and explicit problem solving used by Newton and all the other innovators that have produced modern culture. To further complicate schooling, children have inherent motivational biases that often clash with the requirements of scholarly activities.

Desire to Learn

This evolutionary view of learning can help us make some predictions about children, one being that they ought to be inclined toward activities that flesh out their innate competencies. An example is a motivation to play with others, which hones their social skills. Likewise, we can expect children will seek out activities that help them develop their biological and physical understandings of the world.

One testable prediction is that children will be much more interested in learning in areas directly related to their folk abilities than to, say, practice solving polynomial equations. This bias would explain why many schoolchildren value social activities with their friends more than achievement in core academic areas. In 2003 psychologist Mihaly Csikszentmihalyi and his collaborator Jeremy Hunter, both at Claremont Graduate University, found that students experienced the lowest levels of happiness while doing homework, listening to lectures and doing mathematics, whereas they attained the highest levels when talking with friends. A preference for engagement in peer relationships may not be useful for mastery of algebra, but it follows logically as an evolved developmental bias for a highly social species.

A related prediction is that the core of a person's

The chasm separating our innate knowledge and humankind's vast cultural, scientific and technological legacy is widening at a fast pace.

Children can easily learn to throw a ball, but grasping the underlying physics requires effort—and, often, assistance from a teacher.





Evolutionary science can help educators predict how children will act in school. For example, they may surmise that studying math requires effort and that working in groups will require close supervision.

self-schema will be defined in terms of his or her standing with respect to peers—critically important from an evolutionary perspective—rather than schooling. Evidence to date supports this idea; the best determinant of global self-esteem from childhood to adulthood is perceived physical attractiveness, not test scores.

We can make a related prediction about how children will learn in groups. Although popular in education circles, from an evolutionary perspective working in groups with peers ought to not be particularly effective, unless a teacher provides strong guidance. Conversations are predicted to drift to topics that are of greater evolutionary relevance than the task at hand, such as gossip. Seemingly trivial, such chatter can reveal crucial details about the structure of social networks.

Several evolutionary psychologists have argued that children's social engagement and other developmental activities can sometimes result in academic learning. Early in their schooling, the boundary between folk abilities and new knowledge is fuzzy. Children's natural interest in novelty and their desire to learn their culture will also get them started in school, but I predict it will not be sufficient to maintain long-term academic engagement. If my model is correct, then deploying the mechanisms for conscious problem solving will require significant effort. Without an explicit assumption that learning will require hard work, we risk having children assume that they will pass their classes with ease—and thus when they begin to experience failure, they are at risk for making attributions that may undermine their later engagement with school.

Indeed, experimental studies show that changing student attributions about the learning of a difficult subject, such as mathematics, from a focus on ability to an emphasis on effort results in greater engagement in mathematics classes and improves learning, as psychologist Lisa Blackwell, then at Co-

lumbia University, and her colleagues found in 2007. Early in formal school, the point at which children transition from tasks they find easy to more challenging assignments—such as going from counting small sets of numbers to managing larger sets—may be the critical first place for addressing children's beliefs about education and instilling an expectation that it requires an investment of time and energy. Of course, many teachers do focus on the importance of effort, but studies such as Blackwell's suggest that more can be done for many children.

We are at a point in our history where the cultural knowledge and abilities needed to function in modern societies—all acquired very recently in our evolutionary history—have far outstripped the mechanisms for learning that we inherited from our early ancestors. Schools are the central venue in which culture meets evolution during a child's development. Considering children's academic development with an eye to evolution has the potential to answer key instructional questions, such as why many students need explicit instruction to learn to read but not to speak. It also tells us why many children value social relationships more than academic learning. Of course, insightful parents and teachers already know what their kids like, but the lens of evolution can help us reason through their preferences and suggest new ways to improve the education of young minds. **M**

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The Many Faces of (Happiness)

Cultural twists on the concept hint at new ways of lifting your spirits and making you more content with life

By Suzann Pileggi Pawelski



Lankasana, a 23-year-old Maasai warrior, sports long, ochre-stained, braided hair extensions and carries a bow and arrow, a short sword and a steel-tipped spear. He spends his days raiding neighboring villages and protecting his own tribe from attacks by wild animals. For fun, he wrestles fellow tribesmen and practices his aim by tossing spears at tree trunks. Lankasana once killed a lion armed with only a sword, but not before the lion clawed his shoulders, leaving huge scars.

Living in remote villages in East Africa, the Maasai build simple homes out of mud, dung and sticks. These hunter-gatherers have no running water or electricity and minimal exposure to Western society and media. They engage in rituals that may seem unappealing to Westerners, such as adolescent circumcision, branding and bovine blood drinking.

Psychologist Ed Diener of the University of Illinois and his son, psychologist Robert Biswas-Diener of Portland State University, have traveled to the remote villages of the Maasai in northern Tanzania and southern Kenya several times over the past 15 years. The father-son team is at the forefront of research attempting to unravel the makings of happiness. Diener, a leading investigator in the field, had conducted dozens of studies on happiness around the world. But because most studies are done in industrial societies, he and his son were curious to see how

groups not living in modern cultures, such as the Maasai, would measure up.

The researchers' questions were part of a bigger project to measure happiness across the globe. First conducted in 2005, the Gallup World Poll is an attempt to assess how individuals are faring on various indices of well-being, economics and health, among other measures. The poll covers approximately 155 countries, a representative sample of 98 percent of the world's population. "What we find is that countries vary enormously in happiness," says Diener, who is also a senior scientist at Gallup.

The results emerging from the world poll suggest that society and culture can play a big role through the importance they place on positive emotions and beliefs about how to achieve a state of well-being. At the same time, the fact that people as different as the Maasai and the Danes can all achieve joy suggests



Happiness flourishes in many nonindustrial cultures. In a world poll, the African Maasai (left) scored high by one important measure: feeling good. The Amish (center) also experience a lot of joy. Costa Ricans (right) reportedly boast the most positive feelings of any culture in the world.

that humans can obtain pleasure and satisfaction in many different ways.

A Wealth of Good Feelings

In the burgeoning field of positive psychology, investigators are still trying to agree on a definition of happiness. Some think of this state in emotional terms. Other scientists believe happiness comes from a more reasoned appraisal of life satisfaction. To capture both facets, Diener measures something he calls subjective well-being, which combines emotional reports with cognitive self-assessments across various domains, such as work, income and relationships.

Biswas-Diener used such a test when he queried the Maasai. The 358 participants reported how they felt about their life in general and how often in the past month they experienced joy and amusement, among other emotions. Additionally, the respondents rated their food, friendships, health and other important aspects of their lives. To their surprise, Biswas-Diener and his colleagues found that Maasai villagers are quite happy—happier than many other

people in similar circumstances and just as happy as many individuals living in developed societies.

He and Diener—along with social psychologist Joar Vittersø of the University of Tromsø in Norway—also tested two other groups leading their lives in nonindustrial societies, the American Amish and the Inughuit people of Greenland. They found that all three groups rated above neutral in subjective well-being, with the Maasai doing best of all. But in specific domains—namely, income and food, both of which are related to material resources—the Maasai were less satisfied than the Amish and Inughuit. The Maasai also lagged in their views on their overall health and access to medical care as compared with people in modern societies, Diener says. Yet “on a global scale, the Maasai are pretty happy with life,” Diener concludes.

The fact that the Maasai rated their material resources poorly might suggest that money can buy at least some kinds of happiness. It does seem to have a stronger effect on general satisfaction than on positive emotions [see box on page 54]. As long as basic needs are met, however, money appears not to have much of an effect.

For example, research suggests that although the U.S. is economically richer than Denmark, the Danes are psychologically better off. The difference may lie in a person’s ability to trust other people’s good intentions. Scientists have linked happiness with so-called social capital, which includes measures of public trust and cooperation. In a survey in 2010 of the Danish population, Biswas-Diener, Vittersø and Diener found most Danes expressed faith in their government and business sectors and expected to have a lost wallet returned to them. In contrast, Americans viewed both as corrupt and doubted a stranger would give a wallet back to its owner.

The researchers also analyzed social capital in both societies using a “law and order index” includ-

ANIKA BUESSEMEIER Redux Pictures (left); ALAMY (center); TOBIAS HAUSER Redux Pictures (right)

FAST FACTS

Joy to the World

- 1>> The Gallup World Poll, which includes a psychological assessment of people in 155 countries, shows that nations vary enormously in how happy their citizens are.
- 2>> Scientists have linked happiness with so-called social capital, which includes measures of public trust and cooperation. National pride can also improve your quality of life.
- 3>> People in some cultures rate their life satisfaction according to how well they live up to social norms; citizens elsewhere base their judgment on how good they are feeling.

ed in the Gallup World Poll. The rating reflects the respondents' confidence in the local police, how safe they feel when walking alone at night, and whether they or someone close to them had recently experienced a theft. Danes scored significantly higher on this index than Americans did.

