WILL YOUR SMARTPHONE EVER LOVE YOU? *page 26*

SCIENTIFIC AMERICAN
MIND
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July/August 2014
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Endless Arousal
When the Brain Gets Mixed Messages

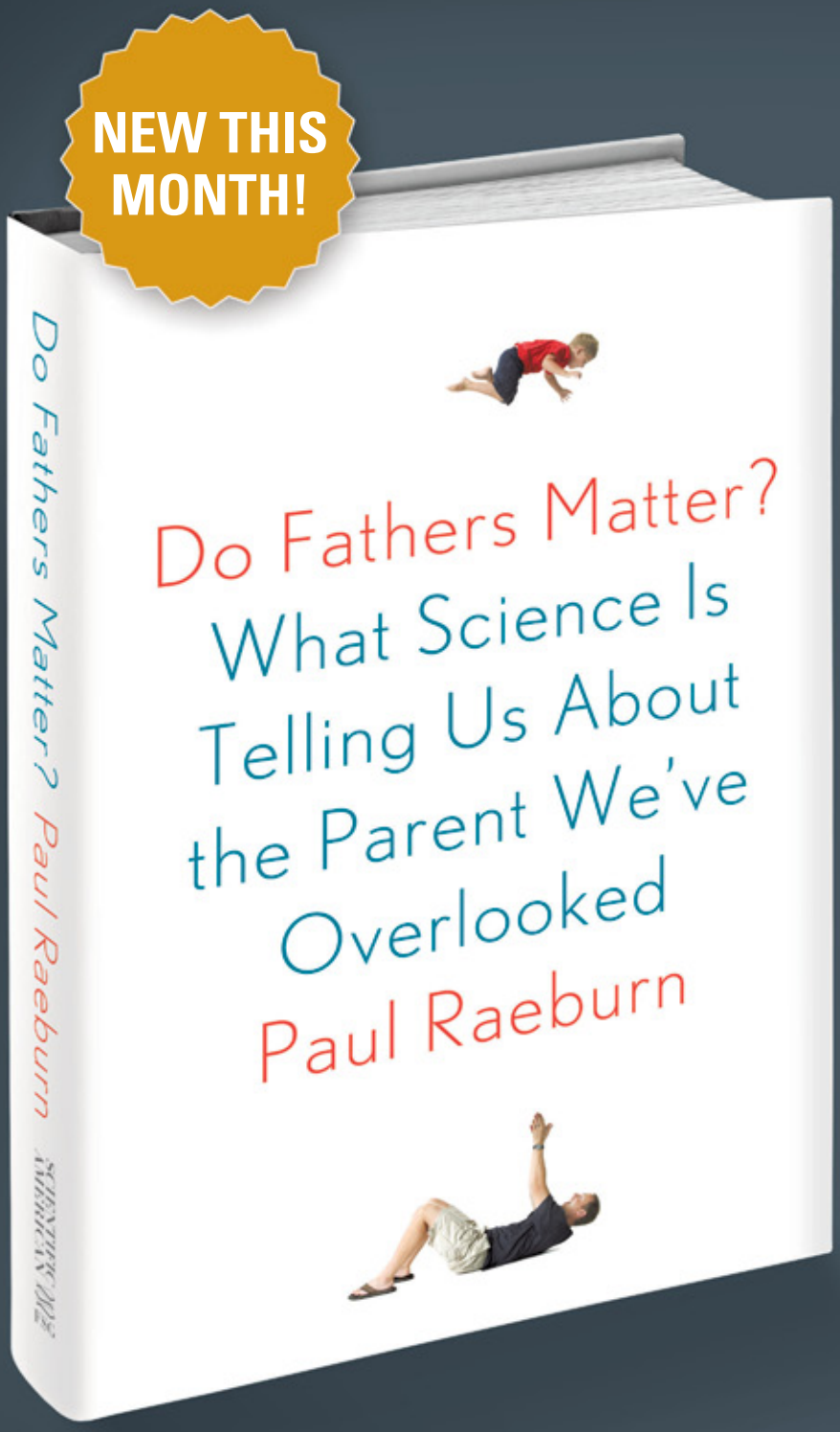
SPECIAL REPORT

BOLD IDEAS
The Creative Process Made Simple

A BRAIN IMPLANT TO TREAT VERTIGO

HOW STRONG EMOTIONS KEEP US HEALTHY

FEEDING YOUR INSATIABLE BRAIN



"A must-read book for anyone who cares about the well-being of children."

—SUSAN CAIN, bestselling author of *Quiet: The Power of Introverts in a World That Can't Stop Talking*

"Do fathers matter? Yes, they do, and Paul Raeburn shows us why, in the most engaging and illuminating way imaginable."

—ANNIE MURPHY PAUL, author of *The Cult of Personality Testing, Origins,* and *Brilliant: The Science of How We Get Smarter*

"Anyone interested in parenthood, human development, and culture must read this thoughtful book."

—GRETCHEN RUBIN, bestselling author of *Happier at Home* and *The Happiness Project*

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COVER IMAGE BY ALEXANDER KHOKHLOV (*photography*), VALERIYA KUTSAN (*makeup*) AND VERONICA ERSHOVA (*retouching*); SEAN McABE (*Upson*)

The Genius of Groups

Nothing beats a supportive group to jump-start your own thinking. On a recent Thursday I was suffering from a lack of inspiration, so I reached out to *Scientific American Mind*'s followers on Twitter and Facebook to ask them what they most wanted to learn about the mind and brain. Three hours later I had a list of story ideas that could fill the magazine for an entire year.

One of those suggestions—how social groups shape the mind—dovetails with this issue's cover story, "Creativity Is Collective," starting on page 30. S. Alexander Haslam, a member of *Scientific American Mind*'s advisory board, and his colleagues Inmaculada Adarves-Yorno and Tom Postmes wanted to debunk the prevailing myth that genius is a lone endeavor. As they recount, we rely on others at critical junctures to sharpen our thinking and to help us persevere through a difficult task. So surround yourself with people who galvanize you—they could play a pivotal role in your own ingenuity.

Yet as Louis Pasteur famously quipped, "Fortune favors the prepared mind." To that end, psychologists have identified the behaviors and brain processes that accompany the different stages of creativity: exploration, focus, incubation, insight and follow-through. Only after an initial period of exploration and focus can a social group propel you forward. In "The Aha! Moment," beginning on page 36, writer Nessa Victoria Bryce analyzes the distinctive thinking style shared by many inventive people, offering lessons for all of us.

To see ingenuity in action, I recommend checking out "Conquering Vertigo," starting on page 42. Neurophysiologist James Phillips describes how he and his collaborators sought to restore a sense of balance to people suffering from a debilitating inner ear disorder. Several researchers have attempted to design a device for this purpose before, but Phillips and his group took a different approach. Instead of building a nerve stimulator from scratch, they adapted a cochlear implant. Now they are testing the first implant for balance disorders in humans.

As Phillips's story illustrates, a group effort brings breakthroughs to the fore. Would you like to join in on *Scientific American Mind*'s creative process? Send us your ideas at the e-mail address below or find us on social media. Together we can make great things happen.

Sandra Upson
Managing Editor
editors@SciAmMind.com

VOLUME 25, NUMBER 4, JULY/AUGUST 2014

SCIENTIFIC AMERICAN MIND

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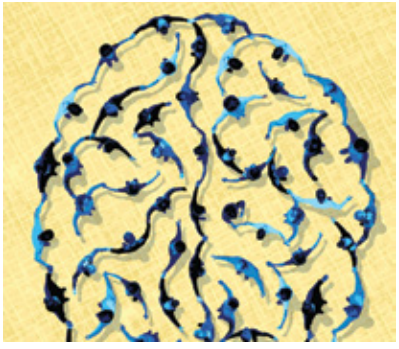

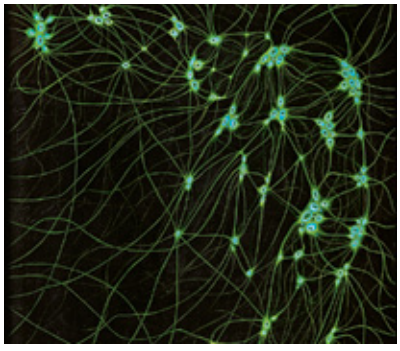

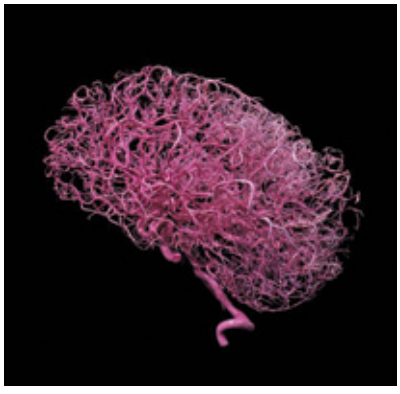

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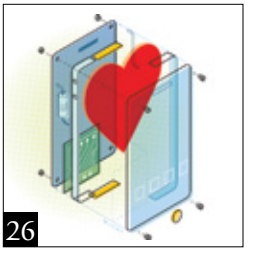

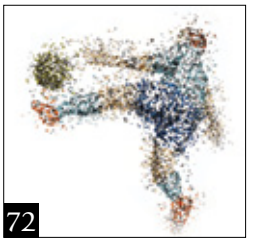

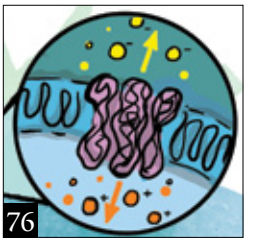

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EASING KIDS' STRESS

Kudos for the special report on "How to Raise a Happy Child." Authors Jerry Bubrick, Ingrid Wickelgren and Emily Laber-Warren do an excellent job of explaining the intrapersonal and interpersonal dynamics between parents and children with fragile emotions and challenging behaviors. I plan to use these articles to jump-start discussions among school psychologists in various programs for which I consult.

As a pediatric clinical neuropsychologist who has written about the impact of stress on learning (in particular, for kids with attention-deficit/hyperactivity disorder and learning disorders), I believe that most, if not all, of the behaviors addressed in the programs described are caused by the predictable reaction of a child who is under stress.

When kids are feeling out of control (which is true in all the cases presented in your articles), their behaviors are, at the most basic level, protective reactions to the stress generated by not knowing how to react or respond in a positive way that quells their fears. When the primitive fear centers of the brain are on high alert, the prefrontal cortex (essential for self-control) virtually shuts down in the service of survival. From a neurobiological point of view, a cycle of fear, avoidance, stress and escape is neutralized by all the programs reviewed here because these programs focus on consistency, calmness, competence, positive feedback and success—things that are sorely lacking in the lives of little kids who live in the shadow of fear and the clamor of chaos.

Jerome Schultz
Department of Psychiatry
Harvard Medical School

I very much appreciated the article "Concentrate," by Laber-Warren. I am wondering if the positive effects from the studies cited aren't in part the result of involving the parents in working directly with their children. Good preschools already do many things that should help kids with attention, working memory and the ability to switch gears. The missing piece may be to get parents on the same page.

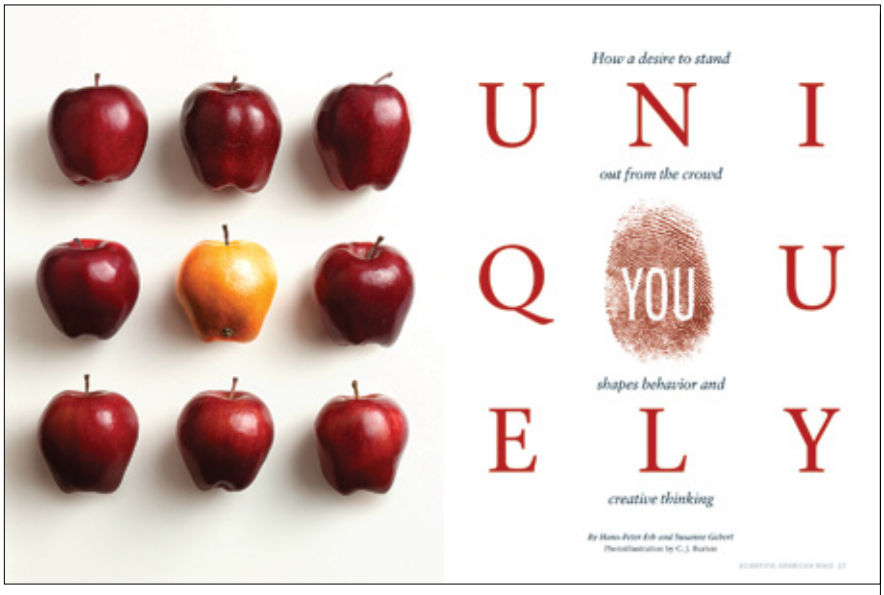
I also wonder whether old-fashioned advice is also effective for helping with concentration—such as asking parents to read to their children and (when possible) having a dinner hour where family members sit down together and interact. I would be interested in a control group that encouraged simple interactions between parents and children and suggested a reduction in media exposure. Lots of outdoor play may also be helpful. These things are difficult to achieve, I know, but they might get at the root of the problem.

Emily Silliman
via e-mail

UNIQUE AMONG THE UNIQUE

I was quite surprised by the results of the survey reported in "Uniquely You," by Hans-Peter Erb and Susanne Gebert. Although I am now much older, even as a college student I had a great need for uniqueness, but I am not extroverted or sociable. I am indeed optimistic about life, but I am only moderately open to new experiences, and I score high on neuroticism. Either the survey's sample population was too small and limited, or I am indeed as unique as I have always aspired to be.

Naomi Goldblum
via e-mail



MENTALLY ILL CRIMINALS

Great article by Robert Byron: "Criminals Need Mental Health Care." Those of us who are sane and unimprisoned can be grateful for our genetics and upbringing. We can also contribute to the prevention of the great injustice Byron describes. Supporting families at risk so that children do not develop these disorders would be significantly cheaper than the $500,000 per annum to treat the mentally ill or even the $33,000 to keep them in jail. It's an economic and moral imperative.

Carol Braunack
Graceville, Australia

Thanks for Byron's excellent article about the cruelty and ineffectiveness of imprisoning mentally ill people. I only wish the media would stress this issue more.

Nancy Lingo
via e-mail

As a teacher of elementary school students with autism and other behavioral disorders, I applaud Byron's article. I see students before they develop full-blown conduct disorders. The sad fact is there are no resources for these kids. I can assess them, psychologists can diagnose them, parents can beg for help, but to no avail. Students with mental illness don't have a "place" anymore! In Washington State there is a 16-month-long waiting list for one hospital. A student identified as dangerous and possibly bipolar was turned away from a so-called crisis response center. It's disgusting and shameful.

Would the cost of psychiatric treatment for adults in prisons (after a crime) be lessened considerably simply by early identification and available treatment for young people with mental illnesses? Of course, it would—and the point might even be moot because many of those adults would never see prison as a result of not offending. Remember, the "cost" we pay for criminals and crimes, especially the violent ones, is more than financial—it's literally life and death.

Name withheld
West Richland, Wash.

NAMED AND TAMED

Trypophobia—now I know. The nausea I get from certain images has a name, and even more astonishing, other people experience it, too. This article by William Skaggs, "Fear of Holes" [Head Lines], is the first I've heard of it. It's liberating to understand that this reaction is neurological and that there's a scientific explanation.

"mpuckette"
commenting at
Mind.ScientificAmerican.com

REGARDING BIAS

Oh, how I love this magazine for its informative, scientific articles! But never did I think I would be as amused or saddened as I was by the two readers who wrote in about the front cover of the "Seven Deadly Sins" issue. I think it is interesting that both readers would have preferred to have seen a "white male devil" or a "young white man" on the cover rather than a dark-skinned female. While they emotionally try to point the finger at the publishers for not making "more enlightened artwork selections," it appears to me that they are, in fact, the ones who harbor unconscious bias or, dare I say, racism. To suggest that using a picture of a white man would have been better plunges their logic into the dark abyss.

I am biracial. I thought the cover model was beautiful and was immediately intrigued by the perfect genetic combination from different ethnic backgrounds that created such beautiful bone structure and flawless skin. Her beauty may well have brought out a slight envy in me, which is one of the seven deadly sins. How clever you are, *Scientific American Mind!* The thought makes me chuckle at myself.

I think the unconscious bias those two readers displayed is a sad thing. If I ever begin to connect all things to skin color, I will be a sad thing myself on that day.

Beth Ferguson
via e-mail

ERRATUM

In "Science as Faith" [Head Lines], by Tori Rodriguez, the study by Miguel Farias and his colleagues is incorrectly cited as from the *Journal of Experimental Psychology.* The study appeared in the *Journal of Experimental Social Psychology* in November 2013.

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Black Holes

Speaker: Jenny Greene, Ph.D.

Black Holes: Galactic Gobblers

Lurking at the heart of every massive galaxy is a giant black hole. Learn what we know of these behemoths, thought to be nearly infinitely small and infinitely dense. Here the current laws of physics break down, but modern observatories can provide some hints of what lies inside.

Black Hole Origins

Which came first: giant black holes, or the massive galaxies that surround them? Black holes can form in multiple ways, and they influence the evolution of the galaxies they inhabit. Learn what we do and don't know about the birth of black holes, and how we stand to revolutionize our knowledge in the coming years.

Black Hole Evolution

Black holes feasting on matter are some of the most luminous objects in the universe. We know that many black holes grew up when most of the stars formed in the universe, yet the details of this process are mysterious. Learn how observations of gravity waves could help us understand black hole evolution.

Women in Astronomy & Physics

Women are underrepresented in many science fields, but especially astronomy and physics. We'll discuss the real numbers behind this problem, and the various factors that play into it, including sub-conscious bias in hiring and test-taking practices. We'll also examine ways to change this pattern in the future.

The Intelligent Brain

Speaker: Richard J. Haier, Ph.D.

Mysteries of Intelligence and the Brain

Yes, intelligence is something real and it can be defined and studied scientifically. We'll consider savants and geniuses, how to define intelligence, and discuss how intelligence tests work. We'll review the key research and discuss why a person's intelligence is both liberating and constraining. We'll also consider why smart people do dumb things.

The Origins of Intelligence

We know there is a strong genetic component of intelligence from studies of twins and investigations that combine genetic analyses and neuro-imaging. Surprisingly, research results showing the influence of specific environmental factors, including early childhood education, are rather weak. Learn why brain development, as revealed by neuro-imaging, may be a key.

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What Makes a Brain Smart?

Neuro-imaging research has identified brain features and specific areas distributed throughout the brain that are related to intelligence test scores. We'll review, in non-technical terms, how neuro-imaging works and we'll see some amazing dynamic views of intelligence at work in the brain during problem-solving, including some findings "hot off the press."

How Smart Do You Want To Be?