But another factor might hold sway over our perceptions of happiness. Previously Diener had found evidence that materialism is associated with unhappiness. And in South Korea, subjective well-being is

erally able to trust strangers, mastering particular skills and feeling respected by others.

Another source of happiness appears to come from thinking highly of your homeland. In a study published in February 2011 University of Illinois graduate students Mike Morrison and Louis Tay, along with Diener, analyzed responses from 132,516 people in 128 countries who had rated their past, present and future life satisfaction (including their standard of living, job and health), as well as their

In poor countries, happiness may depend on factors such as social success and group membership.

low despite its economic prosperity. In a keynote speech in 2010 to the Korean Psychological Association, Diener presented data gathered around the world from participants who were asked to rate on a scale from 1 to 9 how much they value material wealth. South Koreans report high average ratings of 7.24 relative to other economically flourishing countries, such as the U.S. at 5.45, and Japan at 6.01. South Korea also ranks poorly on happiness among wealthy nations, according to the Gallup World Poll's findings. Anger and depression are widespread in South Korea, and the suicide rate is the highest of the 34 richest nations in the world. Although several forces most likely contribute to the situation, researchers hypothesize that greater competition among citizens creates a more stressful environment overall. For example, in South Korea universities are neither big enough nor sufficiently numerous to accommodate the large numbers of hardworking young people who apply every year, denying many adolescents access to a critical gateway to employment.

Sanguine Citizens

The case of South Korea is just one piece of evidence that money and happiness do not necessarily go hand in hand. Costa Rica is another—the nation is a much happier place with per capita income just half that of South Korea. “Happiness in Latin American nations is higher than one would expect on the basis of their wealth,” says sociologist Ruut Veenhoven of Erasmus University of Rotterdam and director of the World Database of Happiness, an ongoing registry of scientific studies. Costa Rica and some of its neighbors might abound in the ingredients that researchers have found to be most important for happiness—social and psychological factors such as possessing strong ties with family and friends, being gen-

contentment with their country, on a scale from 1 to 10. The researchers found that citizens of poor, non-Western nations, such as Bangladesh and Ethiopia, value national satisfaction more than those of richer, Western nations such as the U.S. and Denmark. The citizens of these wealthier nations tended to place more importance on personal factors such as standard of living and health.

The finding that those who felt good about their country also tended to report a higher quality of life was most dramatic in poor countries, where daily life is a challenge and people have trouble meeting basic needs. In these places, citizens' well-being may depend more on external factors such as their perceptions of their social success and group membership. But a sense of belonging, the researchers say, can be an important source of happiness and life satisfaction for everyone. According to social identity theory, fitting in with a group is integral to an individual's identity, influencing his or her feelings of self-worth [see

LIFE SATISFACTION Overall appraisal of life, including work, income and relationships	POSITIVE FEELINGS Enjoyment, smiling and laughing
HIGHEST	HIGHEST
 Denmark Finland Netherlands Canada Sweden	 Costa Rica Canada Paraguay Laos Ireland
LOWEST	LOWEST
 Sierra Leone Haiti Tanzania Zimbabwe Georgia	 Georgia Armenia Serbia Sierra Leone Bosnia

In a global happiness survey, a country's rank depended on how you sliced the term. Still, Canadians scored well—and Georgians poorly—no matter the measure.

For more on cultural differences in happiness, visit ScientificAmerican.com/Mind/sep2011/happiness

(The Author)

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Being extroverted enhances well-being only if most people in the culture are similarly outgoing.

“The Social Cure,” by Jolanda Jetten, Catherine Haslam, S. Alexander Haslam and Nyla R. Branscombe; *SCIENTIFIC AMERICAN MIND*, September/October 2009]. By shifting our focus away from our individual lives and toward our country, we Westerners may be able to tap this source of pleasure.

Still, our ability to attain such a sense of belonging might be limited by how well we match our culture. In a study published earlier this year psychologist Ashley Fulmer of the University of Maryland, along with Diener and their colleagues, surveyed more than 7,000 people from 28 countries to examine how personality and culture interact to affect well-being. The researchers found, for example, that being extroverted enhances well-being only if most people in the culture are similarly outgoing. In another study (to be published in the *Journal of Personality and Social Psychology*), Diener and his colleagues found that religious individuals benefit psychologically if they live in a society where religion is widespread. Likewise, an extrovert in an “introverted” country such as Japan or a religious person living in a “nonreligious” country such as Sweden is less hap-

py than a person whose personality is a good match for the society. “Fitting into your culture is very important,” Diener says.

The extent to which a person identifies with a group can, in turn, influence whether that individual links happiness with his or her own feelings or the notions of others. In a study in 1998 of more than 60,000 individuals from 61 countries, psychologist Eunkook M. Suh, then at the University of Illinois, along with Diener and their colleagues, observed that when assessing life satisfaction, members of societies that emphasize group identity, such as China and India, tend to place great value on social norms—that is, how closely their behavior matches socially accepted actions. In contrast, members of individualistic nations such as the U.S. and Sweden base their happiness almost exclusively on their emotions.

Within a culture, social versus emotional factors show more variation. In 2008 Suh, now at Yonsei University in Seoul, Korea, Diener and psychologist John Updegraff of Kent State University had 101 European-Americans complete a questionnaire that asked subjects how frequently they experienced vari-

Green with Satisfaction

Money can buy happiness, but perhaps not in the way you thought. In 2010 psychologist Ed Diener of the University of Illinois and his colleagues reported that money does not directly or dramatically lift your spirits—but it can boost your satisfaction with life. Using a Gallup World Poll sample of roughly 136,000 people from 132 countries, the researchers asked respondents to rate their life on a scale from 0 to 10 and to answer questions revealing the extent to which they experienced various positive and negative emotions the previous day. Along with annual household income, the researchers audited the luxury goods participants owned. Additionally, they measured social and psychological factors: Were you treated with respect yesterday? Do you have family or friends you can count on in an emergency? Did you learn something new during the day? Were you able to do what you do best? Could you choose how you spent your time?

Researchers found that standard of living predicted overall life assessment better than it did the balance of positive and negative emotions. Having your psychological needs met, on the other hand, engendered more positive feelings on the day assessed. Thus, luxury goods can make you feel more satisfied



but do not make your life more enjoyable. The thrill of buying a new sports car or 50-inch plasma television fades quickly even if you might remain proud of owning these items. —S.P.P.

JOHN POWELL/Alamy

ous emotions and how strongly they thought close companions would approve of their way of life. The researchers found that some respondents focused on what they thought they *should* do rather than what they would like to do. For these individuals, happiness rested partly on how they measured up in others' eyes. Other participants relied much more heavily on their own emotions, attitudes and personal beliefs in judging their life satisfaction.

Life, Liberty And ...

Some psychologists argue that happiness measures reflect more of a Western than an Eastern perspective on well-being. People of Eastern descent living in the U.S. consistently report lower levels of subjective well-being than people from Western heritages, but the ratings may not reflect actual contentedness. Instead recent research indicates that Americans with an Asian background do not value the presence of positive emotions in their lives as much as other Westerners do. In a study published in 2009 psychologist Derrick Wirtz of East Carolina University, along with Diener and their colleagues, decided to investigate the role of heritage by having 46 vacationing European and Asian-Americans report, seven times a day, to what extent they were feeling pleasant, sociable, calm, happy and joyful as well as unpleasant, irritated, guilty, sad and worried. A month after returning home, the participants tried to remember how often they had experienced these various emotions during their trip. They also rated how likely they would be to go on the same vacation again.

While on their holidays, European- and Asian-Americans experienced positive and negative emotions to a similar extent. Afterward, however, the European-Americans *remembered* more good moods than the Asian-Americans did, and Asian-Americans recalled more bad feelings. Whether the European-Americans wished to repeat their vacation was related to the number of positive emotions they remembered, indicating that they considered positive feelings paramount; Asian-Americans' desire to redo the trip seemed tied not only to good feelings but also to the absence of negative emotions, hinting that success in their eyes is just as much about preventing bad outcomes as promoting positive ones.

In a similar study published in 2002 psychologist Shigehiro Oishi of the University of Virginia found that the same two groups rated their days as comparably good or bad, but European-Americans remembered being happier than they actually were, and Asian-Americans' memories were more in line with their daily reports. "In Eastern countries, every event has positive and negative sides. A totally

positive condition is considered very unlikely and possibly related to a superficial view of life," observes Antonella Delle Fave, a psychologist at the University of Milan in Italy. As Delle Fave sees it, Easterners learn to detach themselves from their emotions, embracing a life of evenness rather than of ups and downs.

Many people see success as an important ingredient for happiness—and it can be. But Diener urges caution when defining success as Americans typically do. In addition to positivity itself, he says that Americans sometimes overemphasize fortune and fame and undervalue the use of personal strengths and the achievement of results that benefit others. Diener says success boosts well-being if it comes from excelling at activities that you and others respect, rather than from simply doing *better* than others.

Although we do not know for sure why the Maasai are as happy as they are, Diener and Biswas-Diener hypothesize that part of the reason is that they focus on what they have rather than what they lack. In addition, they have a lot of self-respect and possess the skills they need to flourish, critical components of psychological health, Diener adds. The Maasai do vary in wealth, but the disparities are not great, and they all live a materially simple life, explains Biswas-Diener, which might mean they compete less with one another.

Although no one is suggesting that we buy swords and hunt lions (although the practice might add adventure to our lives), we can still learn a thing or two from Lankasana. We could spend more time doing what we enjoy and are good at, looking out for the greater good and bonding with our friends and family, Diener concludes. Just pondering these ideas might even earn you a smile. **M**



Asian-Americans are emotional realists. They remember their feelings more accurately than European-Americans, who tend to recall being happier than they actually were.

(Further Reading)

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PASSION FOR POSSESSIONS

Mine!

Ownership of objects plays a critical role in human identity

By Bruce Hood

Hayley has finished making a beautiful butterfly with a cookie cutter, which she pressed into the lump of Play-Doh that she just took from Pat.

“So whose Play-Doh did you use?” Pat asks.

“Yours,” Hayley replies.

“And whose butterfly is that?” Pat says.

“Mine,” answers Hayley confidently.

In a court of law, a jury would be disinclined to agree with Hayley. Most adults would think that the original owner of the material, Pat, has some rightful possession despite Hayley’s creative input.

In this case, Hayley is a typical three-year-old whom we invited into our laboratory in Bristol, England, and Pat—my graduate student, Patricia Kanngiesser—is investigating children’s developing attitudes toward ownership. Our studies entail structured scenarios in which materials are borrowed, exchanged and sold. These experiments are part of a rapidly expanding area known as behavioral economics, which is unraveling the cognitive processes that lead humans to

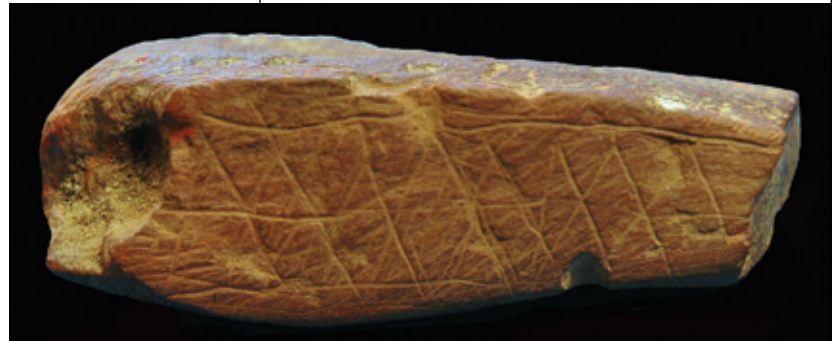
CORBIS



make decisions about ownership and transactions. Our research may involve children and Play-Doh, but ownership is at the heart of some of the most acrimonious disputes in the history of humankind.

So far researchers have found that the concept of owning things develops very early, especially for those objects that children use for comfort and grow attached to. Over the course of our lives, we increasingly use objects to express our self-identity. What

function. Some animals, notably a number of different bird species, collect objects or even steal them, although it is doubtful they could understand or respect ownership rights. Magpies are famously known to have an eye for shiny things. Australia's peculiar male bowerbird collects and assembles objects into an elaborate display as part of a courtship ritual to attract females. This birdbrained collecting reflects relatively instinctual behavioral patterns. In contrast, through-



Various species forge ties with objects. Magpies (left) may glom on to shiny things, such as painted grass. But only humans truly covet possessions. One early man-made treasure is a block of ochre etched with a geometric pattern (right).

is more, simply choosing an object endows it with more worth, in our mind, than an identical object we did not select. This partiality is apparently rooted in brain mechanisms that evaluate potential losses and gains in terms of their emotional significance. At least in Western cultures, humans treat objects as extensions of themselves, explaining why some of us seem to overreact to the loss of, or damage to, our personal possessions.

Charter Chattels

Our predilection for object ownership may be a uniquely human trait. We are the only species that both makes and covets possessions. Other primates may fashion rudimentary tools for cracking nuts or prodding termite hills, but these artifacts are often discarded after they have served their temporary

out civilization humans have contemplated, produced, collected, exchanged, valued and even revered objects for their own sake.

One of the earliest examples is a block of ochre engraved with crosses found in the Western Cape of South Africa. Most likely a piece of art or possibly a sacred object, this relic indicates that for at least 70,000 years humans have been making and treasuring objects for their aesthetic value. Art objects appearing later in this Upper Pleistocene epoch are more elaborate and labor-intensive, which suggests that early humans invested considerable time and effort in creating these artifacts as opposed to focusing on, say, foraging or hunting.

Today manufacturing technologies have all but replaced the need for us to make our own things. Although we are said to be living in the age of disposables, we still retain a need for ownership. The most conspicuous examples of this desire are the emotional attachments we forge with sentimental objects that extend far beyond their functional use or market value. The phenomenon appears early in development—about 60 percent of Western children become inseparable from objects such as stuffed toys or blankets. Linus from the cartoon strip *Peanuts* dragged his blanket wherever he went. Any parent of a child with an attachment object can attest to the importance such rags and raggedy stuffed toys have—especially when they are lost. These anointed items are considered unique and irreplaceable: children refuse to swap them for identical copies or newer versions, and bonding with more than one item is rare.

Object attachment early in life probably stems

EDDIE KEOGH Corbis (magpie); COURTESY OF CHRISTOPHER HENSILWOOD (ochre)

FAST FACTS

To Have and to Hold

- 1>> In a survey of more than 2,000 adults conducted in 2007 by a motel chain in the U.K., one in five traveling salespeople slept with their childhood teddy bear.
- 2>> People who chose their own \$1 lottery ticket would only sell it back for \$8, on average, compared with the mere \$2 demanded by those who were simply given the ticket.
- 3>> Shoppers remember more items dropped into their own basket than they do those put into another person's.

from the Western practice of separating infants for sleep. Infants find blankets or stuffed animals left in the crib and use them to soothe themselves. Consistent with this theory, biopsychologist Mieko Hobara of the New York State Psychiatric Institute reported in 2003 that attachment objects are much less prevalent in Japan, where infants sleep with their mothers into middle childhood. (The researchers found that only 38 percent of the Japanese children they tested had these items.)

Extreme fondness for specific objects increases between the ages of one and three, plateaus between three and four, then drops around age six. Yet many individuals retain these sentimental items into adulthood. An eminent neuroscientist on the editorial board of this magazine famously travels everywhere with his dilapidated Steiff teddy bear, indicating that attachment is not the preserve of the weak-minded.

Furthermore, the trauma we experience from the loss of these sentimental possessions has a common physiological basis. In a study published in 2010 my colleagues and I asked 31 adults to cut up photographs of their childhood sentimental objects. We found that this process elicited significant anxiety as measured through subtle changes in the electrical conductance of the skin. Asking the par-

One eminent neuroscientist famously travels everywhere with his dilapidated Steiff teddy bear.

ticipants to destroy photographs of their valuable objects such as cell phones with no sentimental attachment to them, in contrast, produced far less of a response.

We Are What We Own

Objects can elicit possessiveness for reasons other than comfort. Young children fight over toys and other items to establish self-identity and dominance over others. In nurseries across the country the shrill cries of “mine!” are followed by tears and feeble attempts by adults to persuade children clutching at objects that “sharing is good.”

American psychologist William James was one of the first to appreciate that the things we own serve an important function as markers for self-identity. In 1890 James wrote in his *Principles of Psychology*, “A man’s Self is the sum total of all that he CAN call his, not only his body and his psychic powers, but his clothes and his house, his wife and children, his ancestors and friends, his reputation and works, his lands and horses, and yacht and bank-account.”

Because our belongings define part of who we are, institutions such as prisons remove them deliberately to eradicate the sense of self. Some of the most harrowing images from the Nazi concentration camps are the piles of personal possessions and

Objects often serve as extensions of the self. People tend to choose brands that they feel express who they are—or would like to be.



luggage that were taken away from the victims in an attempt to remove their identity. These objects are now regarded as sacred. In 2005 Michel Levi-Leleu, a 66-year-old retired engineer, took his daughter to an exhibition in Paris about the Holocaust on loan from the Auschwitz-Birkenau State Museum. In the collection he spotted his long-lost father's cardboard suitcase with his initials and address. Levi-Leleu demanded its return, which led to a legal battle with the museum. Four years later the parties settled, agreeing that the suitcase would be loaned to the Paris exhibition on a long-term basis.