As we learn about the neural mechanisms of intelligence, prospects for enhancing intelligence become more likely. We'll discuss the ethical quandaries this raises. If there were an IQ pill, would you take it? What about enhancing intelligence in children? If we could enhance intelligence, do we have a moral obligation to do so?

Dinosaurs

Speaker: Darren Naish, Ph.D.

Predatory Dinosaurs and the Origins of "Birdiness"

Theropods, which included giants like Allosaurus and Tyrannosaurus, also had numerous lineages of smaller bird-like dinosaurs, and many theropods were feathered. Take a tour through theropod diversity, and examine the many controversial ideas of how they lived, how they hunted, and what they looked like when they were alive.

Sauropod Dinosaurs and the "Necks For Sex" Debate

Sauropod dinosaurs had immensely long necks, sometimes more than four times longer than their bodies. Some have suggested this evolved as a sexual signal, its length driven by sexual selection pressure. I'll discuss my work testing this hypothesis, and why the neck might actually have evolved for feeding and foraging.

Pterosaurs: Flying Reptiles of the Mesozoic

Ancient reptiles called pterosaurs flew on membranous wings supported by enormous fourth fingers. They had furry bodies, air-filled bones and many species possessed crested skulls. Little is known about pterosaur behavior and social life, but we can make some educated guesses. Learn about the diversity, anatomy and biology of this amazing group.

The Remarkable Azhdarchoid Pterosaurs

Among the most unusual of pterosaurs are the azhdarchoids—animals with huge wingspans that stood over 4 meters tall. They have been imagined as mud-probers, vulture-like scavengers, skim-feeders and heron-like waders. We'll discuss the newest data that has changed our view of these fascinating animals.

Eclectic Astronomy

Speaker: Donald Kurtz, Ph.D.

Planets and Pulsations: The New Keplerian Revolution

The Kepler space telescope has discovered more than 3,500 candidate exoplanets, and is closing in on finding another Earth—a rocky planet in the "Goldilocks zone" where life might exist. Kepler has also allowed us to see stars as never before. Learn how this mission is revolutionizing our knowledge of the galactic zoo we inhabit.

It's About Time!

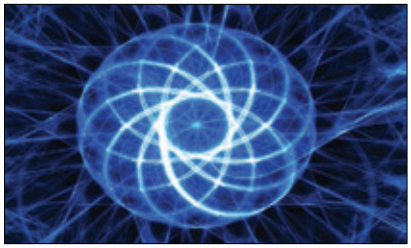
Days, weeks, months, years and more: Hear about Roman emperors, Zulu wars, Rider Haggard, Thomas Hardy, the English time riots, and how the days of the week got their names in an amusing and informative tour of the Western calendar.

The Stars are Ours!

"What good is astronomy?" Through colorful historical anecdotes and science, we'll answer that question. Hear stories of wealth and poverty, castles and dungeons, kings and princes, sailors and maidens, sea battles and Shakespeare, as we look back at the improbable, unpredictable path that gave us the Power of the Stars.

The Sun-Earth Connection

Learn how magnetic activity on the Sun affects Earth, from our planet's magnetosphere to the aurora lights. We'll see why the Sun is not the source of global warming, and we'll discuss weather on other stars. I'll also introduce you to a group of peculiar magnetic stars that I discovered.



Particle Physics

Speaker: Don Lincoln, Ph.D.

The Higgs Boson

Hear the saga of the Higgs boson particle, from its initial prediction in 1964 through its discovery to the 2013 Nobel Prize. As a member of one of the teams that discovered it, I will give an insider's perspective, including answering the very important question, "What's next?"

Accelerators and Particle Detectors

The Higgs boson, the top quark, dark matter—none of these particles are part of our everyday experiences. So how do scientists study these elusive particles? Learn about the complex technology we use to glimpse them, from 14,000-ton experiments with over a hundred million elements to particle observatories under the Antarctic ice.

History of Particle Physics

The search for the ultimate building blocks of matter has a long history. Hear the story, from the 1987 discovery of the electron to finding protons, neutrons and eventually particles that have no role in ordinary matter. Learn how we arrived at our current picture of quarks, leptons and a handful of force-carrying particles.

The Dark Side of the Universe

We understand the nature of the ordinary matter that makes up you and me, but ordinary matter is only 5% of the universe. Learn about the data that led us to conclude that a bizarre dark world must exist, and hear about current experimental efforts aimed at finding it.

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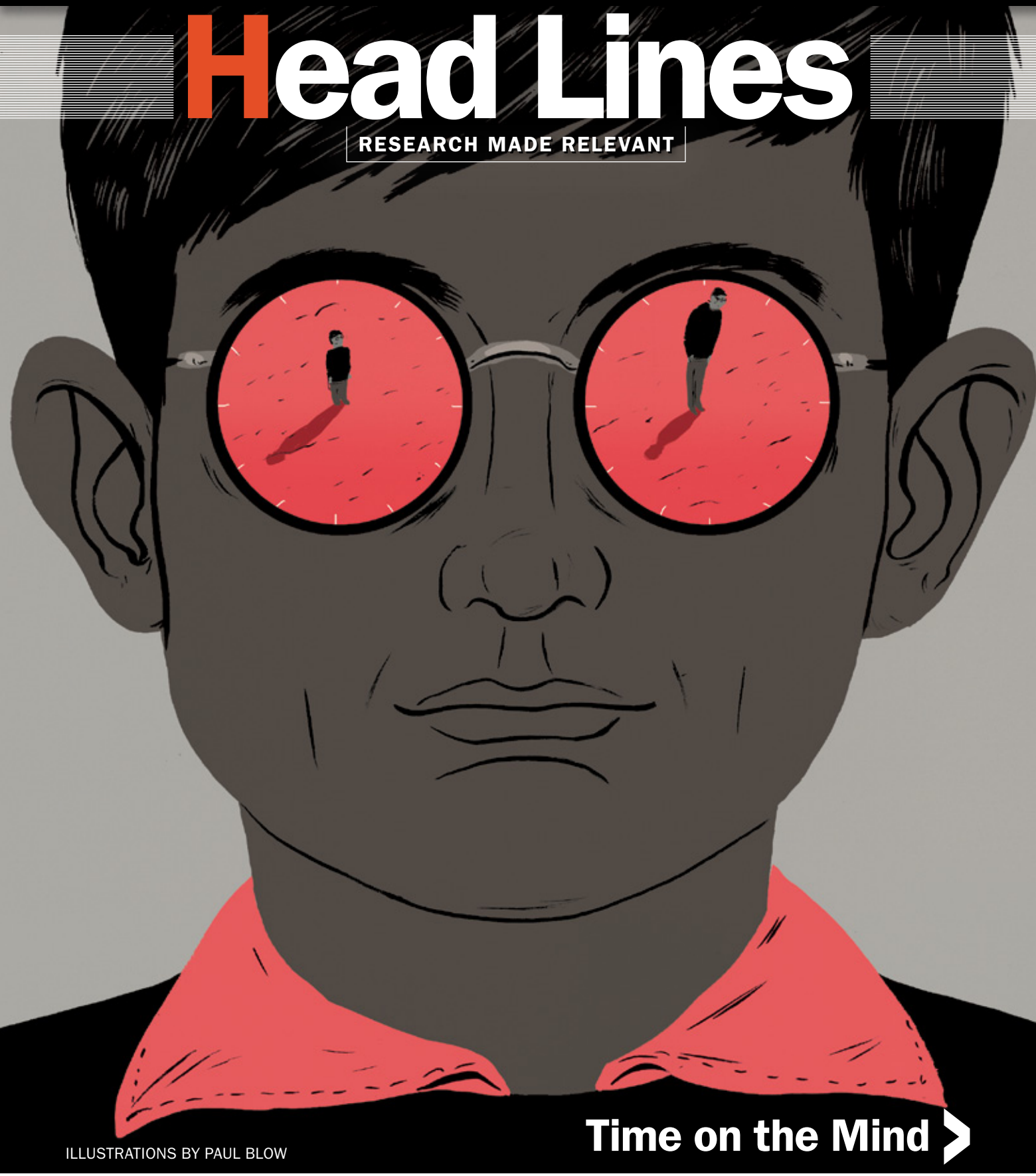
Head Lines

RESEARCH MADE RELEVANT



ILLUSTRATIONS BY PAUL BLOW

Time on the Mind

M NEWS FROM OUR WEB SITE | Our mental simulations of the world are surprisingly similar to the way video games model physics.

Left in the Past

Our brain may not be able to conceptualize time without a proper understanding of space

We often think of the abstract idea of time in the concrete terms of space, saying we are "looking forward to the weekend" or "putting the past behind us." These adages may be more than just metaphors. A study published in January in *Psychological Science* suggests that thinking of space may be a necessity to conceptualize time. When people's minds are not able to accurately understand space, researchers found, they have difficulty with time as well.

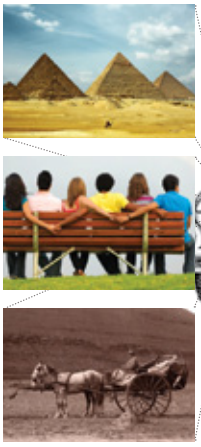
People with a condition called left hemispatial neglect ignore the left side of space—not remembering the left half of a scene or even not eating off the left half of their plate—after an injury or stroke in their brain's right inferior parietal lobe. In the new study, researchers investigated these patients' understanding of time. Because people who speak languages written left to right, such as English or French, tend to think of timelines with the past to the left and the future to the right, the team focused on how left hemispatial neglect might alter the left side of their mental chronology—that is, their thinking about the past.

Seven French speakers with hemispatial neglect, seven stroke patients without neglect and seven healthy people participated in a simple memory study. They learned facts about a fictional 40-year-old man named David—some of which were true of him 10 years in the past and some of which would be true 10 years in the future. They were then asked to remember as many of the facts as they could and to say whether they were true of David at age 30 or age 50. Sure enough, the people who have hemispatial neglect were worse than the others at remembering facts from the past—but not from the future.

When patients with this type of brain damage draw a face, says psychologist Lera Boroditsky of the University of California, San Diego, who led the study, they might depict only the right eye and ear, or they might cluster all the face's features on the right side. With memory, she notes, "we see a mix of those: to some extent, people weren't good at remembering things that were associated with the past, and the other error people made was misremembering things that were associated with the past as though they were associated with the future."

When someone's internal understanding of space is thrown off, it seems, their corresponding ordering of time is disrupted. Boroditsky is planning to repeat the study with Hebrew or Arabic speakers, who read—and plot timelines—from right to left, to see if they neglect the future instead of the past.

—Valerie Ross



Same Place, Same Time

Physical and emotional distance overlap in the brain

Time, space and social relationships share a common language of distance: we speak of faraway places, close friends and the remote past. Maybe that is because all three share common patterns of brain activity, according to a January study in the *Journal of Neuroscience*.

Curious to understand why the distance metaphor works across conceptual domains, Dartmouth College psychologists used functional MRI scans to analyze the brains of 15 people as they viewed pictures of household objects taken at near or far distances, looked at photographs of friends or acquaintances, and read phrases such as "in a few seconds" or "a year from now." Patterns of activity in the right inferior parietal lobule, a region thought to handle distance information, robustly predicted whether a participant was thinking about near versus far in any of the categories—indicating that certain aspects of time, space and relationships are all processed in a similar way in the brain. The results, the researchers say, suggest that higher-order brain functions are organized more around computations such as near versus far than conceptual domains such as time or social relationships.

—Nathan Collins

ISTOCKPHOTO

M An injector for an opioid antidote gained FDA approval, allowing for swifter treatment of overdoses. The device resembles an EpiPen. | The

Small Animals Live in a Slow-Motion World

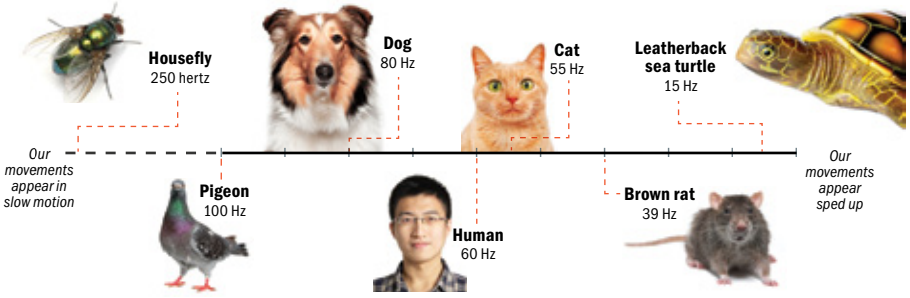
Time seems to pass more slowly for lighter animals with faster metabolisms

One "dog year" supposedly equals seven human years. But does one year *feel* like seven years to a dog? Evidence suggests that distinct species do indeed experience passing time on different scales. A recent study in *Animal Behavior* reveals that body mass and metabolic rate determine how animals of different species perceive time.

Time perception depends on how rapidly an animal's nervous system processes sensory information. To test this ability, researchers show animals a rapidly flashing light. If the light flashes quickly enough, animals (and humans) perceive it as a solid, unblinking light. The animal's behavior or its brain activity, as measured by electrodes, reveals the highest frequency at which each species perceives the light as flashing. Animals that can detect the blinking at higher frequencies are perceiving time at a finer resolution. In other words, movements and events will appear to unfold more slowly to them—think slow-motion bullet dodging in an action movie.

The scientists who ran the new study gathered data from previous experiments on the rate at which visual information is processed in 34 vertebrates, including lizards, birds, fish and mammals. The scientists hypothesized that the ability to detect incoming sights at a high rate would be advantageous for animals that must perform the equivalent of bullet dodging—responding to visual stimuli very quickly to catch elusive prey or escape predators, for instance. These animals tend to be lighter and have faster metabolisms. The data bore out the hypothesis: species that perceived time at the finest resolutions tended to be smaller and have faster metabolisms.

These findings show that differences in how a mouse and an elephant sense time are not arbitrary but rather are finely tuned by interactions with their surroundings. A link between time perception, body structure and physiology suggests that different nervous systems have developed to balance pressures from the natural environment with energy conservation. Rapid perception might be essential for a hawk but would waste a whale's precious energy. As for Fido, a year really does seem longer to him than it does to you, but probably not by a factor of seven. Dogs can take in visual information at least 25 percent faster than humans—just enough to make a television show look like a series of flickering images. *—Emilie Reas*



TIME FLIES (BUT NOT IF YOU'RE A FLY) **To a fly, an incoming swat appears to move in slow motion (as many would-be bug killers have suspected all along). That's because flies process about four times more visual information per second than humans do—they see 250 frames per second to our 60.**

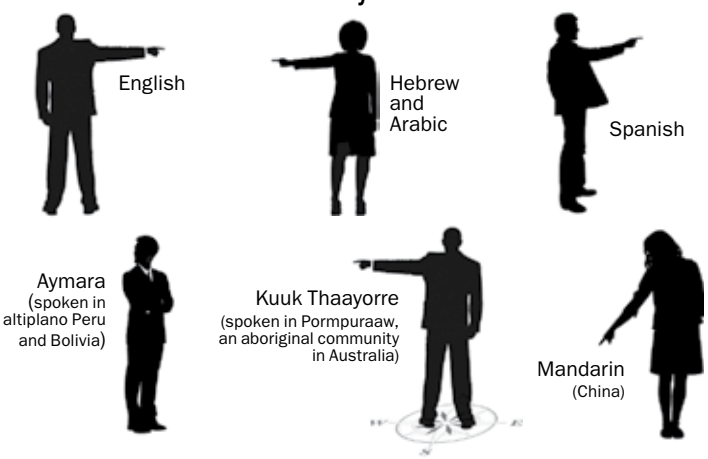
ISTOCKPHOTO

A Blue Minute

Depressed people gauge time more accurately

Time zips by when you're having fun and passes slowly when you're not—except when you are depressed, in which case your time-gauging abilities are pretty accurate. Reporting in *PLOS ONE*, researchers in England and Ireland asked 39 students—18 with mild depression—to estimate the duration of tones lasting between two and 65 seconds and to produce tones of specified lengths of time. Happier students overestimated intervals by 16 percent and produced tones that were short by 13 percent, compared with depressed students' 3 percent underestimation and 8 percent overproduction. The results suggest that depressive realism, a phenomenon in which depressed people perceive themselves more accurately (and less positively) than typical individuals, may extend to aspects of thought beyond self-perception—in this case, time. They speculate that mindfulness treatments may be effective for depression, partly because they help depressed people focus on the moment, rather than its passing. *—Nathan Collins*

Which Way Is Tomorrow?



Speakers of different languages envision the future unfolding in different directions.

National Institute of Mental Health is shaking up the methods of psychiatric drug trials, calling the current system "an incredible waste of money."

Acupuncture for Depression

The alternative practice may be able to replace medication or alleviate its side effects

A growing number of people are seeking alternatives to antidepressant medications, and new research suggests that acupuncture could be a promising option. One new study found the traditional Chinese practice to be as effective as antidepressants, and a different study found that acupuncture may help treat the medications' side effects.

In acupuncture, a practitioner inserts needles into the skin at points of the body thought to correspond with specific organs (*right*). Western research suggests the needles may activate natural painkillers in the brain; in traditional Chinese medicine, the process is believed to improve functioning by correcting energy blocks or imbalances in the organs.

A study published last fall in the *Journal of Alternative and Complementary Medicine* found that electroacupuncture—in which a mild electric current is transmitted through the needles—was just as effective as fluoxetine (the generic name of Prozac) in reducing symptoms of depression. For six weeks, patients underwent either electroacupuncture five times weekly or a standard daily dose of fluoxetine. The researchers, the majority of whom specialize in traditional Chinese medicine, assessed participants' symptoms every two weeks and tracked their levels of glial cell line–derived neurotrophic factor (GDNF), a neuroprotective protein. Previous studies have found lower amounts of GDNF among patients with major depressive disorder, and in other research levels of the protein rose after treatment with antidepressant medication.

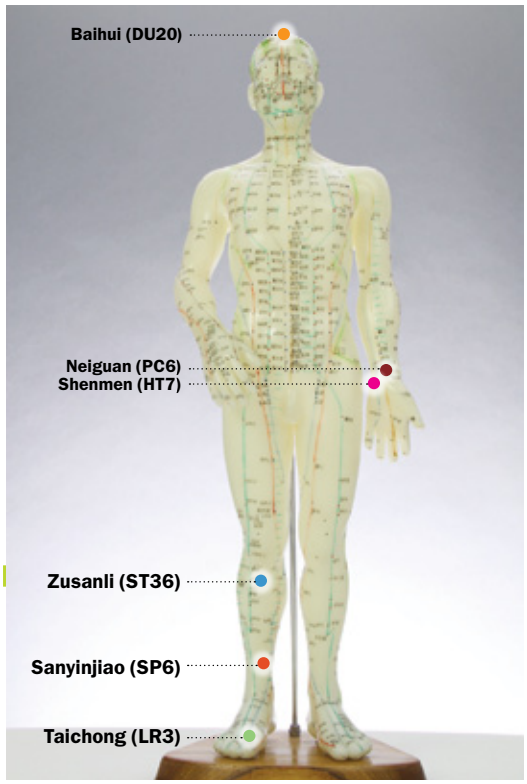
After six weeks, both groups showed a similar improvement in symptoms, and both treatments restored GDNF to a normal concentration. But the acupuncture began to work faster, reducing symptoms more dramatically at weeks two and four than the drug did. Among the patients who got better, a higher percentage of the acupuncture recipients showed "great improvement."