In addition to contributing to our sentimental sense of self, possessions can also serve as an expression of personal preferences. That is, individuals choose to buy products they believe reflect qualities they would like to be associated with—a pattern that modern advertisers have been exploiting for years. Advertisers understand that consumers identify with brands; the more a brand signals success, the more people want it. Rolex watches, iPods and Nikes are just some of the branded objects for which people have lost their lives while defending themselves from thieves.

Professor of marketing Russell W. Belk of York University in Canada calls this materialist perspective the “extended self.” We are what we own, and when these possessions are violated through theft,

The students placed much greater value on the mugs in their possession than on other people's identical mugs.

loss or damage, we experience such an event as a personal tragedy.

Only recently, I had this happen to me. I do not consider myself particularly car-proud, but when someone deliberately scratched the paintwork on my VW Golf a couple of months back, I felt very upset—as if the crime had been intentionally perpetrated against me. Despite knowing the act was random, I felt enraged. Ruthless killers and drug dealers may have a special appreciation for the importance of possessions. Vince, the hit man from the modern classic movie *Pulp Fiction*, complains to Lance, his dealer, after discovering that

his Chevy Malibu has been keyed:

Vince: “I had it in storage for three years. It was out five days, and some d**kless piece of sh*t f**ked with it.”

Lance: “They should be f**king killed, man. No trial. No jury. Straight to execution.”

Of course, I would not go as far, but when someone violates your personal property, the act is certain to stir deep emotions.

The Endowment Effect

Even ephemeral ties to objects can affect our choices. In what is now regarded as a classic study in behavioral economics from 1991, Nobel Prize-winning psychologist Daniel Kahneman of Princeton University and his colleagues handed out \$6 college coffee mugs to a sample of Cornell undergraduates and then allowed them to trade with their classmates. The students swapped roles as buyers and sellers over several trades, and the researchers compared the offers with the selling prices for the mugs. To its surprise, Kahneman's team found that very little trading occurred. The reason became apparent in the discrepancy between the prices and offers for the mugs: the students placed much greater value on the mugs in their possession than on other people's identical mugs, pushing the selling prices up and the offer prices down. This bias, known as the endowment effect, has been replicated many times with items ranging from bottles of wine to chocolate bars.

Just the prospect of eventually owning some-

By taking away a prisoner's possessions, law-enforcement officials strip the person of a piece of his identity.





When something we own is defaced, we may experience the act as a personal assault.

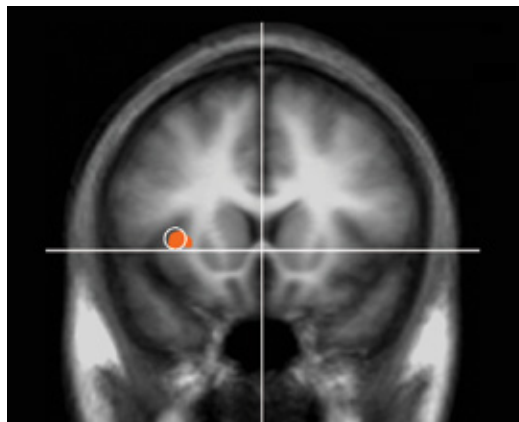
thing—you are bidding for an item in an auction, say—makes you value it more, especially if you have had a chance to handle the item before buying it. In 2008 psychologist James Wolf of Illinois State University and his colleagues at Ohio State University staged a mock auction—again, of coffee mugs—with 84 students. Half the participants handled the mugs for 10 seconds before the sale, whereas the others held them for three times as long. The researchers found that the average winning bid of the students in the 30-second examination group was significantly higher (\$5.80) than was the average bid from the 10-second group (\$3.70), suggesting a stronger endowment effect for those who had more contact with a mug.

The scientists then repeated the experiment with another 60 students to check whether the heightened arousal induced by the live competition could be responsible for the higher valuations of the longer-held objects. They used a sealed bid procedure, in which the top offer is placed in a closed envelope, and found that the average offer from the longer examiners (\$3.07) was still significantly higher than that from the students who held the objects for less time (\$2.24). (The somewhat depressed bids indicate, however, that the live scenario has some effect.) The researchers also found that the more time an individual held the highest bidder position in an online auction—boosting the buyer's hope of future ownership—the more that person paid relative to what he or she had originally intended to wager, a behavior known as auction fever.

A commonly accepted explanation for the endowment effect is that it reflects something called loss aversion. According to this theory, put forth by Kahneman and his co-workers, people consider a loss as more significant than an equivalent gain;

in other words, we fear losses more than we welcome gains [see “When Words Decide,” by Barry Schwartz; SCIENTIFIC AMERICAN MIND, August/September 2007].

Neuroscientist Brian Knutson of Stanford University and his colleagues have discovered patterns of neural activity consistent with the idea that our emotional reactions to potential losses and gains fuel the endowment effect. In a 2008 study his team used functional MRI to reveal increased activation of the nucleus accumbens, a region of the brain's reward circuitry, when people look at products they like, irrespective of whether they are buying or selling those products. When we think we can buy an item at a bargain price, the medial prefrontal cortex, another part of the reward system, is also activated—



Activity in the right insula (orange) reflects our tendency to over-value what we own. The area lights up when we sell a possession for less than we expected. Its activity may underpin our disappointment.

(The Author)

BRUCE HOOD is director of the Bristol Cognitive Development Center at the University of Bristol in England. He is author of *SuperSense: Why We Believe in the Unbelievable* (HarperOne, 2009) and the forthcoming book *The Self Illusion* (Oxford University Press).

but not if the price is too high. But when subjects are told to sell a desired product at a lower price than they had expected, the insula in the right hemisphere becomes active. The activation of this region signals discrepancy between anticipated goals and outcomes and could be regarded as the neural correlate of disappointment. Moreover, the greater the activity in the right insula, the more pronounced the endowment effect—that is, the more a participant overvalued the possession he or she was asked to sell.

These imaging findings provide a biological signature for loss aversion by showing that a discrepancy between perceived value and the offered sale price produces a negative emotional response. It is not simply that we have a bias toward items we own, but we also feel bad about selling one of those items for a price below what we believe it is worth.

Monkey Business

The endowment effect has been observed in children as young as six years old, suggesting that it may be basic to human cognition. The effect is not uniquely human, however, because other primates display it as well. In a study published in 2007 primatologist Sarah Brosnan, then at Emory University, and her colleagues coached chimpanzees to exchange their food and “toys,” such as bits of knotted rope, for other items. The researchers found that the primates were reluctant to trade their food for new edible items but traded toys freely. Ordinarily when the animals were given a choice of edibles, they did not show a preference for these particular foods, suggesting that the chimps attach

The capuchins readily learned to trade with the experimenters who gave them the best deals.

greater value to food items once they “own” them.

Yale University psychologist Venkat Lakshminaryanan and his colleagues sought to examine whether other species that had been trained to buy and sell food would display similar behavior. As the researchers reported in 2008, they trained capuchins—the “organ grinder” breed of monkey that often appears in movies such as *Night at the Museum*—to trade tokens for food. The Yale scientists even provided the animals with little wallets in which to keep their money. The capuchins readily learned to trade with the experimenters who gave them the best deals, showing that they have good economic sense. Soon it became clear how much each monkey was willing to pay for different foods. When the monkeys were given food to trade, they, like

humans, expected a higher sale price than they were prepared to pay for the same food.

Just this year Kanngiesser in my lab reported that several species of great ape, including gorillas and orangutans, exhibit the endowment effect. Kanngiesser’s work also confirms a key difference between humans and other primates, one that Brosnan’s chimp study hinted at: monkeys and apes exhibit the endowment effect only when it comes to food; they do not display it with other items, not even with tools that could be used to retrieve food (which have more intrinsic value than Brosnan’s “toys” did). So far only humans show endowment for objects.

Cultivating Ownership

In spite of 30 years of research on the endowment effect, investigators have only recently started to look at the phenomenon in populations other than North American students. Other cultures, it turns out, have different attitudes toward object ownership than ours does. For example, in 1988 marketing expert Melanie Wallendorf and anthropologist Eric Arnould of the University of Arizona compared southwestern Americans with Nigerian villagers and discovered that the villagers value gifts from others more and exhibit less of an endowment effect for their possessions. The finding is consistent with the prevailing view that the Nigerian villagers are less focused on individual belongings and more on culturally meaningful objects that are frequent-

Monkeys display the endowment effect: capuchins expected to receive more money for food they had to trade than they were willing to pay others for the same food. Here a capuchin “pays” a scientist with some of its money.



COURTESY OF LAURIE R. SANTOS Yale University



Children understand ownership only from their own point of view. The importance of respecting other people's stuff sinks in later in life.

ly exchanged and shared within the community.

In a study published last year psychologist William W. Maddux, now at INSEAD in Paris, and his colleagues established that the endowment effect was also not as strong in East Asian college students as it was in Western ones. The researchers reasoned that Western culture, which is more individualistic, may produce a stronger attachment to objects as an extension of the self. In a clever twist, Maddux's team also asked the 116 students in the study to write either about their relationships with other people or about themselves, a task that can realign an individual's focus. When East Asians concentrated on themselves, they endowed things they owned with greater value; Westerners instructed to write about others showed a reduced endowment effect. The way society regards the self—whether attention centers on a person as an individual or as a member of a group—appears to influence people's attitude toward possessions.

In my lab, we are investigating when children begin to develop those attitudes toward ownership. Last year, for example, we found that when it comes to deciding who owns an object, even very young children appreciate the labor that goes into making the item, but preschoolers rarely consider who owned the materials in the first place, which is some-

thing that adults factor in. Children also see ownership as limited to their own possessions, whereas adults respect the belongings of others. We now are trying to clarify exactly when in childhood the more mature understanding of ownership develops.

Getting a sense of the timing of these transitions may bring us closer to the origins of our conventions about who owns what. These ties may be culturally influenced, but they appear to build on a deep-seated human need to own things. This need, which may have arisen from a primitive tendency to covet food, is a crucial psychological process that shapes the way we view ourselves and others. **M**

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Can People Have Multiple Personalities?

Although many therapists think it is possible, research raises doubts

BY SCOTT O. LILIENFELD AND HAL ARKOWITZ



IN THE SHOWTIME series *United States of Tara*, actress Toni Collette plays Tara Gregson, a Kansas mother who has dissociative identity disorder (DID), known formerly as multiple personality disorder. As with others with DID, Tara vacillates unpredictably between various personalities, often referred to as alters, over which she does not have control. One of these alters is a flirtatious and flamboyant teenager, another is a traditional 1950s housewife, and a third is a boisterous Vietnam War veteran.

Many films, such as *The Three Faces of Eve* (1957) and *Me, Myself, and Irene* (2000), similarly portray individuals as possessing more than one personality. Some of them even confuse DID with schizophrenia [see “Living with Schizophrenia,” by Scott O. Lilienfeld and Hal Arkowitz; SCIENTIFIC AMERICAN MIND, March/April 2010]. Even the revised fourth edition of the American Psychiatric Association’s diagnostic manual, published in 2000, specifies the core features of the disorder as the “presence of two or more distinct identities or personality states.” Yet despite the pervasive popular—and professional—portrayal of this disorder, research casts doubt on the idea that anyone truly harbors more than one personality.

Dramatic Differences

Plenty of evidence supports the idea that DID is not merely a matter of faking and that most people with the condition



are convinced that they possess one or more alters. Although a few DID patients have only one alter—the so-called split personality—most report having several. In a survey conducted in 1989 by psychiatrist Colin Ross, then at Charter Hospital of Dallas, and his colleagues, the average number of alters was 16. Interestingly, that is the same number of alters purportedly possessed by Shirley Ardell Mason, the woman known as Sybil in the 1973 best-selling book and two made-for-television movies that popularized the diagnosis of multiple personality disorder. (Later evidence emerged suggesting that Sybil’s pri-

mary therapist encouraged her to display multiple personalities, creating a huge sensation.) In rare cases, the number of alters may reach into the hundreds or even thousands.

Differences among alters can be nothing short of astonishing. Alters within the same patient may be of different ages, genders, races and even species, including lobsters, ducks and gorillas. There have even been reported alters of unicorns, Mr. Spock of *Star Trek*, God, the bride of Satan, and Madonna. Moreover, some practitioners claim that alters can be identified by objective characteristics, including distinct handwriting, voice patterns, eyeglass prescriptions and allergies. Proponents of the idea of multiple personalities have also performed controlled studies of biological differences among alters,

revealing that they may differ in respiration rate, brain-wave patterns and skin conductance, the last being an accepted measure of arousal.

The question of whether people can harbor more than one character has important legal and therapeutic implications. If they can, and if patients are often unaware of their alters’ actions, a legal defense of “not guilty by virtue of DID” may be justifiable. Other scholars have argued that each alter is entitled to separate legal representation. As professor of law Ralph Slovenko of Wayne State University noted in 1999 in an article, some

COURTESY OF SCOTT O. LILIENFELD (Lilienfeld); COURTESY OF HAL ARKOWITZ (Arkowitz); LINO (multiple faces)

judges have even required each alter to be sworn in separately prior to testifying.

In treating these patients, many therapists try to get them to integrate their discrete personalities into a coherent whole. In doing so, they may help patients contact “undiscovered” alters and forge lines of communication among alters. For example, Ross has advocated

they had previously encountered in a different alter state—reveal a lack of transfer of memories across alters, subtler tests usually reveal that memories formed by one alter are in fact accessible to others. In these less direct tests, which tend to be more sensitive and less prone to intentional manipulation of responses, subjects may be asked, for example, to com-

treat DID patients use hypnosis, which may fuel these people’s difficulties in distinguishing fantasy from reality. Thus, DID may reflect an effort by individuals to make sense of extremely puzzling behaviors and feelings, a hypothesis proffered by the late psychologist Nicholas Spanos of Carleton University.

If so, techniques for making alters

(Subtler tests usually reveal that memories formed by one personality are in fact **accessible to others.**)

naming alters and holding “inner board meetings” in which they can converse, share opinions and provide information about missing alters. Psychiatrist Frank Putnam of Cincinnati Children’s Hospital has argued for the use of DID “bulletin boards” on which alters can post messages for one another in notebooks or other convenient venues.

Putting the Pieces Together

Despite such practices, persuasive evidence for discrete coexisting personalities in individuals is lacking. The reported distinctions among alters are mostly anecdotal, unconfirmed and difficult to interpret. For instance, the handwriting and voices of people *without* DID may also vary over brief periods, especially after a mood change. And disparities in physiological reactions, such as brain waves or skin conductance, could be similarly attributable to differences in mood or thoughts over time, according to University of Arizona psychologists John J. B. Allen and Hallam L. Movius. Individuals with DID almost surely experience dramatic psychological changes across situations, so it would be surprising if their physiology did not change as well.

If alters are truly distinct personalities, they should have memories that are inaccessible to other alters. Yet Allen and psychologist William G. Iacono of the University of Minnesota reported in a 2001 review that although most direct memory tests—such as asking patients to recall a list of words in one alter state that

plete a word such as “kin_” after an alter was presented with a related word, say, “queen.” Most subsequent studies bear out this conclusion, suggesting that alters are not distinct entities.

If alters are not discrete personalities, what are they? One hint: individuals who develop DID often meet the diagnostic criteria for borderline personality disorder, bipolar disorder and other conditions marked by instability. Indeed, a review in 1999 by one of us (Lilienfeld) and his colleagues found that between 35 and 71 percent of patients with DID also have borderline personality disorder. Understandably, then, many individuals prone to DID are bewildered by their unstable moods, self-destructive behavior, impulsivity and erratic relationships and are seeking an explanation for these disturbances. If psychotherapists or others ask suggestive questions such as “Is it possible that a part of you you’re not aware of is making you do and feel these things?” patients may become convinced that their mind houses multiple identities.

Data show that many therapists who

talk to one another may backfire, encouraging patients to falsely believe that the varied thoughts and feelings reside separately in their minds, often rendering them more difficult to integrate. For example, a patient could become convinced that one of her alters is responsible for her intense anger toward her husband, causing her to disregard her true feelings.

A better approach would be to help patients understand that their painful psychological experiences are created not by different personalities but by different aspects of one troubled personality. That way those suffering could begin to come to grips with these experiences and recognize that their thoughts and feelings are genuinely their own. **M**

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Send suggestions for column topics to editors@SciAmMind.com

(Further Reading)

- ◆ **Assessing the Validity of Amnesia in Dissociative Identity Disorder: A Dilemma for the DSM and the Courts.** John J. B. Allen and William G. Iacono in *Psychology, Public Policy, and Law*, Vol. 7, No. 2, pages 311–344; June 2001.
- ◆ **Alters in Dissociative Identity Disorder: Metaphors or Genuine Entities?** Harald Merckelbach, Grant J. Devilly and Eric Rassin in *Clinical Psychology Review*, Vol. 22, pages 481–497; 2002.
- ◆ **Dissociative Identity Disorder: Multiple Personalities, Multiple Controversies.** Scott O. Lilienfeld and Steven Jay Lynn in *Science and Pseudoscience in Clinical Psychology*. Edited by Scott O. Lilienfeld, Steven Jay Lynn and Jeffrey M. Lohr. Guilford Press, 2003.