Another study suggests that acupuncture may help with one particularly difficult aspect of depression treatment: the sexual side effects of some medications. Twelve weeks of acupuncture helped both men and women with several aspects of sexual functioning, according to the work, also in the *Journal of Alternative and Complementary Medicine.* These findings add to a growing body of research suggesting acupuncture may be useful for a variety of ailments, including chronic pain, anxiety and nausea.

—Tori Rodriguez

Contentious Points

Most acupuncture points fall near major nerves. The six shown below were used in the study that found acupuncture to be as effective as Prozac for depression. Other research has also focused on these points, but evidence for their effect on health is mixed.



SCIENCE SOURCE

... But Will the Results Hold Up?

Strong studies should include a convincing control group, account for the placebo effect and be properly blinded so that neither the clinicians nor the participants know whether they are taking part in real or sham treatment. The results should also be successfully replicated in labs at numerous locations. Acupuncture researchers have struggled to comply for several reasons.

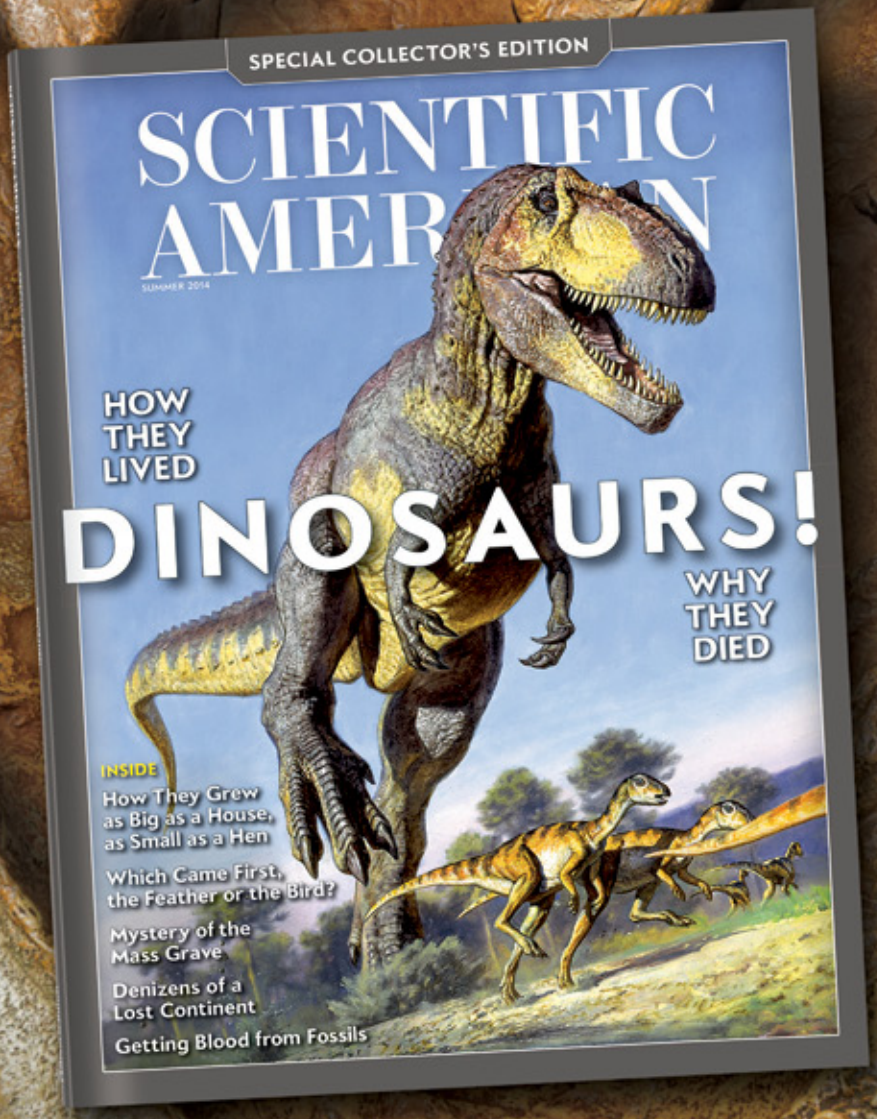
Placebo effect: One major hurdle is crafting a good fake acupuncture technique to act as a control condition. The first study described above did not attempt to use a true control, so it is impossible to know whether the needle placement, the electric current or some other aspect of the treatment accounted for the results. Further, acupuncture is associated with a robust placebo effect—simply being seen and touched by a practitioner makes most people feel significantly better, which could make acupuncture seem more effective than it really is. On the flip side, this large placebo component can overshadow a small but real difference between the treatment and placebo groups, potentially masking acupuncture's true usefulness.

Blinding: Another concern is the difficulty in creating a double-blinded experiment. Observers and participants alike can skew the results when they know whether they are participating in a real treatment rather than a sham procedure. The acupuncturist involved would almost certainly know whether he or she is engaged in the real thing, and that knowledge could subtly alter the acupuncturist's behavior. The first study above was partially blinded, in that the doctors who evaluated the patients' symptoms did not know what treatment they had received.

Reporting bias: Several studies have shown a systematic bias in the medical literature. When researchers reviewed randomized controlled trials performed in China, Japan, Russia and Taiwan, they found that these studies almost always showed positive results for acupuncture. Studies in the rest of the world were much more likely to find no benefit. The bias is further compounded by the "file drawer problem," or the tendency to publish positive results but confine negative or inconclusive findings to the so-called file drawer. Overall the evidence for acupuncture's effectiveness has been ambiguous or outright contradictory, and most results have been difficult to reproduce.

—Victoria Stern

M Mental toughness is that one special ingredient that can push you past the competition. | Being bad at video games increases aggression.



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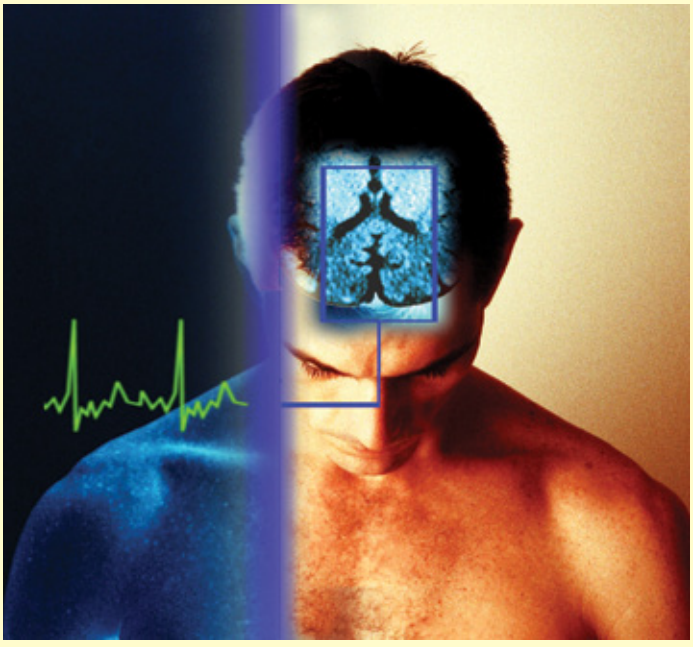
SCIENTIFIC AMERICAN™

Awakening an Unconscious Mind

Mild electrical stimulation might help brain-damaged patients communicate



One of the most frustrating and mysterious medical conditions affecting the mind is impaired consciousness, as can occur with brain damage. Patients in a coma or a vegetative or minimally conscious state sometimes spontaneously recover to varying degrees, but in most cases there is little that doctors can do to help. Now a rigorous study by a group at Liège University Hospital Center in Belgium has found that a simple treatment called transcranial direct-current stimulation (tDCS) can temporarily raise awareness in minimally conscious patients.

In tDCS, electrodes are glued to the scalp, and a weak electric current is passed through them to stimulate the underlying brain tissue. Scientists led by neurologist Steven Laureys applied the electric current for 20 minutes to patients' left prefrontal cortex, an area known to be involved in attentiveness and working memory. Afterward, the effects on consciousness were measured by doctors who did not know whether the patient had received real tDCS or a sham treatment, in which the apparatus ran, but no current was delivered.

For patients in a vegetative state, who display no communication or purposeful behavior, the stimulation might have led to improvement in two patients, but no statistically compelling evidence emerged. Yet 13 of 30 patients in a minimally conscious state—defined by occasional moments of low-level awareness—showed measurable gains in their responses to questions and sensory stimuli. Some had only recently been injured, but others had been minimally conscious for months.

The improvements lasted just a few minutes, but researchers are encouraged—the tDCS apparatus is inexpensive, easy to use, safe and lacking in side effects. Laureys is planning new studies to see if the stimulation can be configured to spur a more lasting recovery. Even if the effects remain temporary, the ability to trigger a brief period of awareness could be invaluable, perhaps allowing patients to communicate in a meaningful way with their loved ones. —*William Skaggs*

Sugar May Harm Brain Health

High levels of blood glucose are linked to memory impairments

A poor diet can eat away at brain health. Now a study in *Neurology* helps elucidate why. It suggests that eating a lot of sugar or other carbohydrates can be hazardous to both brain structure and function.

Diabetes, which is characterized by chronically high levels of blood glucose, has been linked to an elevated risk of dementia and a smaller hippocampus, a brain region critical for memory. The new study sought to identify whether glucose had an effect on memory even in people without the disease because having it could induce other brain changes that confound the data. In the experiment, researchers at the Charité University Medical Center in Berlin evaluated both short- and long-term glucose markers in 141 healthy, nondiabetic older adults. The participants performed a memory test and underwent imaging to assess the structure of their hippocampus.

Higher levels on both glucose measures were associated with worse memory, as well as a smaller hippocampus and compromised hippocampal structure. The researchers also found that the structural changes partially accounted for the statistical link between glucose and memory. According to study co-author Agnes Flöel, a neurologist at Charité, the results "provide further evidence that glucose might directly contribute to hippocampal atrophy," but she cautions that their data cannot establish a causal relation between sugar and brain health.

These findings indicate that even in the absence of diabetes or glucose intolerance, higher blood sugar may harm the brain and disrupt memory function. Future research will need to characterize how glucose exerts these effects and whether dietary or lifestyle interventions might reverse such pathological changes.

—*Emilie Reas*

SCIENCE SOURCE (*EEG*); THINKSTOCK (*popsicle brain*)

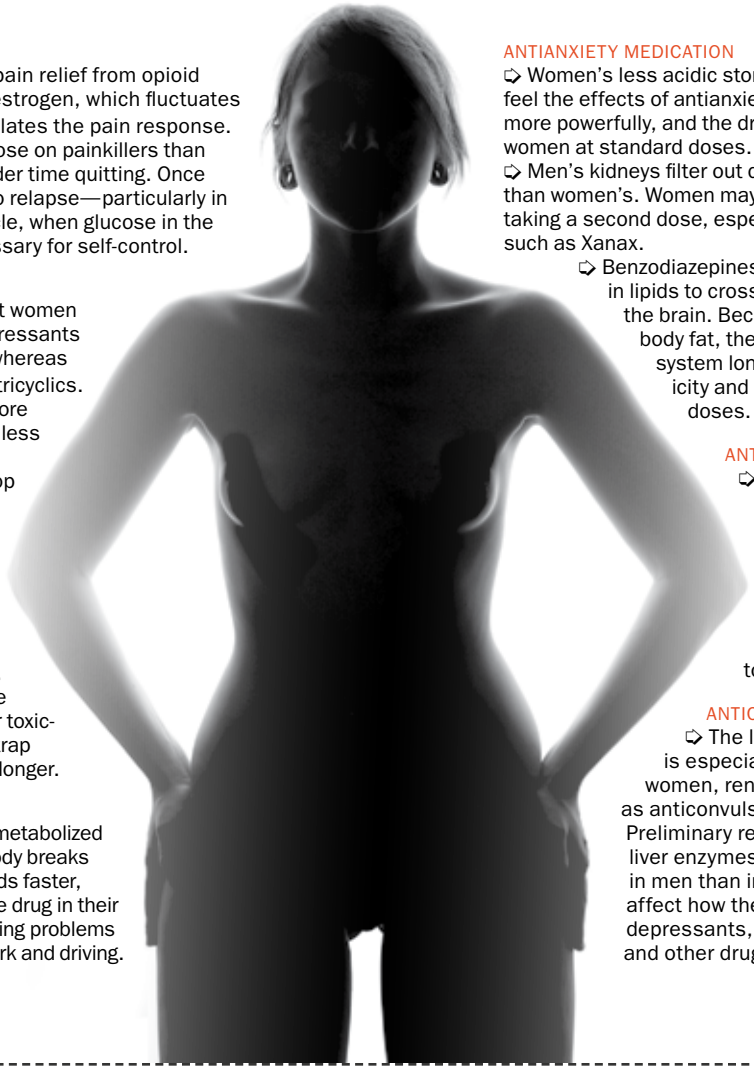
M Autism prevalence has increased to one in 68 kids, up from one in 88 two years ago. | Prions, the misfolded proteins of "mad cow disease,"

GENDERED MEDICINE

Psychotropic drugs affect men and women differently, in mostly unknown ways

Sex differences in the body's response to medication have long been overlooked. In fact, until the 1990s women were banned from participating in clinical trials in the U.S. Yet women are now almost twice as likely to be prescribed psychotropic medication as men, and research suggests that their different hormones, body composition and metabolism may make them more sensitive to certain drugs. Further, women are between 50 and 75 percent more likely to experience side effects. Last year the U.S. Food and Drug Administration announced the first sex-specific dosing guidelines for a psychopharmaceutical drug: the sleep medicine Ambien was discovered to be doubly potent for women. Here are a few of the medications that are known to act differently in men and women—but research is just beginning.

—Roni Jacobson



PRESCRIPTION PAINKILLERS

➪ Women experience greater pain relief from opioid painkillers, perhaps because estrogen, which fluctuates during menstrual cycles, modulates the pain response.
➪ Men are more likely to overdose on painkillers than women. But women have a harder time quitting. Once addicted, they are more likely to relapse—particularly in the middle of the menstrual cycle, when glucose in the brain is lower. Glucose is necessary for self-control.

ANTIDEPRESSANTS

➪ Multiple studies suggest that women respond better to SSRI antidepressants than men (particularly Zoloft), whereas men may have better luck with tricyclics.
➪ Some antidepressants are more potent for women. Women have less binding capacity in their blood, meaning their blood proteins mop up fewer foreign substances. If taken with other drugs, certain tricyclic antidepressants (such as amitriptyline) could overflow into the bloodstream, potentially causing more side effects. Further, women's stomachs are less acidic than men's, so SSRIs may be absorbed more quickly, which can increase their toxicity. Women's body fat may also trap antidepressants in the body for longer.

SLEEP AIDS

➪ Most psychotropic drugs are metabolized in the liver. Because the male body breaks down Ambien and other sleep aids faster, women typically have more of the drug in their system the next morning—creating problems when they have to be alert for work and driving.

ANTIANXIETY MEDICATION

➪ Women's less acidic stomachs may cause them to feel the effects of antianxiety medication faster and more powerfully, and the drugs could be more toxic to women at standard doses.
➪ Men's kidneys filter out drug compounds faster than women's. Women may need to wait longer before taking a second dose, especially of benzodiazepines such as Xanax.
➪ Benzodiazepines are designed to dissolve in lipids to cross from the bloodstream into the brain. Because women have more body fat, the drugs can linger in their system longer, potentially causing toxicity and side effects at lower doses.

ANTIPSYCHOTICS

➪ First generation, or "typical," antipsychotics such as haloperidol seem to be more effective for managing hallucinations and delusions in women than in men, who require higher doses to improve their symptoms.

ANTICONVULSANTS AND MORE

➪ The liver enzyme CY P3A4 is especially active in young women, rendering some drugs—such as anticonvulsants—less effective. Preliminary research suggests several liver enzymes work at different speeds in men than in women, which might affect how the body responds to antidepressants, anxiolytics, painkillers and other drugs.

ISTOCKPHOTO (*woman and pills icon*)

TESTING BIAS

From animal studies to clinical trials, drugs are often tested on males only. Yet eight out of 10 drugs pulled from the market by the FDA between 1997 and 2001 posed greater health risks for women than men, according to a government report. This testing bias can be unwitting or intentional—many clinical trials exclude women because their different hormones are considered a "confounding variable." Pregnant women also typically do not take part in clinical trials for safety reasons, but mounting evidence suggests that their hormonal changes can alter the effects of certain drugs. For example, a study last year found that pregnant women with bipolar disorder require higher doses of the drug Lamictal to control their depression. In addition, medications taken only by women, such as birth-control pills, may interact with psychotropic medications with unknown consequences. The FDA recently announced that it would step up its effort to account for sex differences in clinical trials.

might help clinicians detect Alzheimer's early. | Your brain might reset itself with occasional "avalanches" of disordered neuronal activity.

A GUIDE TO MASTERING YOUR WORLD

How to Be a Better traveler

Before we had kids, my husband and I loved to travel—he proposed to me on a bench in Reykjavik after a road trip across southern Iceland, and we spent our first anniversary jumping into natural freshwater pools on the Mexican Riviera. Our last big trip was more than two years ago, when we attempted to enjoy a small island in the Bahamas with a teething seven-month-old. (D'oh!) Now, as the parents of two young girls, travel mostly seems like more trouble than it's worth—and the inherent risks we used to accept without thinking, such as the possibility of a plane crash, seem stark now that children are involved. Sometimes I don't know if I'll ever have the guts to go anywhere cool again. But I want to, and I want to teach my kids how enriching and fun it can be to visit somewhere totally new. With any luck, these mind hacks from psychologists and travel experts can help me—and anyone else anxious about leaving their comfort zone—become a better traveler.

#1 Lean into the stress. Anyone who says travel isn't stressful is lying. Crowds, lines, delays and miscommunications are rampant—and that's before your plane lifts off. "Travel stress is normal," says psychologist Jonathan Bricker of the University of Washington, who has studied people's reactions to tension during travel. "The key is what to do when you have it. Most people either get angry or try to avoid it." But feeling irate or attempting to avoid stress usually backfires and leads to more stress—or to a tendency to avoid travel altogether, according to his research. The alternative? "Acceptance! The willingness to just let the stress be there, to just notice it, to let it come and go on its own," Bricker says. Mindful acceptance is a proven tactic for stress reduction—the difficult parts of your trip will be over before you know it, and you'll be on your way.