The Burden of Lying

Fibbing is tough on the brain. New strategies expose liars by adding to the load

BY WRAY HERBERT



ONE OF MY GUILTY PLEASURES is the long-running TV show *NCIS*, a drama focused on the Naval Criminal Investigative Service. The hero is a former marine, now Special Agent Jethro Gibbs, a disciplined detective with an uncanny ability to observe and question criminal suspects. Gibbs doesn't say much or display a lot of emotion in the interrogation room—indeed, his cool demeanor is his trademark—yet he is a keen lie spotter.

Psychological scientists are fascinated by real-life versions of the fictional Gibbs. Detecting lies and liars is essential to effective policing and prosecution of criminals, but it is maddeningly difficult. Most of us can correctly spot barely more than half of all lies and truths through listening and observation—meaning we are wrong almost as often as we are right. And half a century of research has done little to polish this unimpressive track record.

But scientists are still working to improve on that, and among them is social psychologist Aldert Vrij of the University of Portsmouth in England. Vrij has been using a key insight from his field to improve interrogation methods: the human mind, despite its impressive abilities, has limited capacity for how much thinking it can handle at any one time. So piling on demands for additional, simultaneous thought—or cognitive “load”—compromises normal information processing. Because lying is more cognitively demanding than telling the truth, these compromised abilities should be revealed in detectable behavioral clues.

Why is lying more demanding? Imagine for a few minutes that you're guilty of a murder, and Gibbs is cross-examining you. To start, you need to invent a story, and you also have to monitor that tale constantly so it is plausible and consistent with the known facts. That task takes a lot of mental effort that innocent truth tellers do not have to spend. You also



need to actively remember the details of the story you've fabricated so that you don't contradict yourself at any point. Remembering a fiction is much more demanding than remembering something that actually occurred. Because you're worried about your credibility, you're

most likely trying to control your demeanor, and “looking honest” also saps mental energy. And you're not just monitoring yourself; you're also scanning Gibbs's face for signs that he might be seeing through your lie. That's not all. Like an actor, you have the mental de-

MATT MENDELSON (Herbert); DARREN KLIMEK/Getty Images (interrogation)

(The liars' verbal descriptions did not match up well with their drawings—and the inconsistencies **exposed their lies.**)

mands of staying in character. And finally, you have to suppress the truth so that you don't let some damning fact slip out—another drain on your mind's limited supply of fuel. In short, the truth is automatic and effortless, and lying is the opposite of that. It is intentional, deliberate and exhausting.

Testing the Limits of Lying

So how could Gibbs and other detectives exploit the differing mental experiences of liars and truth tellers? Here are a few strategies that Vrij and his colleagues have been testing in the laboratory, which they describe in a recent issue of the journal *Current Directions in Psychological Science*.

One intriguing strategy is to demand that suspects tell their stories in reverse. Narrating backward increases cognitive load because it runs counter to the natural forward sequencing of events. Because liars already have depleted cognitive resources, they should find this unfamiliar mental exercise more taxing than truth tellers do—which should increase the likelihood that they will somehow betray themselves. And in fact, that is just what happens in the lab: Vrij ran an experiment in which half the liars and truth tellers were instructed to recall their stories in reverse order. When observers later looked at videotapes of the complete interviews, they correctly spotted only 42 percent of the lies people told when recounting their stories without fabrication—below average, which means they were hard to spot—but a remarkable 60 percent when the liars were compromised by the reverse storytelling.

Another tactic for increasing liars' cognitive burden is to insist that suspects maintain eye contact with their question-



Sweating and other physiological signs of anxiety are not good indicators of lying—honest people get nervous under questioning, too. Asking suspects to maintain eye contact is a better strategy because it requires extra concentration.

er. When people have to concentrate on telling their story accurately—which liars must, more than truth tellers—they typically look away to some motionless point, rather than directly at the conversation partner. Keeping eye contact is distracting, and it makes narration more difficult. Vrij also tested this strategy in the lab, and again observers spotted lies more easily when the liars were required to look the interrogator in the eye.

Drawing Out the Truth

A third strategy that could be surprisingly effective is to ask suspects to draw a picture. Putting pencil to paper forces people to give spatial information—something that most liars have not prepared for as part of planning their lies and that, therefore, overtaxes their mental resources. When Vrij and his colleagues asked volunteers what their offices looked like, after

instructing half to tell the truth about their occupations and half to lie, both truth tellers and liars gave the same amount of detail in their verbal responses. But when Vrij asked them to draw their offices, the liars' drawings were much less detailed than those of the truth tellers. In another of the experiments, volunteers were questioned about a lunch date that only some subjects had actually attended. The liars' verbal descriptions of the restaurant did not match up as well with their drawings as did the truth tellers'—and the inconsistencies exposed the lies.

All these tricks may seem like overkill when we think about the fictional detectives we know,

including NCIS agent Gibbs, who seem able to ferret out every fib they hear without using any strategies other than their intuition. But in real life, such people are exceedingly rare; psychological scientists call them “wizards” because of their seemingly supernatural lie-detection skills. Researchers have been trying—without a lot of success—to unravel these wizards' strategies. Until they do, less sophisticated lie catchers may be able to exploit the mind's cognitive deficits, using tricks such as Vrij's, to catch the bad guys in their deceptions. **M**

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

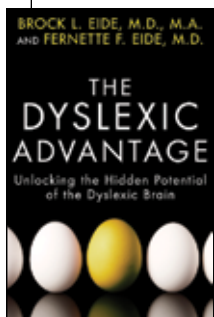
WRAY HERBERT is writer in residence at the Association for Psychological Science.

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- ◆ **Outsmarting the Liars: Toward a Cognitive Lie Detection Approach.** Aldert Vrij, Pär Anders Granhag, Samantha Mann and Sharon Leal in *Current Directions in Psychological Science*, Vol. 20, No. 1, pages 28–32; February 2011.

books

> BRAINY BENEFITS



The Dyslexic Advantage: Unlocking the Hidden Potential of the Dyslexic Brain

by Brock L. and Fernette F. Eide. Hudson Street Press, 2011 (\$25.95)

Perhaps the most challenging part of being dyslexic is the miscon-

ception that it makes people unintelligent or slow. In response, Brock and Fernette Eide have delivered a compelling call to action in their new book *The Dyslexic Advantage*: it is time to stop classifying dyslexia as a learning disability and start appreciating that different brain-wiring patterns allow people to process information in unique ways. When it comes to learning, they argue, there is no good or bad, right or wrong, only a difference in style, which should be fostered rather than corrected.

Although people with dyslexia may struggle with the fine-processing skills of reading and writing, often unintentionally interchanging letters and words, they can excel at “big picture” thinking. People with dyslexia frequently prefer thinking in narrative form, a proclivity that makes them natural storytellers, and they tend to have exceptional spatial navigation skills, visualizing 3-D structures with ease.

The Eides present functional MRI studies to illustrate what is different about the dyslexic brain. For instance, imaging shows that when people with dyslexia read, the right side of their brain dominates, which might help them absorb bigger themes in a text. They also exhibit deficits, however, in parts of the left hemisphere associated with reading and writing and understanding symbols. The nondyslexic brain splits the task more evenly between hemispheres.

The authors interweave case studies from their own psychological practice with current research on dyslexia. They also highlight a few of the world’s dyslexic elite, such as acclaimed novelist Anne Rice and entrepreneur Richard Branson, both of whom struggled with traditional schooling before using their unique skills to thrive. Although it would be easy to assume that Rice and Branson flourished because they triumphed over their

disability, the Eides contend that they succeeded *because* of their condition. Being dyslexic allowed them to break from conventional ways of thinking to dream of fantastic new worlds and create alternative solutions to vexing problems.

Despite offering a fresh perspective on dyslexia, the Eides agree with traditional psychologists on the need to intervene at an early age. But unlike their contemporaries, the authors are looking not to fix perceived weaknesses but rather to foster the individual strengths each child displays. —*Brian Mossop*

> INSANE SUCCESS



A First-Rate Madness: Uncovering the Links between Leadership and Mental Illness

by Nassir Ghaemi. Penguin Press, 2011 (\$27.95)

In 1972 Thomas Eagleton was chosen to

run as the democratic vice-presidential nominee under George McGovern in the race against Richard Nixon. But it soon emerged that Eagleton suffered from depression and had received shock treatment for it. A scandal erupted, and Eagleton stepped down, forming a cloud that still hovers over politics today.

Psychiatrist Nassir Ghaemi thinks the public is mistaken in wanting leaders who appear sane and mentally healthy. In *A First-Rate Madness*, he proposes that Eagleton may have actually been the best candidate to deal with a national crisis *because of*, not in spite of, his depression.

The crux of Ghaemi’s argument is that people who are depressed exhibit what psychologists have dubbed “depressive realism”—an all too accurate view of the world. Since the 1970s, when the concept of depressive realism first surfaced, some studies have suggested that people who are mentally healthy actually have overly optimistic ideas about their place in the world.

Being depressed, on the other hand, can give people keener powers of perception and heightened abilities to assess complex or tumultuous situations. In fact, various studies have shown that being bipolar can make people more creative, resilient and in tune with their environment.

Ghaemi details “case studies”

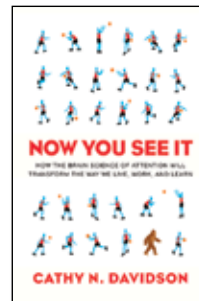
wherein he examines respected political figures—such as Abraham Lincoln, Winston Churchill and John F. Kennedy—who lived with depression or mania, or both, and argues that these qualities enhanced their leadership skills. Conversely, he asserts that leaders considered mentally healthy do well during times of peace and prosperity but falter during crises because they lack the practicality or creative thinking skills that leaders with mental disorders often exhibit. Ghaemi offers an anecdote in support of his point: the sane British prime minister Neville Chamberlain thought Adolf Hitler was someone who could be reasoned with, but Churchill saw from the beginning that the strategy would never work.

On the surface, the theory may seem counterintuitive. But Ghaemi provides exhaustive research and makes a compelling case for his point, which is perhaps best summed up by an aphorism from Martin Luther King, Jr.: “Human salvation lies in the hands of the creatively maladjusted.” —*Frank Bures*

> WEB WORLD

Now You See It: How the Brain Science of Attention Will Transform the Way We Live, Work, and Learn

by Cathy N. Davidson. Viking Adult, 2011 (\$27.95)



Although the Internet has redefined how we access information, many schools and employers still expect their students and staff to behave just as they did 100 years ago, working rigid hours and performing assembly line–like tasks. But digital games, social media and virtual environments are rewarding our brains differently, forging new ways to learn and do business.

In her new book *Now You See It*, Cathy N. Davidson—a self-identified “student of the Internet”—uses infant language learning to argue that our attention is strongly guided by experience and culture. Eastern and Western babies, for example, differ vastly in the phonemes they recognize at an early age. They each learn to pay attention to distinct sounds, those that elicit a reaction or a reward from their caretakers.

Davidson argues that the Internet has likewise altered where we focus our attention. Boundaries once drawn by

►► Roundup: Quirks and Quibbles

Two books and one TV series explore the oddities of the human mind.

Extraordinarily complex as the human brain may be, it is far from perfect. Human memory is unreliable; we are easily swayed by advertisements; and we tend to hold fast to superstitions. In his new book **Brain Bugs: How the Brain's Flaws Shape Our Lives** (W. W. Norton, 2011), neuroscientist Dean Buonomano explores these neural “bugs,” delving into studies that reveal why the brain may have developed some of its quirks.

Is it possible to directly observe the brain at work? In a thought-provoking read, psychologists Paolo Legrenzi and Carlo Umiltà argue that the public has become unduly obsessed with brain imaging. **Neuromania: On the Limits of Brain Science** (Oxford University Press, 2011) debunks the budding idea that a study or news report accompanied by a colorful brain image is more reliable than research that does not use flashy functional MRI technology.

Have you ever been curious to see the world through a newborn's eyes? Now you can come close. The PBS series **The Secret Life of the Brain** (with clips available online at www.pbs.org) takes viewers on a ride through the developing human brain, from birth to death. For instance, viewers will learn that only four weeks into gestation neurons are already forming at a rapid rate of 250,000 per minute and that our brains continue to produce new neurons even into our seventies. —Victoria Stern



COLIN ANDERSON Getty Images

physical distance, language or expertise can now be bridged with a backlit screen and a few mouse clicks. Through a series of anecdotes, she asserts that the true trailblazers of this shifting landscape, from small-town teachers to key players in giant corporations, are those melding skills needed online with those that serve both the classroom and the workplace. It is impossible to pay attention to everything at once, but by collaborating—sharing links on our favorite social media sites or working together in a multiplayer role-playing game—we learn how powerful the wisdom of the group can be.

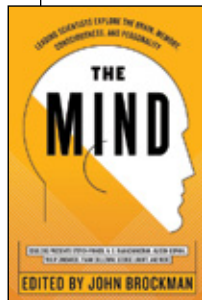
Although the book provides glimpses of the brain's inner workings, *Now You See It* is not for those readers seeking the latest insight into the neuroscience of learning or attention. In fact, most of Davidson's explanations are oversimplified. But dismissing the book on those grounds alone would be shortsighted.

The book's purpose and strength are in detailing the important lessons we can glean from the online world. Rather than focusing on how games such as World of Warcraft or the social-networking services of Twitter and Facebook change our brains, Davidson believes we should foster these newfound skills, building curricula around interactive multiplayer games and training workers using virtual environments.

If Davidson is right, 21st-century society will move away from categorizing people based on standardized tests, which

are crude measures of intelligence at best. Instead we will define new metrics, ones that are better aligned with the skills needed to succeed in the shifting global marketplace. And those who cannot embrace this multidisciplinary world will simply be left behind. —Brian Mossop

► NEVER MIND



The Mind: Leading Scientists Explore the Brain, Memory, Consciousness, and Personality

Edited by John Brockman. Harper Perennial, 2011 (\$14.99)

As a research psychologist, when I see a book that claims to reveal “everything you need to know about the mind,” I keep my hopes up and my expectations low.

This new book, edited by legendary literary agent John Brockman, dashed most of my hopes. It contains conversations with 16 prominent neuroscientists, biologists and psychologists, but only one is female—a clue about one of the book's flaws, namely, that much of its content is obsolete.

In the first chapter, for example, in a chat between Brockman and psychologist Steven Pinker of Harvard University, Pinker complains about theories of mind that are “decades out-of-date” while advancing an information-processing theory of

the brain that is also out-of-date. This gaffe can be explained, perhaps, by the fact that the interview took place in 1997. Since that time, great strides have been made in neuroscience, which has gradually been coming to grips with the fact that the brain works *nothing* like a computer, contrary to Pinker's assertions. Fully half the interviews in this book took place in the 1990s—a serious problem when one is looking at one of the fastest-moving fields in all the sciences.

Also troubling, every chapter has long been available in unedited form on Brockman's Web site, Edge.org, created to be a forum where outstanding scholars and scientists could interact. As one might expect, the experts featured in the book are often talking to *one another*, not to the general public.

The biggest problem with the book, however, has to do with the diversity of topics it tackles. Eight of the book's 18 chapters say nothing about either brain or mind, focusing instead on topics such as birth order, morality and even protozoan parasites. How these various forays are related to either mind or each other is unclear.

These negatives notwithstanding, if you want a quick introduction to some of the smartest and most interesting thinkers around—Stanislas Dehaene of the Collège de France in Paris, Vilayanur S. Ramachandran of the University of California, San Diego, Steven Rose of the Open University in Milton Keynes, England, and others—read this book or simply click on Edge.org. —Robert Epstein

asktheBrains

Where are the images and ideas from dreams located in the brain, and is there any way to capture them?

—Derek Meier, Chicago



Mark A. W. Andrews, director and professor of physiology at Lake Erie College of Osteopathic Medicine at Seton Hill University in Greensburg, Pa., replies:

THE ANSWER to the latter part of your question is simply, “No.” Although we have technology that can measure general brain activity, we have no method for assessing or capturing our individual thoughts and dreams.

To evaluate our future potential to do so, it is important to understand which areas of the brain are associated with dreaming. Most dreams occur during the stage of sleep when slumberers start making rapid eye movements, called REM sleep. The imagery a sleeping brain concocts appears to originate in the reticular formation (RF), a diffuse, intricate collection of more than 100 networks of neurons arranged throughout the brain. The RF helps to regulate essential processes, including waking and sleeping cycles and cardiac function. The RF’s neural networks link up with the cerebral cortex, which regulates how we think and remember. But the widespread connections between the RF and the rest of the brain make dreams difficult to study.

In addition to the RF, dreaming involves the limbic system, often referred to as the emotional brain. Areas of the visual cortex responsible for recognizing complex visual scenes as well as the anterior cingulate gyrus, which governs attention and motivation, are also active during REM sleep. Interestingly, regions of the frontal cortex involved in thought and judgment while we are awake remain relatively calm throughout REM sleep, possibly accounting for the bizarre and

illogical content of some dreams.