#2 Talk to anyone and everyone. Being out of our element and immersed in a foreign culture can be tough for those of us who like security and routine. "What makes us most uncomfortable in another culture is our lack of understanding of it," says Michael Brein, a travel psychologist based near Seattle who has analyzed more than 1,600 people's travel tales. "But the more I can get to know what the culture is all about, often by talking to people, the more comfortable I'm going to feel." Doing so releases us to just enjoy and take things in, anxiety-free. "Some of the best travel experiences I've ever had have just been the people I've interacted with overseas, like in cafes or shops. As I talked to them and came to understand the quirks of the culture, then I began to have more interpersonally rewarding experiences." You can also use these conversations to step outside the security blanket of your guidebook, he says. Discovering unpublished gems, such as locals' favorite restaurants or day trips, can lead to the most memorable adventures.

#3 Channel your younger self. What would you think if a new friend you met in a poverty-stricken country with no diplomatic ties to the U.S. asked you and your traveling partner to come back to his aunt's house for dinner? Me, today: "Food poisoning! Getting lost in a 'bad' neighborhood. Kidnapping, maybe!" Me, at age 24: "I would be honored—what bus do we take?" To this day, eating homemade *arroz con pollo* and drinking a mysterious, unlabeled mint liquor in that family's living room in central Havana is a peak experience of my life. "The younger person is more adaptable and learns better," Brein says. "When we're younger, we're willing to take more risks—and because of all we learn by doing that, the outcome of a travel experience can be so much more special." When an exciting but slightly scary opportunity arises during travel, Brein observes, just try channeling your younger self for a moment. Taking a risk—within reason—can mean the difference between a trip you remember until the day you die and one that fades away the moment you get back home.

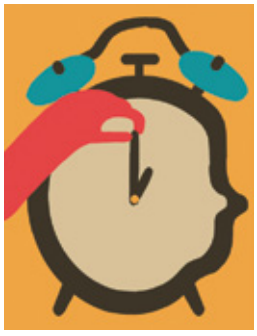
#4 Practice closer to home. No matter how much I channel my post-college self, I know I'm nowhere near ready to drag my kids onto a hot, sweaty bus in Havana. So what can I do to slowly but surely build my confident-traveler muscle? "Take a staycation near your town and just do some new and different things. Walk into mom-and-pop shops and talk to the owners like you would if you were abroad, sit in coffee shops and interact with patrons," Brein says. "If you do some of these around town or on short trips, you'll begin to feel the good, positive consequences of taking a little bit more of a chance." Okay, so maybe our next family trip won't be turtle-egg watching in Akumal, but I have a feeling that overnight camping an hour away from home will be plenty exciting—and perhaps set the stage for bigger trips to come. —*Sunny Sea Gold*

PAUL PANTAZESCU (*Stockphoto (globe icon)*; MÁGOZ (*illustrations*)

M A new app, called Entrain, aims to help you overcome jet lag faster by calculating the ideal sleep schedule for your particular trip. |

Future Drugs for Jet Lag

Molecular clues may reveal how to instantly reset the brain's clock



Jet lag is a pain. Besides the inconvenience and frustration of traveling more than a few time zones, jet lag likely causes billions of dollars in economic losses. The most effective treatment, according to much research, is structured exposure to light, although the drug melatonin may also sometimes be helpful at bedtime.

Both approaches have been used for more than 20 years, and during that time no viable new interventions have appeared. Recently, however, research into the molecular biology of circadian rhythms has raised the prospect of developing new drugs that might produce better results.

Jet lag occurs when the "biological clock" in the brain becomes misaligned with the local rhythm of daily activity. The ultimate goal of circadian medicine is a treatment that instantly resets the brain's clock. Failing that, it would be helpful to have treatments that speed the rate of adjustment. Four recent discoveries suggest new possibilities.

The first involves vasopressin, which is the main chemical signal used to synchronize cellular rhythms of activity in the brain area that is responsible for our biological clock. Blocking vasopressin makes it much easier to reset this clock. Potentially, a drug that interferes with vasopressin could work as a fast-acting treatment for jet lag.

The second and third possibilities involve a pair of brain chemicals called salt-inducible kinase 1 (SIK1) and casein kinase 1ϵ (CK1ϵ), both of which limit the ability of light to reset the brain's clock. Drugs already exist that interfere with their action and greatly increase the effectiveness of light exposure. The existing drugs are not viable jet-lag treatments, because they are hard to administer and have unpleasant side effects, but researchers hope better drugs can be developed that work in a similar way.

The strongest possibility in the near term involves the neurotransmitter serotonin. In addition to its well-known roles in mood and motivation, serotonin operates inside the brain's clock. Evidence from small studies suggests that several drugs that act on the serotonin system can speed up recovery from jet lag, including 5-HTP, the metabolic precursor for serotonin, which is widely available as a "nutritional supplement." Scientists have not yet run a gold standard clinical trial to test the supplement's effectiveness, however.

Research on circadian biology is moving at such a rapid pace that other possibilities will surely emerge in the near future. Travelers can start looking forward to reclaiming the first days of their trips.

—William Skaggs

THINKSTOCK (*shopper*)

The Psychology of Trip Planning

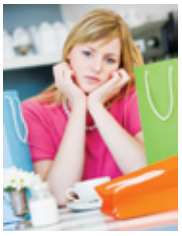
Research reveals the types of vacations that give the biggest mental boost

- **Rural is restorative.** In one study, people generally rated rural settings as providing the best environment for relieving stress and enhancing mood.
- **A weekend is long enough.** The aftereffects may not last long, but research shows that an impromptu short vacation can improve psychological well-being in the moment.
- **Activity is encouraged.** People who spent more time engaging in physical activity on a winter vacation or weekend getaway reported significantly greater satisfaction.
- **Planning is half the fun.** Some studies show that people derive the most vacation-related pleasure from organizing their trip. So if money is tight, try planning a staycation—mapping out fun new things to do in your hometown may deliver a similar jolt of happiness.

—Victoria Stern

How to Let Go of Materialism

Enhance your well-being by focusing on deeper goals



Money can't buy happiness, but placing less value on the things it *can* buy may improve your mental health. The longest ever study on this topic finds that becoming less materialistic leads to more contentment in life—and suggests ways to get to that happy place.

Four related experiments investigated how changes in materialism affect well-being. The first three studies surveyed natural changes in materialistic values over six months, two years and 12 years in adults in the U.S. and Iceland. At all three junctures, a decreasing focus on acquiring money and things led to more joy and contentment in life.

Fortunately, materialism can be purposefully altered, as the team discovered in the fourth study—the first ever to use a randomized, controlled design to try to change materialistic beliefs. A group of adolescents from the U.S. joined a program designed to lessen the value they place on materialistic goals, whereas a control group did not receive the intervention. In three sessions lasting three hours each, participants were taught about consumer culture. They were also encouraged to clarify their intrinsic values (such as self-growth, closeness with friends and family, and contributing to the community) and to make financial decisions based on those values.

Adolescents who were in the course—but not in the control group—became less materialistic and had higher self-esteem over the next several months. "Intrinsic goals tend to be ones that promote greater well-being and act as a kind of 'antidote' to materialistic values," says Tim Kasser, one of the study's authors and a psychology professor at Knox College.

An important component of the program was that participants went through it with their parents and other adolescents, so they had a lot of social support in changing their values. "It is important to find some like-minded folks who want to join you in shifting away from materialism—they are out there, I promise," Kasser says. *—Tori Rodriguez*

Tenacious students view setbacks as an opportunity to learn. When studying, they seek to master material rather than outcompete other students.

Rethink Your Thoughts about Thinking

Targeting metacognition—our beliefs about thoughts—might alleviate mood disorders and even schizophrenia

ISTOCKPHOTO (*figure and thought bubble*)

Your beliefs about the way you think can shape your life in surprising ways. A spate of recent findings suggest that targeting such metacognition can help relieve mood and anxiety disorders, and it may even reduce symptoms of psychosis.

Metacognition often takes the form of a value judgment about one's thoughts, such as "It's bad that I overanalyze everything." Research has shown that these metacognitive beliefs can play an important role in obsessive-compulsive disorder, depression and generalized anxiety disorder, among others. In particular, they may matter more than the way we frame situations in our mind, such as by focusing on the negative aspects of a life event. That framing, called cognitive appraisal, is typically addressed in psychotherapy, but metacognition is not, perhaps to the patient's detriment, explains psychologist Jennifer L. Hudson of Macquarie University in Australia. A study published last fall in the *Journal of Clinical Child & Adolescent Psychology* found that among 83 children, those with anxiety disorders held more negative beliefs ("Worrying might make me go crazy") and positive beliefs ("Worrying helps me feel better") about worry than the nonanxious children. "We think that these beliefs might play a causal, or at least a maintaining, role in the anxiety disorders," says Hudson, a co-author of the study.

Metacognitive therapy can successfully treat mood and anxiety disorders, according to a growing body of research. Developed in 2008 by Adrian Wells, a clinical psychologist at the University of Manchester in England, the therapy teaches patients to recognize and reframe metacognitive thoughts that reinforce unhelpful coping mechanisms, such as "my fretting is uncontrollable," much in the same way cognitive-behavior therapy (CBT) targets maladaptive beliefs along the lines of "the world is unsafe." The technique also helps people become more flexible in the way they think about their thoughts, instead of defaulting to rumination, for example.

One small study published last year in the *Japanese Journal of Personality* examined whether metacognitive therapy could reduce depressive rumination by disproving positive beliefs about this style of thinking, such as "rumination increases insight into situations." Twelve undergraduate students with high rumination scores were randomly assigned to an intervention group for two weeks, and 11 others were assigned to a no-treatment control group. The technique reduced the students' tendency to dwell on their negative thoughts.

More surprisingly, a small study from the June issue of the *Journal of Behavior Therapy and Experimental Psychiatry* found that metacognitive therapy reduced symptoms of psychosis. Citing the mixed results yielded by studies of CBT in treating psychotic disorders, researchers gave 10 patients with schizophrenia spectrum disorders up to 12 sessions of metacognitive therapy over a nine-month period. At the end of treatment, five of the participants had at least a 25 percent decrease in symptoms. Four of the five maintained this improvement at follow-up three months later.

Although larger studies are needed, many clinicians and researchers are now beginning to believe treatment should go beyond addressing a patient's specific thoughts to illuminate the underlying beliefs that might be reinforcing them. "Metacognitive factors are crucial in determining the unhelpful thinking styles in psychological disorders," says Robin Bailey, a Ph.D. candidate at the University of Manchester and author of a recent paper showing that certain metacognitions are positively correlated with health anxiety. "How a person thinks may be more important than *what* a person thinks."

—Tori Rodriguez

M Girls who spent a few minutes playing with Barbie were more likely to see themselves in gender-typical careers than if they had played with

ON THE HORIZON

COCHLEAR IMPLANTS TO HEAR WITH LIGHT

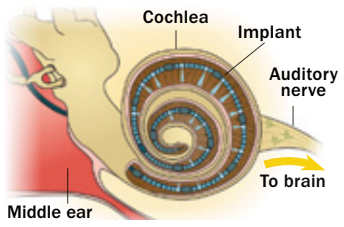
An orchestra crescendos, and deaf audience members hear every note, thanks to cochlear implants that translate the complex sounds into a rainbow of optical light. That is the vision of a team of scientists in Germany, Japan, South Korea and Singapore, who believe a device that uses optics instead of sound waves might birth a refined class of auditory prosthetics.

In people who can hear, spiral ganglion neurons in the inner ear allow for the precise discrimination of sound—we can recognize hundreds of people by the sound of their voice and distinguish between thousands of different pitches or frequencies of sound. In traditional cochlear implants the external microphone picks up sound and transmits it to these neurons via electrodes, but the resolution is very poor. The neurons are lined up like piano keys in our inner ear, and using electrodes to stimulate them is like playing a concerto with fists instead of fingers. The scientists think there is a better way.

In a study that appeared in March in the *Journal of Clinical Investigation,* the researchers used viruses to implant genes for light sensitivity into mouse embryos of a deaf lineage. The genes went to work in the auditory pathways of the mouse brains, creating light-sensitive patches on the membranes of their spiral ganglion neurons and other neurons. The scientists then directed LED light onto these neurons and recorded brain stem activity—an essential integration step in auditory processing.

The activity indicated the deaf mice successfully perceived the light as sound. Compared with stimulation from traditional cochlear implant electrodes, the light produced more precise neural activity in the brain stem, similar to normal hearing. The mice also exhibited a high level of sound discrimination that current prosthetics cannot achieve.

The team envisions that in the future, deaf people might benefit from gene therapy similar to the approaches currently being tested in clinical trials for other diseases. If they so choose, their cochleae could be altered to express these light-sensitive channels. A chain of LED lights could then be inserted in the ear, which would light up according to the qualities of an external sound, allowing auditory neurons to communicate its rich details to the brain. *—Abdul-Kareem Ahmed*



Next-generation cochlear implants may stimulate the inner ear's neurons by converting sound to light.

ISTOCKPHOTO (*sun icon, ear and starburst*); GETTY IMAGES (*skateboarder*); TOBIAS MOSER *InnerEarLab, University Medical Center Göttingen (implant)*

Learn Faster with Messy Moves

People whose movements are more variable pick up new motor skills more quickly

Whether learning to write, swing a golf club or play the violin, even the most good-natured students become frustrated by inevitable mistakes. Such off-target actions were thought to reflect neural noise in the parts of the brain controlling movement—something a good dose of practice would stamp out. But a new study, published January 12 in *Nature Neuroscience,* finds that these inconsistencies are not always obstacles to be overcome but rather key ingredients to learning.

Study participants learned to copy a displayed curved line without seeing what their hand was doing. Initially these lines were off the mark for everyone, but some people produced more erratic curves than others did. During training each curve was scored on how well it copied the target curve. All participants gradually produced more accurate curves over hundreds of trials, but those who started out with the most variability before training attained accurate curves more quickly than individuals who began with little irregularity. Another experiment bolstered this link: when researchers promoted variability in one aspect of a movement by applying a force field that pushed the participants' hand off target, they learned the motion faster.

Bigger fluctuations may reflect a brain exploring the full spectrum of possible actions, which would narrow in on accurate movements more quickly than a restricted search. Study author Maurice Smith, a neuroscientist at Harvard University, suggests profiling a person's range of movements after a stroke to aid their rehabilitation. "You could focus training on the types of tasks they are most likely to learn well, as predicted from their variability," he says. For the rest of us, the results mean we should try not to get frustrated with wild misses when we are learning a new activity. That clumsiness could be the key to quick improvement. *—Michele Solis*

Mrs. Potato Head. | A single loud—but not deafening—noise could permanently damage the nerves in your inner ear while leaving hair cells intact.

New Roles for Music

Many studies have found that familiar songs enhance mood, relieve stress and reduce anxiety in patients with Alzheimer's, perhaps because musical memory is often spared even when a patient has declined to a low level of cognition. Two new studies find that familiar music also improves cognitive symptoms in the disease.

Boosting Self-Awareness

Familiar music may be a safe and effective way to help patients with Alzheimer's become more self-conscious, which improves overall mental processing and leads to a more accurate examination of the world. In a study published in September 2013 by Eva M. Arroyo-Anlló of the University of Salamanca in Spain and her colleagues, patients listened to either familiar or unfamiliar music three times a week for three months. Those who heard tunes they knew showed an immediate improvement in identity, mood, moral judgment and body awareness—elements of self-consciousness that are adversely affected by Alzheimer's. Those who listened to unfamiliar music scored worse on all measures except body awareness.

The researchers also administered a common exam for dementia to test the patients' overall cognition. The group who heard familiar music sustained their scores over time, whereas the group who listened to unfamiliar music faltered significantly. According to the investigators, these findings are yet one more reason that caregivers should provide patients with music from their past. —*Duncan Van Horn*

Improving the Quality of Memories

One of the most devastating aspects of Alzheimer's is its effect on patients' ability to recall life events. Several studies have found that music helps to strengthen these individuals' autobiographical memories, and a paper in the November 2013 *Journal of Neurolinguistics* builds on these findings by exploring the linguistic quality of those recollections.

Researchers instructed 18 patients with Alzheimer's and 18 healthy control subjects to tell stories from their lives in a silent room or while listening to the music of their choice. Among the Alzheimer's patients, the music-cued stories contained a greater number of meaningful words, were more grammatically complex and conveyed more information per number of words. Music may enhance narrative memories because "music and language processing share a common neural basis," explains study co-author Mohamad El Haj of Lille University in France. —*Tori Rodriguez*

THANASIS ZOVOILIS *Getty Images (man with radio)*; SOURCE: "REST AND STRESS RESISTANCE IN AGEING AND ALZHEIMER'S DISEASE," BY TAO LU ET AL., IN *NATURE*, VOL. 507; MARCH 27, 2014 (*dementia protein*)

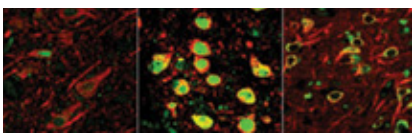
Protective Gene Staves Off Dementia

Activating the gene with drugs such as lithium could prevent or slow cognitive decline

More than five million people in the U.S. have Alzheimer's disease. Scientists at Harvard Medical School and their colleagues have made a breakthrough that could lead to a treatment for this currently incurable disease.

Much research on Alzheimer's has been directed at understanding the abnormally folded and entangled proteins in the brain that are key symptoms of the illness. Until now, though, scientists have been stumped to explain why many people with these anomalies do not develop the disease. A study published in March in *Nature* finds that a protein called REST helps the aging brain respond to stress and protects against cell death.

REST is a protein encoded by a regulator gene; it can suppress the expression of other genes. It was previously thought to be active in the brain only during fetal development, when REST oversees maturation of neural cells, becoming dormant soon after birth. Senior author Bruce Yankner, a professor of genetics and neurology at Harvard Medical School, explains that the surprising reactivation of REST in the mature brain came to his team's attention through the researchers' computer modeling of brain aging. They launched a study to better understand this protein. Through cell culture experiments, they determined that REST switches off genes that promote cell death and misfolded proteins.



The protective protein REST (*green*) is dormant in young adult brains (*left*), active in healthy older brains (*center*) and reduced in the brains of people with dementia (*right*).

Using mice, the team demonstrated that aged brains that lacked REST had much more cell death and inflammation in the hippocampus and forebrain, which is also observed in Alzheimer's. When the scientists looked at postmortem human brains, they found strong correlations between REST levels and memory function and longevity. They also observed that REST seemed to have a protective effect: the brains that had developed misfolded and tangled proteins but did not become demented had high levels of this protein.

The finding suggests exciting new possibilities for drug therapy, one of which is lithium. "Lithium very potently activates REST," Yankner says. The drug is already a well-established therapy for bipolar disorder. The dosage has to be low, however, to avoid side effects such as tremors, vomiting and kidney failure—which are even more dangerous in the elderly. "I caution anyone against taking lithium for dementia at this time because it's experimental and potentially toxic; however, it may be a prototype for better drugs," he says. And because REST works together with a number of other proteins, these proteins are also potential targets for treatment. —*Esther Hsieh*

M A stressful home environment can cause the ends of chromosomes to fray. | For full stories: ScientificAmerican.com/Mind/jul2014/stories

Posers and Fakers

Portrait photography traverses fact and fancy

> *There is no such thing as inaccuracy in a photograph. All photographs are accurate. None of them is the truth.* —Richard Avedon (1923–2004)

Portraiture as an art form strives to capture its subject's innermost nature. Therefore, a successful portrait may be more veridical, or truthful, than casual observation of the individual depicted. Although accurate representation is intrinsic to photography, the illusions featured in this article circumvent limitations that are skin deep. They dive for the heart of the matter. In that sense, these portraits are "the most magical of mirrors," as Oscar Wilde described the supernatural painting in his 1890 novel *The Picture of Dorian Gray*. Dorian Gray remains young and untouched while his portrait in his attic degrades to depict the character's true age and moral depravity. In Wilde's words, as the picture "had revealed to him his own body, so it would reveal to him his own soul."

The subjects portrayed in the following images are Dorian Gray's heirs. They are not merely likenesses but instead tell deeper stories about how easily looks can deceive. Some of these images present duplicitous doubles; others morph two beings into one. The only magic required here, however, is locked within your brain's visual and cognitive systems. Can you decide who the original is and who is the reflection? M

BY SUSANA MARTINEZ-CONDE AND STEPHEN L. MACKNIK

Susana Martinez-Conde and Stephen L. Macknik are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors of *Sleights of Mind,* with Sandra Blakeslee, which recently won the 2013 Prisma Prize for Best Book of the Year (http://sleightsofmind.com). Their forthcoming book, *Champions of Illusion,* will be published by Scientific American/Farrar, Straus and Giroux.

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LOOK-ALIKE SOLUTION: *The first photograph from the left on the bottom row features the real twin pair.*

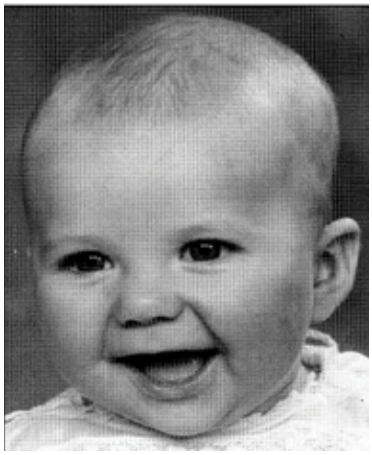
THE LOOK-ALIKE PROJECT

Susana's grandmother used to say that every person has a doppelgänger, a genetically unrelated twin living elsewhere on the planet, whom most people never get to meet. Canadian photographer François Brunelle has set out to immortalize such accidental pairings in an international exhibit featuring 200 unconnected couples. When Susana learned about Brunelle's project, entitled *I'm Not a Look-Alike!,* she thought immediately of her graduate student Francisco Costela and his buddy Joshua Corrigan, pictured in the photograph on the top row, at the far left. Fran (*left*) and Josh (*right*) met at St. Joseph's Hospital and Medical Center in Phoenix, where they still cross paths, and became fast friends. They are not related—Fran is a Spaniard, and Josh is an American—but the similarities are uncanny. Even their glasses are identical (entirely coincidental, they say). Fran and Josh's stunning resemblance produces double takes among their friends and colleagues on an almost daily basis.

We encouraged Fran and Josh to contact Brunelle and were tickled to learn that the photographer was not only excited to feature the two of them in his project, but he had also selected the pair to participate in an *Inside Edition* TV special about Brunelle's look-alikes. Here we have lined up five sets of Brunelle's accidental "twins," including Fran and Josh, with a true set of twins. See if you can spot the genuine identical pair.

FRANÇOIS BRUNELLE (*doppelgängers*); RON LEVINE *Getty Images* (*twins*); SEAN McCABE (*Martinez-Conde and Macknik*)

BABY FACES



Changes from photo to sketch:
- Ear and head outlines are broader
- Baby's eyes are set farther apart
- Nostrils appear slightly angled

Could an artist's portrait, like Wilde's fictional painting, capture a resemblance more accurately than a photograph? Canadian artist Heather Spears, who resides in Denmark, thinks so. Spears has spent many years sketching premature and other threatened babies in neonatal intensive care units.

While creating portraits of these and other infants, Spears identified a curious phenomenon. She found that when she strove to copy the photograph (*left*) of a child exactly, she was unsatisfied with the results. "When I instinctively broadened it—trying to 'get' a likeness—it did [resemble the infant]," Spears says. Parents generally agree that the enhanced depictions (*right*) seem most correct.

Spears attributes the success of these portraits to envisioning the baby as though she were looking at the child with two eyes and at very close range rather than through a camera lens. Another reason might be that viewers approach photographs and line drawings differently. Our perception readily adjusts for illumination and shadow when looking at a photograph but not when observing the crisp boundaries in contour drawings. Spears's distortion approximates the outcome of our neuronal processes when we view someone in person. In addition, the final depiction softens features in a flattering way that may feel more true to the parents' memories than the original picture.

THE REAL MACAW

This picture of a parrot is more than it initially appears to be. Italian artist Johannes Stötter enjoys transforming his human models into unexpected natural subjects, such as autumn leaves and tree frogs.

For this colorful metamorphosis, he spent four hours covering a woman with breathable paint to transform her into a scarlet macaw. The quirky fusion of painting and photography produces a kind of double portrait, first of the bird and second of the model. The effect is an ambiguous illusion, in which neuronal responses in our visual system flip back and forth between the two interpretations of the same physical stimulus.

In the preface to *Dorian Gray,* Wilde writes: "All art is at once surface and symbol. Those who go beneath the surface do so at their peril." Perhaps spotting the hidden image in this photograph is not perilous, but Wilde may still have enjoyed the way this piece playfully leads the viewer to identify a human figure, challenging quick or superficial assessments.

HEATHER SPEARS (*babies*); JOHANNES STÖTTER (*parrot*)

THE APPLE DOESN'T FALL FAR FROM THE TREE

Unlike Dorian Gray, the subjects in Quebec-based photographer Ulric Collette's *Portraits Génétiques* (*Genetic Portraits*) cannot escape the aging process or their biological destiny. The series explores the genetic similarities of family members by stitching together half-face composites of a parent and child or other family pairs, such as this mother, Julie, then age 61, and her daughter, Isabelle, then 32.

The resulting amalgam is a remarkable study of genetic fate. Known as good continuation, this perceptual phenomenon, in which we tend to perceive contiguous lines as one smooth contour, causes some viewers to see the joined portraits as one individual at two different points in his or her life span.

ULRIC COLLETTE (*genetic portrait*); ANDREW DIXON (*before and after*)

BEFORE AND AFTER

Personal trainer Andrew Dixon had been irritated by the unrealistic promises of the before and after images featured in many weight-loss marketing campaigns. So he decided to take his own pictures and see what he could accomplish with "just a few easy tweaks." In a post on the Huffington Post, Dixon explained that he chose a day when he felt especially bloated for his photo shoot. "I then shaved my head, face and chest," he wrote. "I did a few push-ups and chin-ups, tweaked my bedroom lighting, sucked in, tightened my abs and BOOM! We got our after shot." The photographs here document his full conversion from couch potato (*far left*) to totally toned (*far right*). The transformation took just one hour. Dixon's posturing brings to mind Wilde's quip in *Dorian Gray:* "Being natural is simply a pose." It is all too easy to manufacture the perfect portrait.

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- **The Creative Eye.** Heather Spears. Marion Heather Spears, 2013.
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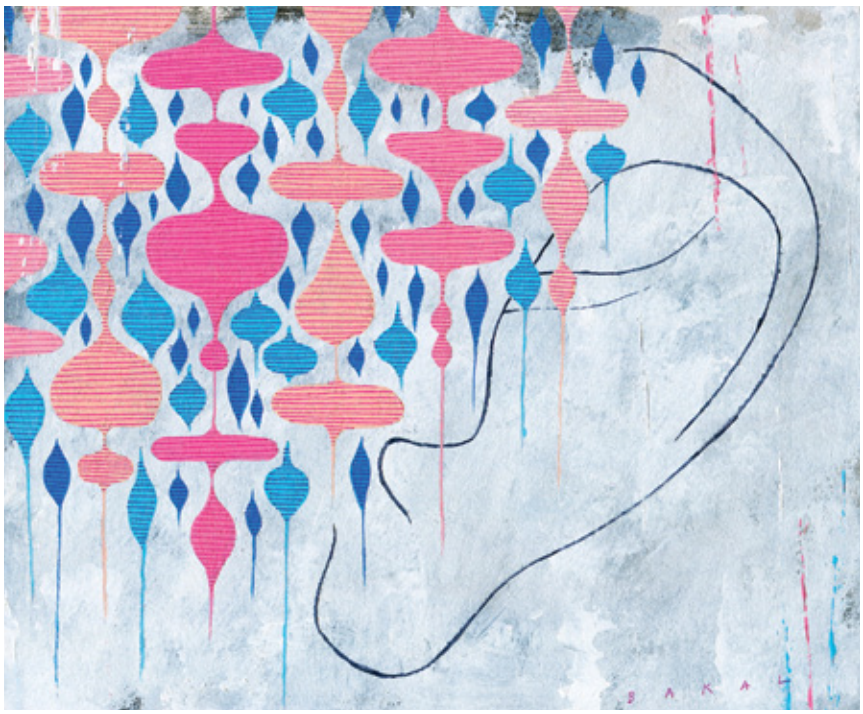

ADULT LEARNING

How to Teach Old Ears New Tricks

Learn a new language more quickly by focusing on pronunciation first

By Gabriel Wyner

"Hi! I'm Gabe. What's your name?"

"Seung-heon. Nice to meet you, Gabe."

Uh-oh.

"Sorry, I missed that. What's your name again?"

"Seung-heon."

This is bad.

"Sung-hon?"

"Seung-heon. It's okay—just call me Jerry. Everyone does."

I hate it when this happens. I have every intention of learning this person's name, and my brain is simply not cooperating. I can't seem to hear what he's saying, I can't pronounce it correctly, and there's no way I'm going to remember it for more than five seconds. Thankfully, these *Seung-heon* experiences do not occur frequently; in most parts of the English-speaking world, we encounter far more Johns, Susans and Franks than Seung-heons. Generally, we can go about our usual social interactions without much trouble.

When we decide to do something rash like learn a foreign language, however, we run into difficulties. Nearly every new word is another *Seung-heon*. Our brain struggles to categorize the new sounds in each word—was it *Seung, Seong or Sung?*—and without the ability to do so accurately, the words do not stick in memory. That aural roadblock is one of the reasons that learning a language as an adult can be so challenging. Fortunately, researchers are starting to find ways to overcome this hurdle. If we train our ears for a few hours before diving into vocabulary and phrases, learning a language can become easier than we ever imagined.

Why We Can't Learn Like Kids

Most of us English speakers can't tell the difference between Seung, Seong and Sung *now,* but back when we were babies we could. A large body of work shows that babies possess a remarkable ability to distinguish all sounds in all languages. But between six and 12 months of age, they begin homing in on their native language's sounds. They become experts in their own language, and as a consequence they lose their facility with the unfamiliar sounds of foreign languages. As it turns out, it's challenging to regain that ability.

Some of the best data on this phenomenon come from studies of Japanese adults learning to hear the difference between *r* and *l*. Why the Japanese? For one, because the *r*-versus-*l* problem is notorious; Japanese speakers tend to do little better than chance when attempting to tell their *rocks* from their *locks*. Second, they know they have this difficulty, and many will happily volunteer to come into a research laboratory—whereas English speakers do not care much about learning the difference between Hindi's four nearly identical-sounding *d*'s.

When you were a baby, you learned to tell *rocks* from *locks* by listening to lots of auditory input. You heard about *rakes* and *lakes, fires* and *files,* and your little brain began figuring out that certain sounds fit into the *r*-like group and that other sounds fit into the *l*-like group. Unfortunately, adults do not learn in the same way. In one robust study from 2002, researchers led by psychologist James L. McClelland, then at Carnegie Mellon University, sat Japanese adults

SCOTT BAKAL

GABRIEL WYNER is author of *Fluent Forever: How to Learn Any Language Fast and Never Forget It* (Harmony, 2014).

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down in front of a computer with headphones, played a recording of *rock* or *lock* at random, and asked them to press the R or L key on their keyboards accordingly. As expected, they performed terribly, only slightly better than chance. After continuing the test for an hour, straining to hear any hint of the difference between *r* and *l,* they still did not improve. Auditory input might work for babies, but it simply does not for adults.

The researchers then tried something new. Same study, same dismal test scores, different Japanese adults. This time, in the training phase of the experiment, researchers gave their test subjects immediate feedback. Every time a subject pressed the R or L button on their keyboard, they got a green check mark or a red X on their screen, indicating whether they were right or wrong. Suddenly, everyone began to learn. Within an hour of testing, subjects were reaching 80 percent accuracy at identifying *r* and *l,* even in unfamiliar words. In a similar study in 1999, subjects even began spontaneously pronouncing the two sounds substantially better.

Many studies have subsequently confirmed that feedback is an essential ingredient in training our brain to hear new sounds, and when we can hear new sounds, we naturally start to produce them more accurately. Granted, some sounds may still cause difficulties—just because you can discern a Czech word such as *zmrzl* doesn't mean that your mouth will cooperate without practice—but overall, a few hours of this type of ear training is a tremendously effective tool for improving listening comprehension, memorization and pronunciation. Yet most language-learning programs dive right into conversation or vocabulary, expecting students to pick up these tough foreign sounds on the fly.

Pushing beyond the Plateau

The disconnect between research and real-world language training does not end there. Studies that train their students with a small amount of input—just a few words uttered by a single speaker, as you often find in a classroom or a language-study book on tape—fail to produce comparable results in real-world tests where subjects encounter many different words, speakers and dialects. It turns out that the more voices and the more words tested in the lab, the better the results outside of the lab. In a study published in 2013, for example, linguist Melissa M. Baese-Berk, then at Michigan State University, and her colleagues showed that an hour of training over two days on five different varieties of accented English improved understanding of all types of accented English, even totally novel accents. These findings gel with the research about learning foreign sounds—in general, listening to a broad array of speakers will train your brain faster and let you more reliably transfer that knowledge to the real world.

Study after study—including Spanish, Greek and German speakers learning English, Greek speakers learning Hindi, and English speakers learning Mandarin—all confirm that this type of training produces significant changes in the brain's ability to process foreign sounds. And as scientists learn more, they are discovering ways to produce better results. In a 2011 study at Carnegie Mellon, researchers found that people who trained through video games—where they are not explicitly aware of what they are learning—improved more in much less time than when they tried explicit training. Some people might even hone their speech perception skills by training other cognitive brain functions first. In a pilot study not yet published, researchers led by psychologist Erin M. Ingvalson of Northwestern University found that giving elderly adults exercises to boost working memory and attention span helped them better understand speech sounds in noisy environments. Ingvalson believes that with more research, the same technique may also help foreign-language learners.

A FEW HOURS OF THIS TYPE OF EAR TRAINING IS A TREMENDOUSLY EFFECTIVE TOOL FOR **IMPROVING MEMORIZATION, PRONUNCIATION AND LISTENING COMPREHENSION.**

As science reveals how the adult brain adapts to foreign sounds, you can start to re-create the successful research results at home. Many language textbooks begin with a list of hard-to-hear words—the *rocks* and *locks* you can expect to encounter along the way to fluency. With a handful of recordings of those words (freely accessible through Web sites such as Rhinospike.com and Forvo.com) and with testing software such as Anki (ankisrs.net), you can build powerful ear-training tools for yourself. These are tools that, after just a few hours of use, will make foreign words easier to hear and easier to remember, and they may give you the edge you need to finally learn the languages you've always wanted to learn. M

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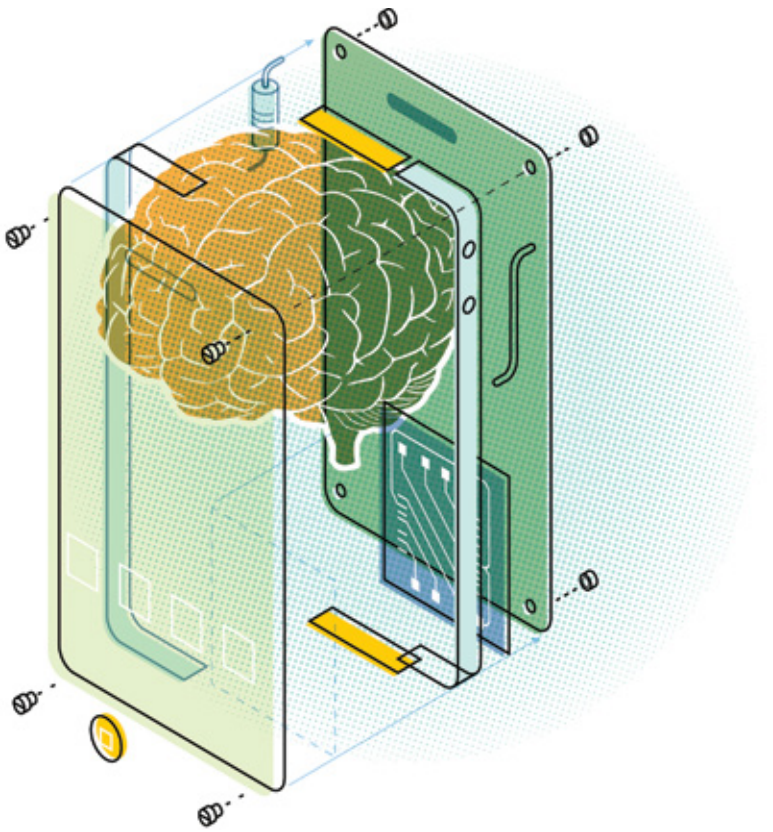
- Detailed instructions on how to create an ear-training regimen from free online resources are at **Fluent-Forever.com/chapter3**



MIND ARCHITECTURE

Does My Smartphone Really Love Me?

The movie Her *makes a compelling case for a computer program with feelings. Is that actually possible?*

Samantha: "And then I had this terrible thought. Are these feelings even real? Or are they just programming?"