Currently scientists are able to probe human brain activity in several ways. We can record brain waves using EEG. With PET scans and functional MRI, we can observe fluctuations in brain activity by measuring changes in blood flow and levels of nutrients.

These established techniques are not powerful enough to document dreams, but a newer method may enable a breakthrough. Recently neuroscientists have implanted single electrodes in the cortex to record the activity of single neurons believed to be associated with a single thought or image. One day such implanted electrodes might let us log and play back our thoughts and dreams.

How much can the brain recover from years of excessive alcohol consumption?

—Paul Howlen, London



Richard Ridderinkhof, professor of neurocognitive development and aging at the University of Amsterdam, answers:

EVIDENCE SHOWS that heavy alcohol use modifies the structure and physiology of the brain, although the extent of recovery after years of abstinence is unclear.

Recent neuroimaging studies have revealed that chronic alcoholism can damage the cerebellum, which plays an important role in regulating motor control, attention and language. It can also cause the prefrontal cortex to shrink and degrade, potentially impairing decision-making skills and social behavior. Studies have also found damage in the white matter of the brain, which connects these regions.

The question remains, however, whether such extensive damage can be reversed after abstaining from alcohol. Researchers have studied the effects of

Years of abstaining from booze can allow brain regions to regain lost volume and can repair neural connections across different regions.

abstinence on the brains of alcohol-dependent individuals by comparing subjects recovering from years of alcohol abuse with those who do not drink or drink minimally. Scientists have also investigated changes in brain volume in initial versus sustained abstinence in one set of subjects.

Several of these studies have shown that years of abstaining from booze can allow brain regions to return to their original volume and can repair neural connections across different regions. Much of this restoration occurs in the system most adversely affected by chronic alcoholism—the frontocerebellar circuitry, which regulates decision making, reasoning and problem solving.

Other reports, however, have found sustained injury in certain areas. Some former alcohol abusers show permanent damage to the hippocampus, a brain region that regulates long-term memory and spatial navigation, and only partial resolution of lesions on the white matter.

Although the effects of abstinence on the alcohol-abused brain vary, it appears that we display at least some ability to recover from the effects of excessive drinking. Future neuroimaging studies should clarify the full extent and potential for recuperation. **M**

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

Think Naturally.

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Head Games

Match wits with the Mensa puzzlers

1 CONFOUNDING COMPOUNDING

Find one word per line that can be added to each noun in the group to make a compound word.

- Boat** **Maid** **Work** _____
- Light** **Strong** **Line** _____
- Fall** **Step** **Ball** _____

2 4 x 4

Arrange the letters QUIZ in the grid below so that each line across, down and diagonally from corner to corner will contain the word QUIZ (or an anagram of it) and no letter is repeated in any line. Three letters have been put in to help you get started.

Q	U		
			I

3 IT MAKES YOU THINK

Replace the last letter of each pair of words with a new letter, making each word into a different English word, then place the new letter on the blank between the two new words. As you read down, what word is formed by the letters in the blanks?

- Flat** _ **Lame**
- Saves** _ **Doom**
- Arid** _ **Dive**
- Kept** _ **Pert**
- Grit** _ **Spit**

4 MADAM, I'M ADAM

What palindromes do the following definitions describe? (Palindromes are words that read the same forward and backward.)

- The heroic tales of Scandinavia**
- Musical pieces performed by one person**
- Something or someone that restores vigor**

5 ODD MAN OUT

Which of these scrambled words does not belong with the others?

ZSUE RPSEESU MCRUYER MRCEIAA

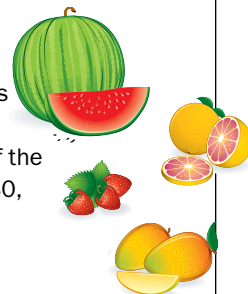
8 A VERSATILE VERB

Attach the same four-letter word to the front of each of the words below to make a totally new word. (Hint: The new words are not compound words.)

_____ **just** _____ **dress** _____ **able**

9 FRUITY ADDITION

At the grocery store, a melon costs as much as a grapefruit plus one-third more; a carton of strawberries costs as much as the melon and grapefruit combined; and a mango costs the price of the strawberries minus the melon. If buying one of each costs \$6.80, what was each item's price?



10 HISTORY EXAM

If Henry VIII could have met Columbus, cross out all the Ws, Xs, Ss and As. If Shakespeare could have met Sir Walter Raleigh, cross out all the Os and Ns. If Henry VIII could have met Shakespeare, cross out all the Rs, As, Bs and Is. If Columbus could have met Pocahontas, cross out all the Hs, Gs, Xs and Ws. If you know your dates, the remaining letters will describe you. What do they spell?

W N B O A R X A I G X H A T S A X A O A X

Answers

could not have met Pocahontas. Done incorrectly, the letters spell NOT SO. Done half right and half wrong, the remaining letters will be just a jumble.)

10. BRIGHT. (Henry VIII could have met Columbus, but he could not have met Shakespeare. Shakespeare could have met Sir Walter Raleigh; Columbus

7. 91,326.
8. Read (readjust, readable).
9. \$1.60 (melon), \$1.20 (grapefruit), \$2.80 (strawberries) and \$1.20 (mango).

3. BRAIN.
4. Sagas, solos, reviver.
5. AMERICA (the other three are from Greek mythology: ZEUS, PERSEUS and MERCURY).
6. Observe, verbose.

1. House, head, foot.
2.

U	Q	Z	I
I	Z	Q	U
Q	I	U	Z
Z	U	I	Q

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ILLUMINATING THOUGHTS

by Dwayne Godwin and Jorge Cham

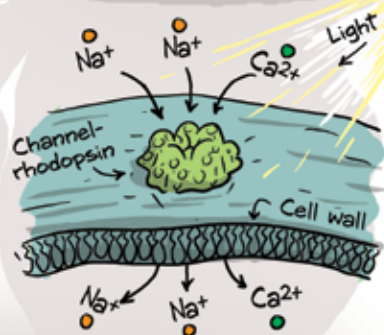


SOMETIMES THE BRIGHTEST IDEAS COME FROM LOOKING AROUND IN THE DARK.

IN THE 1990S CURIOUS SCIENTISTS WERE WONDERING HOW CERTAIN ALGAE WERE ABLE TO RESPOND TO CHANGES IN LIGHT.



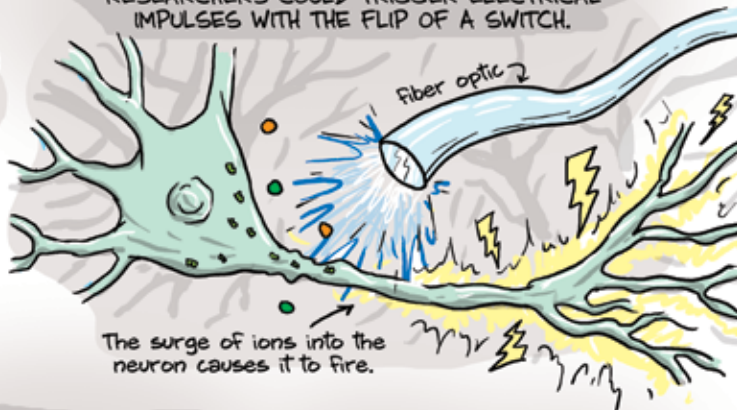
THEY FOUND THAT LIGHT OPENS A PROTEIN GATE CALLED CHANNELRHODOPSIN, ALLOWING IONS TO RUSH THROUGH A CELL WALL.



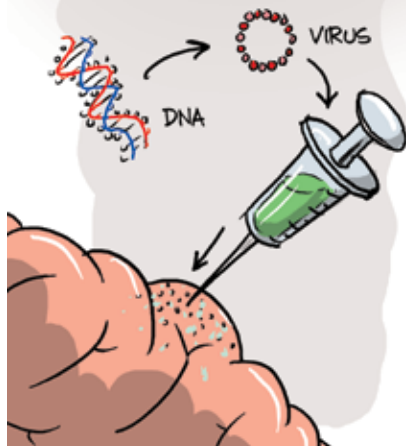
NEUROSCIENTISTS QUICKLY SAW THIS AS A WAY TO POSSIBLY CONTROL AND STUDY THE ACTIVITY OF NEURONS.



BY EMBEDDING THIS PROTEIN INTO THE SURFACE OF SPECIFIC TYPES OF NEURONS, RESEARCHERS COULD TRIGGER ELECTRICAL IMPULSES WITH THE FLIP OF A SWITCH.



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● 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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