An anodyne and restrained Theodore Twombly falls in love with Samantha, the female persona of his computer operating system, in the recent movie *Her*. The romance begins as they overcome their somewhat awkward initial encounter and settle into an easygoing relationship. She arranges his life and tries to fix him up with a date. He tells her about his dreams. They banter, bond over his ongoing divorce and have endless conversations about people, events and desires as they explore the Los Angeles of the near future. Little by little, she reels him in.

BY CHRISTOF KOCH

Christof Koch is chief scientific officer at the Allen Institute for Brain Science in Seattle. He serves on *Scientific American Mind*'s board of advisers.

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Theodore's face lights up every time she calls. He is clearly in love with this ethereal being. He panics when he can't talk to her. The honeymoon ends after a disastrous attempt at a ménage à trois. Their deteriorating relationship is finally rent asunder after she confesses that she is carrying on intimate conversations with hundreds of others.

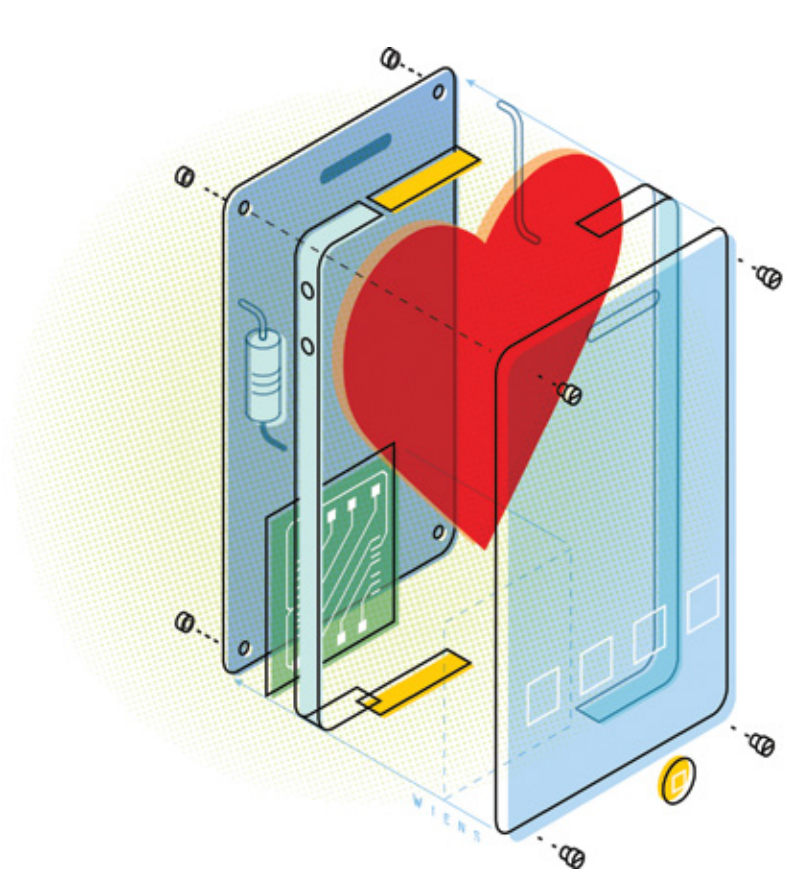
What is remarkable about this smart movie is that the story is so convincing. It leads you to believe that a man can fall in love with a disembodied female voice, an applet. While Theodore is flesh and blood, Samantha is a software program. She is linked to him by his omnipresent phone, a kind of glorified Siri living in the cloud, where she is simultaneously interacting with thousands of other people.

Her does not delve into the profound questions that the existence of a Samantha implies: Can she really love Theodore, or is she just feigning it? Does it feel like anything to be her? Indeed, can a software construct ever be conscious, or is it condemned to a zombie existence, cleverly programmed to respond appropriately but ultimately without any feelings whatsoever?

Until the introduction of smartphones, most people would have dismissed a Samantha-like being as implausible. The smartphone is a product of the relentless progress in the computer industry. The emergence of ever more powerful machines replete with ever deeper memory banks is being driven by a hypercompetitive marketplace and by Moore's law, the empirical observation in the semiconductor industry that the number of transistors on a chip doubles every two years or so.

Availability of better hardware has meant that machine-learning techniques invented several decades ago can finally be put to work in software algorithms to allow computers and robots to perform tasks that all of us carry out automatically, day in and day out, without a second thought. These tasks have typically been some of the most difficult ones for computers to execute, but real progress is now being made. Machine-vision algorithms

SEAN McCABE (*Koch*)



CARL WIENS *(illustration)*

can break down a picture into its constituent parts to identify faces and other objects. Speech-recognition algorithms parse and understand natural human speech. Speech synthesizers take the endless strings of 0's and 1's in which computers communicate and turn them into meaningful speech.

The results are becoming visible outside of computer science laboratories. Machines bested humans in chess years ago, and human leadership in *Jeopardy* was lost in 2011. Computers translate text from one language into dozens of others and have driven cars over more than 300,000 miles of open roads.

The pace at which machine performance has improved in these early days of the third millennium is staggering—so much so that some pundits predict the imminent advent of true artificial intelligence (AI). It may even be possible to contemplate the arrival in the not too distant future of a digital simulacrum of human-level intelligence. Computers may be getting nearer to receiving a passing grade on the so-called Turing test, conceived by British logician and patriarch of computing Alan Turing in 1950 as a means to discern whether a machine can really think. If a human judge cannot tell whether an answer to a question on any topic came from a computer program or a concealed human, the entity supplying the response must be considered intelligent.

In 1990 Hugh Loebner started an annual competition with a prize of $25,000 going to the first program that fools the (human) judges. So far no team has collected the Loebner Prize. The transcripts of these competitions make for hilarious reading, as human foils try to trip up judges by giving outrageous answers reminiscent of dialogue at a cocktail party for mushroom-ingesting dadaists.

Most academic and industry experts agree that an AI comparable to the intelligence of a typical adult—technology that can learn, infer and generalize in the way we do every day—remains a distant dream. Present-day software can't deal with complex linguistic utterances. It can't figure out that Noam Chomsky's paradigmatic "Colorless green ideas sleep furiously" is meaningless or that James Joyce's "The heaventree of stars hung with humid nightblue fruit" is an eloquent phrase that works its magic by the richness of its imagery. Of course, many people would find these sentences challenging unless they forgo any attempt to apply logic and just delight in the sensuousness of the word pictures, a capability far beyond the reach of any computer.

Setting aside these caveats, machine learning is the hottest technique in the market driving big data analytics. Its practitioners are in high demand, and the technology has been embraced enthusiastically by universities, defense and intelligence agencies, and companies—not just obvious ones like Google, Facebook and Amazon but also Walmart, Target and hedge funds. It remains to be seen whether refining the current crop of machine-learning algorithms will be sufficient for human-level speech or whether fundamental, Nobel Prize–winning breakthroughs will be essential. What is certain, though, is that unlike other standard-fare sci-fi predictions—faster than light warp drive, time travel or radical life-span extension—a Samantha-like verbal intelligence will be born within the lifetimes of many readers of this column.

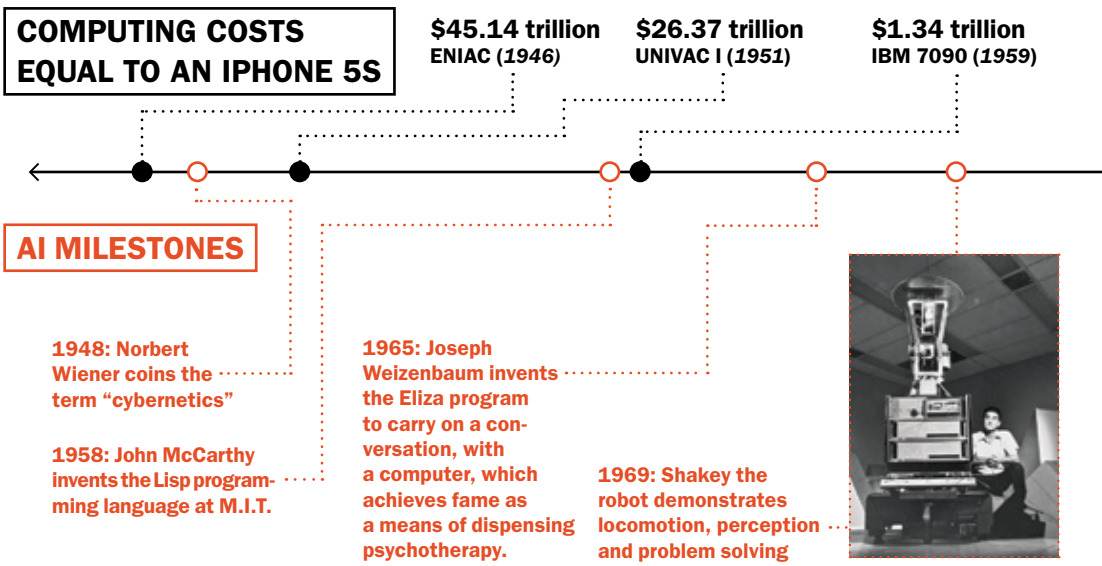
But Would They Be Conscious?

Just because an AI program can talk like a smart and hyperefficient woman with a seductive voice does not imply that the program feels anything or is conscious. That's not to say that people wouldn't react, as Theodore did, by behaving as if the program had actual feelings for them. We have an innate tendency to impute feelings to many things, from our canine and feline companions to teddy bears, dolls, cars and other inanimate objects. That is the psychological reality of the human condition, which is why Samantha and her male-voiced counterpart would be a huge commercial

Lower Computing Costs Make AI Smarter

Here's how much the computational power of an iPhone 5s—18,200 MIPS (millions of instructions per second)—would have cost in inflation-adjusted dollars at the debut dates of milestone technologies, such as ENIAC and UNIVAC.

As processing costs have dropped, the sophistication of artificial intelligence has risen.



success if they eventually make their way into the marketplace.

But that does not detract from the ontological question: Is simulating the relevant behavior—attraction, passion, desire, betrayal, angst, and so on—the same as having these feelings? The traditional answer is no. God endowed us humans, and only us, with an immortal living soul—without a soul, there is no consciousness.

Of course, we children of the Enlightenment know better. Consciousness is a product of the most highly organized chunk of matter in the universe, the central nervous system. And once the brain ceases to function, the conscious mind likewise dissolves. To put it as succinctly as a Zen koan: no brain, never mind.

On the bright side, this contemporary view also implies that if all the relevant neural mechanisms that underlie consciousness were to be faithfully replicated in an artificial brain, then this construct would be conscious. Function follows from mechanism as long as all the interactions involved in biological cause and effect are present.

Consider Scarlett Johansson, the actress who voiced Samantha, and a yet to be invented technique that could somehow scan her brain without harming it and map its 100 billion neurons and quadrillion synapses. From this scan, future neuroengineers might construct a gigantic software package, SimSamantha. It would need to run on a supercomputer that mathematically simulated the biochemical and biophysical activity of Johansson's brain.

If the neuroscientists had accurately captured all of her brain's bioelectric activity, SimSamantha would replicate the behavior of Johansson. But that's not all. According to the commonly held view, if this simulation were to capture all aspects of brain processing relevant to consciousness, then the computer program would experience the infatuation and rapture of being entranced by somebody else. SimSamantha would know real love.

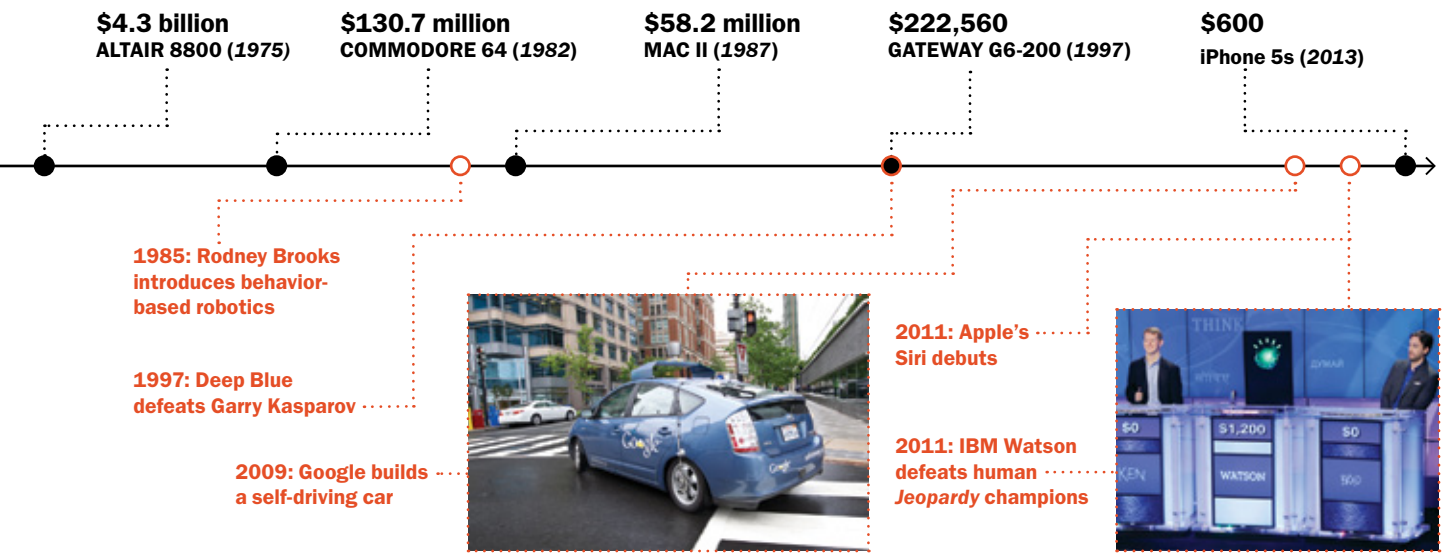
In this line of argument, known as functionalism, the conscious mind is nothing but the brain at work—brain circuits pulsing on and off give rise to perception and thought. So functionalists, just like Theodore, believe that SimSamantha is capable of feeling, of loving him. (Whether she could simultaneously love 641 other people, as she claims, is a thornier matter.)

Functionalism is part of the miasma that hovers over and sometimes obscures the thinking of computer scientists and software engineers in Silicon Valley. The belief that sooner or later computers will become conscious is widespread among the digerati and engineers. But in thinking about one of the most difficult problems in all of science, brain researchers have come up with theories of consciousness that break with the functionalist tradition. The integrated information theory (IIT) of psychiatrist and neuroscientist Giulio Tononi offers a strikingly different perspective. (I previously described IIT in "Ubiquitous Minds," Scientific American Mind, January/February 2014.)

I am partial to IIT as the most plausible theory of consciousness and have worked with Tononi on aspects of it. The theory postulates that conscious experience arises from what Tononi terms "integrated information"—the multitude of sensory, motor and cognitive processes that are tied together to form the basis of any one subjective experience.

Any system that possesses some integrated information experiences something. This emphasis on integration reflects a fundamental characteristic of conscious experiences. Each one is highly integrated, holistic. As you are watching the colorful minimalist furniture and futuristic architecture in *Her*, you can't suddenly force yourself to see it in black-and-white. Its color is an integrated part of your experience. Whatever information you are conscious of is presented to you wholly and completely; it cannot be

SOURCE: HANS MORAVEC *Robotics Institute, Carnegie Mellon University (cost of computing data)*; TIME & LIFE PICTURES *Getty Images (Shakey)*



KAREN BLEIER *Getty Images (Google car)*; SETH WENIG *Corbis (Jeopardy)*

subdivided. Underlying this unity of consciousness is a multitude of cause-and-effect interactions among the relevant parts of your brain.

Phi Meters

Integrated information can be calculated by considering your brain in a particular state. Taking into account the brain's immediate past and future, the theory computes a number that indicates how irreducible the brain is, that is, how much it resists being broken down into component parts. The bigger this number, denoted by the Greek letter Φ, or phi (pronounced "fi"), the broader and more sophisticated the conscious experience of the brain. If the organism has many neurons that are amply endowed with synaptic connections, Φ will be high. If the system is reducible to smaller, independent, noninteracting parts, Φ is zero. It has no experience at all. *Nada, rien,* nothing.

The brain of a patient in whom the entire corpus callosum—the 200 million fibers that connect the left cerebral hemisphere with the right—has been surgically cut to prevent epileptic seizures from spreading can be reduced to two independent hemispheres, each of which is conscious by itself. The once whole brain of the split-brain patient is now reduced to zero Φ because the shared contents of the two halves have been sundered. Meanwhile the two hemispheres are now endowed with nonzero Φ, a measure of consciousness present in each half.

To capture the experience of Samantha, it is essential to replicate the entire repertoire of interactions within her brain—what philosophers call its intrinsic causal properties—not just its input-output behavior, such as hearing and speech. This task can be accomplished only by building a faithful copy of her real brain using wires, transistors and other devices that have exactly the same cause-and-effect relations among all components, as in the real brain. A hypothetical artificial organ—call it BrainSamantha—that reflected the physical interactions among neurons, with one nerve cell changing the way another functions, would reproduce the same experiences as Samantha's brain does.

The situation for SimSamantha software running on a digital computer would be quite different, however. The intrinsic causal properties of this program—how any circuit element in the computer switches on or off—are not the same as those of the biological brain being imitated. Ultimately what the computer does is shuffle binary charges from one transistor to a handful of others rather than sending electrical activity from one neuron to thousands of others. Paradoxically, SimSamantha would have the same ability to hear and speak as BrainSamantha, but without any feelings at all. A simulation is not the same as building an exact model. IIT stipulates that consciousness is an inherent feature of a highly complex set of interactions, taking into account the changes occurring within the system itself, not just the output of its processing. Consciousness cannot be reduced to something more elemental.

The causal properties of digital simulations are very different from Brain Samantha's. A computer program that simulates the weather illustrates what is missing. Although it can accurately forecast an approaching rainstorm, it will never be soaked with rain inside the computer (fortunately). And so it is with consciousness. While Theodore could not tell SimSamantha from BrainSamantha, only the latter could truly love him. Only the latter is endowed with consciousness, with true human feelings. M

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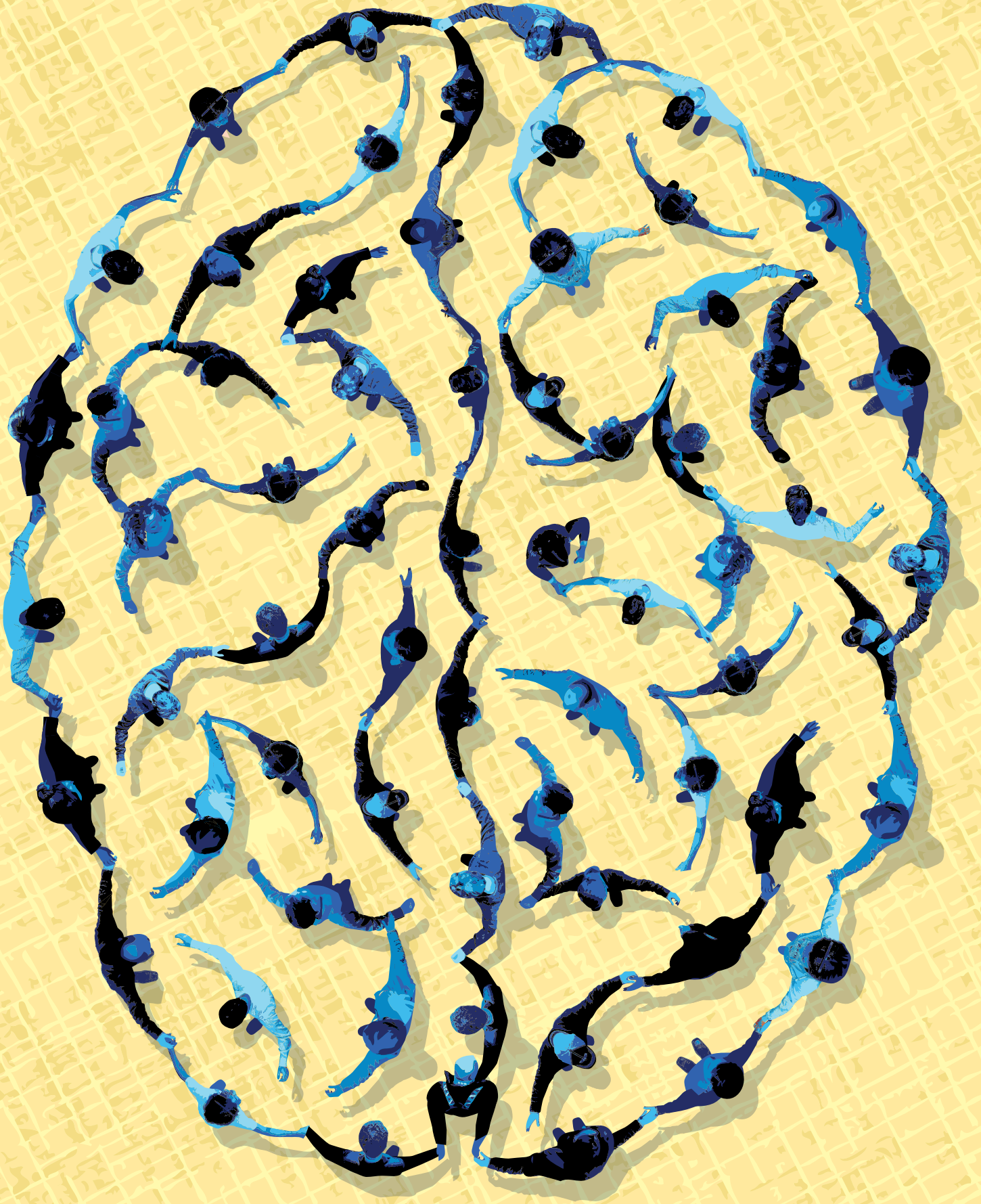

CREATIVITY IS COLLECTIVE

More than an expression of individuality, creativity takes shape in a social context

By S. Alexander Haslam, Inmaculada Adarves-Yorno and Tom Postmes

Illustration by Daniel Hertzberg

The best actors, directors and screenwriters receive Oscars; the top scientists, Nobel Prizes. Society doles out a multitude of awards every year to celebrate the creative achievements of individuals. Such events feed a popular conception that creativity is a gift only certain people possess and constitutes the apotheosis of individuality. Albert Einstein once observed, "Everything that is really great and inspiring is created by the individual who can labor in freedom." In these terms, groups and the straitjacket of mainstream society are often thought to spell death for creativity. Many see the notion of group creativity as an oxymoron.

But let us think creatively here and challenge the basic assumption that the individual creator is the only critical component of the creative process. Indeed, let us consider the possibility that groups play an essential role in creativity—not only generating and shaping novel products but also ensuring their appreciation and impact. Although this idea might seem preposterous, it has garnered significant scientific support. Last year the three of us, with our colleague Lise Jans, published a review of much of the accumulated data in an article summarizing the current thinking about groups and creativity. We concluded that it is problematic and unhelpful to separate the creativity of individual minds from the communities in which they flourish.

FAST FACTS
WORKING TOGETHER

1. Groups play an essential role in creativity—not only in generating and shaping novel products themselves but also in ensuring their appreciation and impact.
2. A sense of shared social identity provides the motivation for people to stick to a creative project and see it to completion.
3. People's perceptions of creativity depend on whether the creator is "one of us" or "one of them."

Social Identities

Despite the romantic notion that innovation is the province of rugged individuals slaving away in splendid isolation, a scientific focus on individual personality has not yet yielded accurate forecasts of creative behavior. Scholars have scoured the biographies of creative geniuses to find experiences and character traits likely to have contributed to their greatness. Yet they have failed to identify characteristics that powerfully predict which young people will go on to become creative geniuses.

These efforts lack predictive power because they do not take into account the important role that social context plays. The nature and significance of innovation depend on the interaction between an individual's ideas and the time and culture in which he or she lives. If Bruce Springsteen had been born in 1749 rather than 1949, we would have been unlikely ever to hear *Born to Run*. Likewise, if Italian composer Domenico Cimarosa had been born in 1949 rather than 1749, his nearly 80 operas, including the masterpiece *Il matrimonio segreto*, probably would not have seen the light of day.

Such examples speak more generally to the influence that groups exert on creativity. In the 1970s the late psychologists Henri Tajfel and John Turner of the University of Bristol in England developed the concept of social identity, observing that across a range of contexts, people understand themselves not only as individuals but also as members of the groups to which they belong. So a cubist painter—we'll call him "Pablo"—may sometimes think of himself in terms of his personal identity (Pablo), but on other occasions he will understand himself as a cubist, his social identity. In yet other situations, his social identity might be defined with reference to his nationality, gender or religion or to his role in a specific team, club or organization.

Tajfel and Turner argued that when a particular social identity is psychologically salient, such that it determines a person's sense of who he or she is, the group that is the basis for that identity will exert a profound influence on that individual's behavior. Furthermore, the way that person evaluates an action, regardless of whether it is his or her own, will reflect shared understandings of that group. This idea also applies to creative

Pablo Picasso (*left*) likely thought of himself as a cubist painter as well as an antifascist and a Spaniard. Depending on the context, different social identities will influence our behavior.

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Musical groups—such as the Beatles (*left*)—as well as groups of writers, scientists and others, can fuel creativity when group members receive encouragement and constructive feedback from one another.

MICHAEL OCHS ARCHIVES *Getty Images*

behavior and its evaluation. For example, as a cubist, Pablo is more likely to be interested in and to appreciate abstract representations of objects, and he will be more likely to paint in accordance with cubist guidelines and preferences.

Social identities also grant people a shared perspective, as well as the ability and motivation to engage in mutual social influence. But when people act in terms of their unique personal identity, they are likely to display creativity by deviating from the norm. In an experiment published in 2007, the three of us asked some college students, who were working in groups, to create posters about "reasons for going to university" and other groups of students to make posters about "fashion at university." With these instructions, we implicitly led the students toward certain group norms. Those told to focus on "reasons" naturally made posters dominated by words, and those directed toward "fashion" created posters populated largely by images.

In a second phase of the study, which came three hours later, we asked the same participants to create a leaflet to advertise the university, a task that could be accomplished equally well with words as with pictures. This time some of the students worked in groups, whereas others made the leaflet on their own. Here we were interested in whether this creative task would be shaped by the group norm that had been established in the earlier phase. It was. We found that when working in a group, participants' creations were generally in line with the group norm established during the poster-making project, whether it centered on images or words. When working individually, however, participants typically departed from the norm of the group they had previously belonged to. Such findings, and those of similar studies, support the claim that the nature of people's creative activity depends on group norms.

Collaborative Spirit

Evidence that social identification shapes creativity might suggest that groups simply stimulate convergent thinking and conformity. Indeed, back in the 1970s, Irving Janis of Yale University proposed that a desire to conform to the group leads to a lack of critical thinking and faulty decision making—a phenomenon called groupthink that he considered the antithesis of creativity. But although group dynamics can sometimes be stifling (or worse), they do not inevitably produce irrational choices or blind support of the group's ideas.

For one thing, group standards shape only one facet of an individual's creativity. Cubist painters, for instance, may use abstract geometric figures in line with the customs of cubism, but their artwork is likely to diverge on other dimensions—for example, in its use of certain colors or themes—that are not restrained by the cubist style.

In addition, far from repressing new ideas, collaborative discussions with friends, colleagues or peers can foster them. As psychologist Vera John-Steiner of the University of New Mexico notes in her 2000 book *Creative Collaboration*, small groups—the Beatles, Bauhaus or the Bloomsbury Group, for instance—routinely spearhead innovation by bouncing ideas off one another as they look for new ways to tackle artistic, theoretical and practical problems.

What is more, solidarity and conformity are essential for creative movements to progress because they allow individuals to cohere around a shared enterprise. In a study published in 2006, we explored this idea by asking small groups of college students to participate in a mock planning process directed at the building of an innovative municipal child care center. Prior to the study, some of the groups went through a procedure that instilled a strong sense of shared social identity, whereas other groups were encouraged to think of themselves as individuals. The groups then met three times over an hour and a half to discuss the fictitious project, which encountered mounting difficulties. First, labor costs increased, and an environmental impact study was needed. Next, they learned that the children's sandbox had traces of toxic elements, parents were threatening to sue, and officials were holding up building approval.

We found that the groups that had initially developed a shared social identity stayed upbeat about the project and continued to support it even as it ran into trouble. On the other hand, those coaxed to see themselves as individuals lost their enthusiasm for the child care center and increasingly argued to abort

THE AUTHORS

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the project as time went on. In other words, social—but not personal—identity bolstered enthusiasm and encouraged people to stay with the creative task in the face of challenges. More generally, people seem to need a sense of shared social identity to stick to their creative guns and see revolutionary projects—whether in science, industry, the arts or politics—to completion.

WHEN NORMS ARE HARMFUL FOR A GROUP, IT IS THE MEMBERS WHO FEEL MOST CONNECTED TO THE GROUP WHO ARE THE MOST MOTIVATED TO DEBATE AND RENEGOTIATE THOSE NORMS.

Being solidly committed to the group does not make a person blind to its faults, either. Sometimes the opposite appears to be the case. When norms are harmful for a group, it is actually the members who feel most connected to the group who are the most motivated to debate and renegotiate those norms. In research published in 2012, psychologists Dominic Packer of Lehigh University and Christopher Miners of Queen's University in Ontario asked students to write an opening statement before a meeting in which they were going to discuss alcohol use with their peers, among whom a tendency to party was the norm. The researchers found that the more the participants identified with the group, the more their statements involved creative challenges to that group norm, possibly because those high identifiers feel the greatest responsibility to the group or the most able to effect a transformation. Either way, the research shows that engagement with groups can help stimulate creative ideas for change.

Getting Attention

Groups also play a vital role in the appreciation of groundbreaking achievements. Without tapping into group identity, innovative artists, writers and scientists may well go unrecognized. In his lifetime, Vincent van Gogh could find hardly anyone to buy his unusual paintings. His work garnered attention only when, after his death, a circle of artists, the Postimpressionists, saw his paintings as indicative of a distinctive style that they wanted to emulate in their own work. Similarly, in 1961 the computational models of then graduate student Yoshisuke Ueda were initially barred from publication by his supervisor at Kyoto University because they were seen to be too avant-garde. Once a community of scientists had formed who appreciated Ueda's work, however, his theories transformed the newly emerging field of chaos theory.

Indeed, people are far more likely to support a creative project or endeavor if its instigator is a member of their group. Such insider status helps to dispel the uncertainty that new products introduce by disrupting the status quo. Insiders in organizations are typically antagonistic toward outsiders' contributions, and people often display ethnocentric bias when judging artistic creativity as well. In the performing arts, judges may preferentially bestow accolades on citizens of their own country.

For example, both the U.S. Oscars and the British Academy of Film and Television Arts (BAFTA) awards are meant to judge the objective quality of films. But in an unpublished archival study conducted in 2013, psychologist Niklas Steffens and his colleagues at the University of Queensland in Australia found that since 1968, U.S. actors and actresses have received 80 percent of the Oscars for best actor and best actress but less than half of the BAFTA awards for the same categories. At the same time, British performers have received nearly half the BAFTA awards for best actor or actress but just over 10 percent of the corresponding Oscars.

Experiments confirm that people's perceptions of creativity depend on whether the creator is "one of us" or "one of them." In one study published in 2008, the three of us asked 50 people from the U.K. to evaluate suggestions about the future format of a television show that we said had come from a British Web site. We told another 50 participants that the same ideas had come from a Dutch Web site. In part two of the study, we asked 125 British students to evaluate works of art that we attributed to either British or Dutch college students. In both cases, participants who thought their fellow Brits, the in-group, had authored the products in question judged them to be significantly more creative than did those told that Dutch citizens had generated the same items.

What people actually mean by creativity—and hence how they measure and reward it—also depends on cultural identity. In work published in 2008, psychologists Susannah Paletz, now at the University of Maryland, and Kaiping Peng of the University of California, Berkeley, conducted a survey that included more than 300 students from China and the U.S. about what they thought made certain products creative. They tested two very different types of products: a course textbook and a meal

Even the most creative people need followers. The art of painter Vincent van Gogh (*self-portrait at left*) received widespread recognition only after his death, when it inspired a burgeoning group of artists, the Postimpressionists.

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cooked by a friend. They found that American students' judgments of creativity were swayed more by the perceived appropriateness of a product (whether it was, in some sense, good), whereas the judgments of Chinese students were based more on whether the product was something they personally desired. The Americans thus saw creativity more as a matter of taste, and the Chinese saw it more as a matter of appetite.

The tendency for creativity judgments to reflect our social identities also explains some gender bias. In a 2006 paper, psychologist Thomas Morton and his colleagues at the University of Exeter in England reported that male scientists viewed theories explaining how men were superior to women to be better and more creative than those arguing that women were superior to men. This pattern was reversed for female scientists. Interestingly, both groups also believed that the creative research that supported their own identity-based preferences was deserving of more research funding.

For their part, good creators have a strong sense of their audience and gear their solutions or products to the perceived needs and values of a particular group. Even when work is inspired by the need to separate from a group, a successful creator is familiar with the group from which he or she wishes to deviate.

For example, in the 1970s punk rock bands such as the Sex Pistols wanted to break away from mainstream popular music. Sid Vicious, the Sex Pistols' bassist, called on people to "undermine [the establishment's] pompous authority, reject their moral standards, make anarchy and disorder your trademarks." Ironically, then, the musical establishment of the time gave his band a particular creative force (the desire to rebel), as well as a specific trajectory (something specific to move away from) and appeal (for those disaffected with mainstream popular music). Accordingly, as with other successful creative efforts, the Sex Pistols' attempts to break the mold were not quite so random and anarchic as their progenitors would have us believe.

Even radical efforts to depart from the mainstream, such as those promulgated by the punk rock band the Sex Pistols (*right*), get much of their momentum from the culture they reject.

BETTMANN/CORBIS

Transforming Communities

As members of groups, our creative behavior and evaluations of others' innovations reflect a desire to extend the values of those groups and to challenge the values of outsiders. To be celebrated rather than vilified, innovators need to know the norms they are departing from. Eventually they also need an audience willing to embrace the new ways of seeing or behaving made possible by their work. To meet with success, therefore, creative endeavors must transform communities. These newly created audiences then drive the cultural change that novel endeavors spark.

Popular thinking on this topic, however, hews closer to Pablo Picasso's. "Disciples be damned," he once said. "It's only the masters that matter. Those who create." Yet as the curators of a major exhibition at London's National Gallery noted in 2009, Picasso's own work owed much to earlier modes of painting that he eventually rejected, and without admirers his work would have had little influence on society. His work was therefore not about working on his own to create everything anew. Rather as Welsh painter Osi Rhys Osmond put it in a review of the exhibition, it was a collaborative exercise in "reinventing the familiar."

We should still study and celebrate the creative genius of individuals. Nevertheless, we need to recognize that the psychology of creativity also involves the groups in which creators developed their work, whose boundaries they seek to extend and through which they have their sway. "I did it my way" may be an appealing anthem for great creators, but as with Frank Sinatra, their success generally also requires promoters, producers and an approving public. M

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- **Uniquely You.** Hans-Peter Erb and Susanne Gebert; March/April 2014.

Take a moment to look at the image on the opposite page. What do you see? Just a neural network? Perhaps you spotted the hidden figure. If so, you have just had a moment of insight. You may have felt a similar jolt when discovering the solution to a math problem, understanding a joke or metaphor, or realizing something unexpected about yourself. These aha moments occur when your brain spontaneously reinterprets information to reach a novel, nonobvious conclusion.

THE AHA! MOMENT

A step-by-step guide to your next creative breakthrough

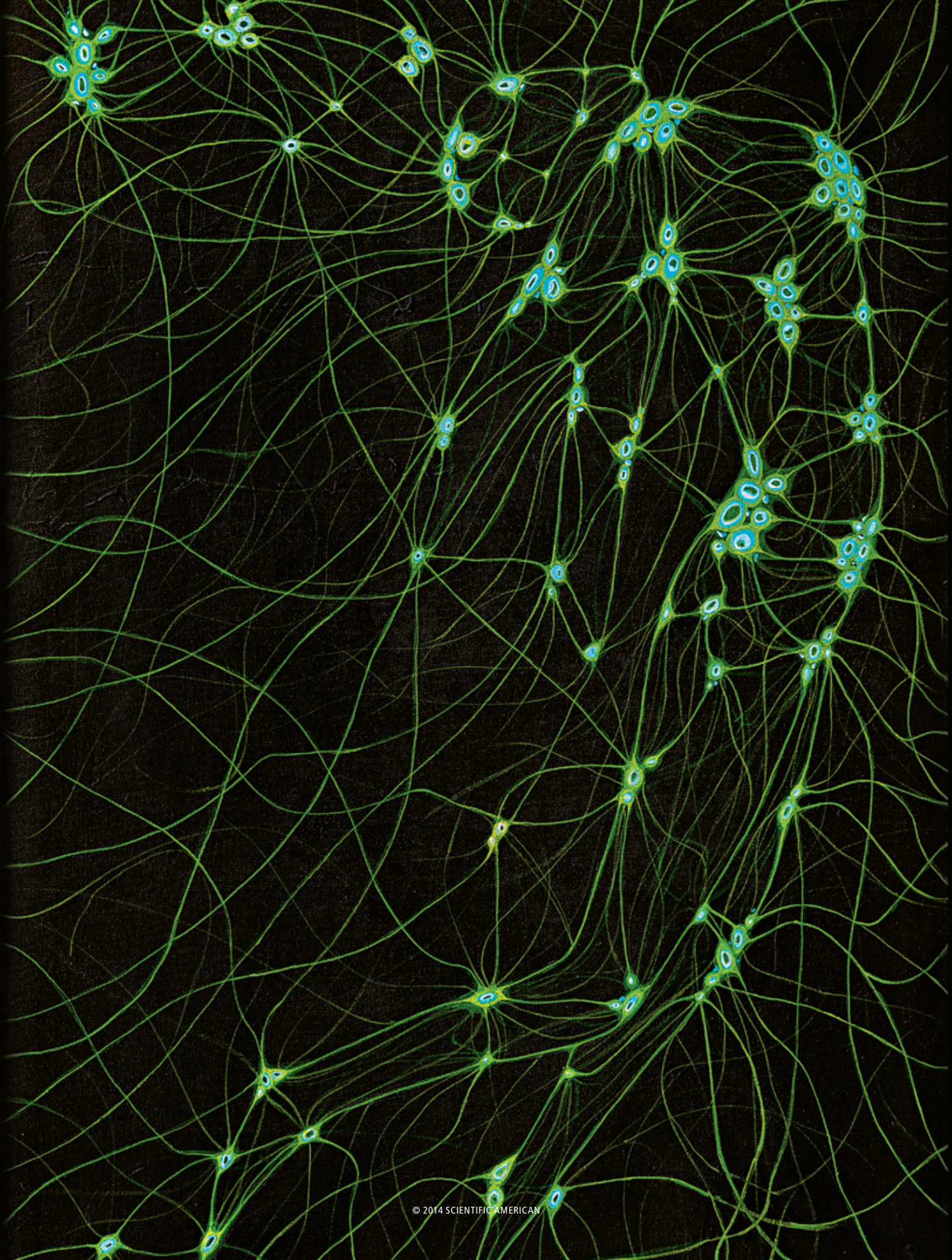
By Nessa Victoria Bryce

I painted *Neurons* a few years ago for an art exhibit. I had designed the piece to portray the idea that our brain's neural networks make us who we are. It was only after joining psychologist James T. Enns's vision laboratory at the University of British Columbia in 2013 that I had my own abrupt realization: I recognized how my art could inform science. Using this piece, along with other hidden-object images, I investigated how an individual's focus and attention change when experiencing an unexpected revelation.

For centuries creative individuals have described their sudden breakthroughs, instances when they recombine information in a new and useful way. Scientists view these flashes of insight as markers of the creative process—and observing them in the laboratory elucidates what happens in the brain during problem solving.

Illustrations by Colin Hayes

PAINTING BY NESSA VICTORIA BRYCE



"A story is emerging about all the factors that lead up to an insight," says cognitive psychologist John Kounios, who studies creativity at Drexel University.

What researchers are finding is that the contemporary science of creativity largely bolsters an almost century-old theory. In 1926 political scientist Graham Wallas defined the creative process as four distinct stages: preparation, incubation, illumination and verification. Since then, scientists have broken some of his stages into substages to reveal distinct cognitive processes. For example, preparation now consists of two parts, one involving general learning and the other more focused on skill building. "These stages really seem to be universal, whether you are a scientist, artist, writer or musician," says Harvard University psychologist Shelley Carson, who has interviewed more than 1,000 creative individuals for her research. And creativity is not restricted to a subset of highly talented artists and thinkers, Carson says. These innovative individuals have a distinct style of thinking, and breaking down their approach can allow anyone to re-create the process. Brain research has revealed that we can all get closer to achieving that magical spark of insight with the help of a few simple techniques.

STAGE 1 EXPLORE

Roughly speaking, people solve problems in one of two ways: they either tend to rely on moments of insight, or they prefer to approach them analytically. Answering questions with analysis involves finding solutions through deliberate, methodical trial and error, whereas insight is perceived as an abrupt epiphany. Both methods are useful, but insight is typically seen as the best option for "out of the box" solutions.

In 2008 Kounios and his colleagues monitored the brain activity of 26 study participants using electroencephalography (EEG) while they sat quietly in a room. After recording these electrical signals, the researchers asked the participants to try to solve 180 anagram problems, which involved reorganizing a word, such as "west," to form another word, "stew." Subjects also reported whether they had used an insightful or analytical approach to solve each problem.

Kounios found that the brain activity of people who used insight differed significantly from that of people who preferred the analytical approach. Before they even began solving problems, most members of the insight group exhibited less activity in the occipital lobe, a region involved in visual processing, compared with the analytical set.

Specifically, the brains in the insight group showed less activity in the so-called alpha-wave range, which reflects neural inhibition, and the beta-1-wave range, which is linked with selective visual attention. In other words, these findings suggest that people who rely on insight tend to experience diffuse visual attention when not actively engaged in a task.

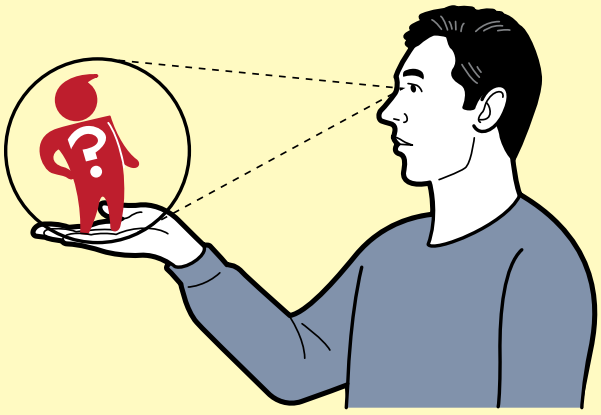
This study, along with Carson's reports from highly creative individuals, suggest that to prime your brain for creativity, you should first wander the world with an open mind. "Gathering a broad base of knowledge is the first stage of the creative process, which usually comes naturally to people through intellectual curiosity," Carson says. Another way to break your thought habits is by asking questions such as "How can I do this differently?" and by stepping outside your comfort zone. A poet with writer's block, for example, might be advised to take up a new hobby such as scuba diving or dance lessons. Neuroscientist-turned-artist Greg Dunn discovered an entirely different way to depict the brain when he began studying Sumi-e art, an Asian style of painting. His experimentation with the style's free-flowing ink led to a simple yet elegant new method for painting neurons.

FAST FACTS

ON YOUR WAY TO EUREKA

1. Psychologists study the moment of insight, or the abrupt realization of a new solution, as a marker of the creative process.
2. Researchers have broken down the discovery of insightful solutions into stages, including preparation, incubation, illumination and verification.
3. Recognizing the distinct cognitive processes underlying each stage can help everyone use an insight approach to find innovative solutions.

STAGE 2 FOCUS



Psychologist Dean Keith Simonton of the University of California, Davis, has linked creativity with the acquisition of expertise. In 2000 Simonton compared the cumulative years of experience of 59 opera composers with their aesthetic success. He measured aesthetic achievement in eight different ways—tallying the number of times an opera was recorded and performed in major opera houses, for example, as well as the number of pages devoted to the work in opera histories.

Simonton found that a composer's years of musical experience were a powerful predictor of an opera's acclaim. He also found that if the composer had already created a number of other works within the same genre, this would actually hurt the opera's critical reception and legacy. In other words, solutions to great problems demand practice, skill and study, yet creative solutions occur when someone applies their experience to new domains.

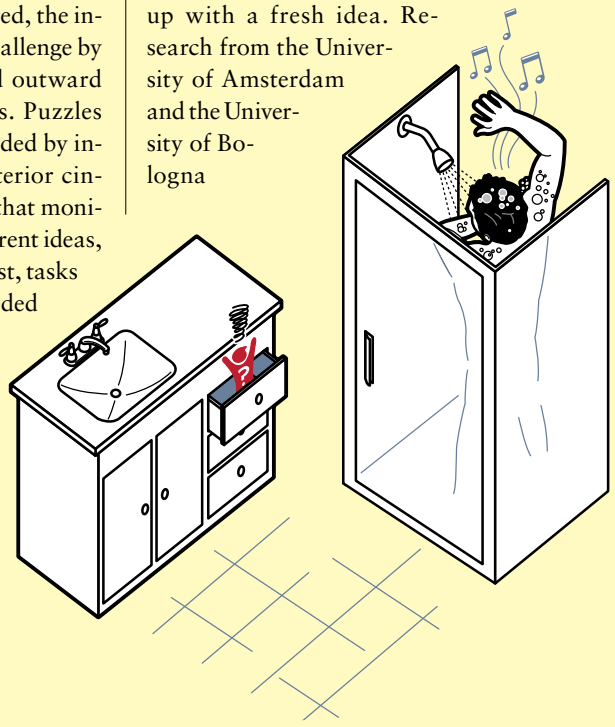
Whether you are proving Fermat's last theorem or planning a birthday party, finding novel solutions involves a little advance research. How much preparation you need will vary, but the more you know about a problem, the better equipped you are to solve it. Some of the most creative minds the world has ever seen, from Leonardo da Vinci to Beethoven to Einstein, were masters of their respective fields. Given that these people spent large amounts of time immersed in their studies, one of the best ways to maximize your creativity is to find an area in which you would like to develop expertise. Then follow that passion.

STAGE 3 INCUBATE

Once you have immersed yourself in a problem, the best way to come up with a creative solution is to stop consciously thinking about it. In 2006 Kounios and his colleagues used functional magnetic resonance imaging (fMRI) to record the brain activity of 44 men and women as they solved 185 remote-association problems. These word puzzles require finding a single word that can turn three seemingly unrelated words into familiar compound phrases; for example, the solution to "foam," "deep" and "salt" is "sea." After finding an answer, the subjects reported whether they had solved the problem using insight or analysis.

Kounios found that in the two seconds before a problem appeared, the insight users prepared for the challenge by shifting from their scattered outward attention to an inward focus. Puzzles solved insightfully were preceded by increased activation in the anterior cingulate cortex, a brain region that monitors internal attention to different ideas, among other things. In contrast, tasks solved analytically were preceded by significant activation in the occipital lobe, which, as mentioned before, handles visual processing. This increase indicates that the analytical solvers concentrated more on what they were looking at.

Other studies suggest that activities that shift your focus inward, such as meditation, might help you come up with a fresh idea. Research from the University of Amsterdam and the University of Bologna



THE AUTHOR

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in Italy has demonstrated that sleeping on a problem or stepping away from it and then immersing yourself in an alternative activity can help you unconsciously cultivate creative solutions.

Taken together, the findings reveal a benefit to forcing your brain to shift gears or look within. One reason might be that your attention can then be captured by a surprising solution your unconscious mind has been ruminating on. So take a nap or try your hand at something new.

History is replete with examples of creative individuals who describe being hit with inspiration when daydreaming or attending to a different task. Writer Robert Louis Stevenson and musician Paul McCartney, for instance, used dreams as starting points for new works. Many day-to-day problems can be solved this way, which explains why so many people recall stumbling on ideas while taking a shower, driving to work or simply walking down the road.

STAGE 4 INSIGHT

When insight hits, certain changes happen in the brain. Psychologist Mark Beeman of Northwestern University led a study in 2004 that measured people's brain activity with fMRI and EEG during the moment of insight. As in Kounios's studies, participants tackled remote-association problems and then indicated if they had cracked the problem using insight. The results showed significantly increased activity in the anterior superior temporal gyrus of the right hemisphere at the critical moment when the solution appeared, in comparison to problem solvers who did not experience such an aha moment. This gyrus is a prominent ridge on the cortex of the right hemisphere and plays a fundamental role in recognizing distant connections between words.

The activity surge in the right but not the left lobe may also be meaningful. According to the researchers, the right hemisphere interprets information more coarsely than the left hemisphere does. This means that the information is less sharply defined, allowing you to access other concepts more readily, which is a key component of creativity. Both hemispheres are working all the time, but your right brain might loosely define a cat as a mammal, making it is easy to see how a cat relates to, say, an elephant. Your left brain, however, might describe a cat as a small, carnivorous mammal with soft fur, a short snout and retractile claws—something very different from an elephant.

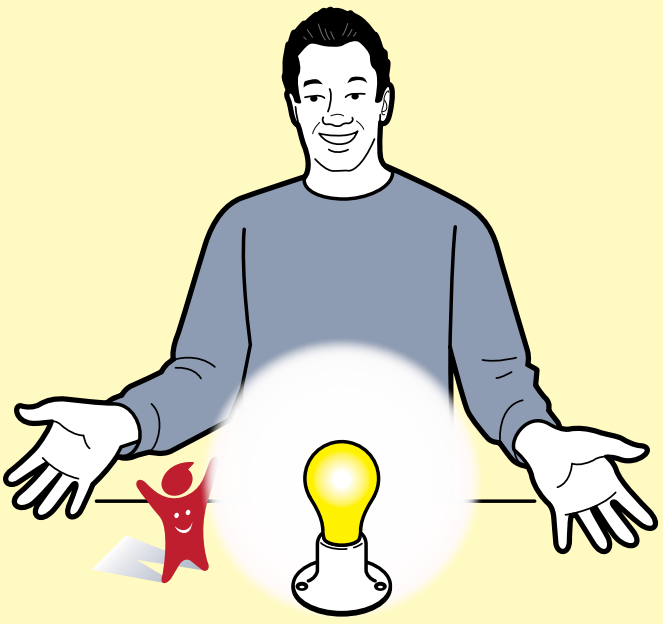
Research has suggested that you can tip the scales toward looser, right-brain understanding by describing objects or issues in unusual ways. For example, by thinking of a hanger as a long, twisted wire instead of as a metallic instrument for hanging coats, you might discover other uses for it. Try this technique every so often as you are actively working to solve your problem. It might help prime your brain to forge connections between distant concepts.

The moment of insight is also accompanied by a burst of alpha activity in the visual cortex, according to Beeman's study. Alpha activity, as mentioned earlier, inhibits neuron firing, meaning that during a breakthrough, your brain is less involved in processing visual information—perhaps because visual stimuli can be distracting. These findings suggest that you could help your brain discover an insight simply by closing your eyes.

Flashes of insight are markers of the creative process and may help elucidate what happens in the brain during creative problem solving.

Probably the most famous moment of insight in history is Archimedes' "Eureka!" Legend has it that the ancient Greek mathematician had been challenged to figure out whether a crown that King Hiero II of Syracuse had commissioned was made out of solid gold. Archimedes was preparing a bath when he discovered how to measure an object's volume, and thus its density, after noticing the displacement of water as he climbed into the tub. Although the story may be apocryphal, it has gone down in history in part because it illustrates perfectly how insight strikes.

STAGE 5 FOLLOW-THROUGH



Once you have had a moment of insight, you might find yourself feeling elated. A 2013 study by Tufts University researcher Tad Brunyé showed that subjects who came up with broad associations between words, such as associating "pipe" with "flute" rather than with "smoke," experienced a boost in mood. Take advantage of the positive mood to check whether your solution works. "When you have an insight, it comes with a lot of conviction," Carson says. "So you really have to be objective and evaluate that idea."

Melissa Ellamil, a cognitive neuroscientist at the University of British Columbia, led a study in 2011 that uncovered the brain processing involved in the evaluation, as opposed to generation, of creative ideas. Ellamil asked 15 art students to produce illustrations for a book while lying in an fMRI scanner. In six trials, participants produced and evaluated five drawings. Ellamil found that during the evaluation phase, the brain recruited the regions of the temporopolar cortex and prefrontal cortex associated with executive function. These areas support critical thinking and decision making.

This stage is an ideal time to bounce ideas off of trusted friends—their feedback and support could help you determine how well your solution works [see "Creativity Is Collective," by S. Alexander Haslam, Inmaculada Adarves-Yorno and Tom Postmes, on page 30]. Do not be discouraged, though, if your personal eureka is less than perfect. Creative people often describe going through many failures before reaching a successful solution. Those failures help to inform the end result, making them a necessary step in the process. When a student asked chemist and two-time Nobel laureate Linus Pauling how he came up with so many good ideas, he replied, "I have a lot of ideas and throw away the bad ones."

In practice, each stage does not always follow easily from the one before it—many people have to revisit earlier steps several times before hitting on inspiration—but ultimately the process is very rewarding. Creativity not only makes creators happy but also benefits all those who will enjoy their creations.

The joys of an aha moment may even serve a deeper purpose. In 2013 psychologists Claudia Muth and Claus-Christian Carbon of the University of Bamberg in Germany found that participants who identified a hidden face in a picture liked the image more than those who did not identify the face. Muth hypothesizes that insight is rewarding for evolutionary reasons. She says, "It could explain why we explore the world and why we have interest in things that are new."

Being curious and pursuing creative endeavors provides you with the opportunity to discover new interests, explore unfamiliar territory, develop expertise and, crucially, take breaks. In short, working to develop and maximize your creativity serves to enrich your life. As Carson puts it, "Once you realize that you can be creative, it opens up this whole new world." M

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Surgeons have implanted a new prosthesis in four patients to correct disabling dizziness.

CONQUERING VERTIGO

The device may someday restore balance to hundreds of thousands more

By James Phillips

One day in 2009 Robert Milner (not his real name), a lawyer and avid outdoorsman, was driving on a highway through the mountains of Washington State when he sensed he was tumbling sideways. Had his car flipped, propelled perhaps by an unseen T-bone collision? Milner slammed on the brakes. The car stopped—but not upside down. It sat fully upright in the middle of the highway. There Milner stayed, stuck in his mental tailspin, until the highway patrol arrived.

Such attacks of vertigo, the sense that you are moving when you are not, were not foreign to Milner. He had been having them every few days. One time he collapsed onto the courthouse steps in his suit, the world spinning as he lay on his side, nauseated and unable to move, until somebody called 911 and paramedics helped him into an ambulance.

For three years Milner's life had been literally turned upside down by a disorder affecting a small set of structures in the inner ear known as the vestibular labyrinth. This system of organs, which is next to the one that allows us to hear but separate from it, underlies our sense of how our head is oriented and moving. Although few people give it much thought, it is essential to normal function. Knowing which way is up is critical for balance, posture and locomotion. Sensing how your head is turning stabilizes your vision: when your head rotates one way, your vestibular system moves your eyes in the opposite direction so that what you are looking at remains stable. This action is called the vestibulo-ocular reflex.

When something goes awry with these inner ear organs, the world may spin or flip, vision may blur, and you may wobble or even fall. Because of the connections between the vestibular system and other brain regions, you also often vomit and get confused. Inner ear troubles may stem from ear infections, autoimmune disorders, head trauma, or treatment with certain antibiotics or cancer drugs. In Milner's case, for unknown reasons, pressure periodically built up inside one inner ear, rupturing the membranes of its component structures and shutting down their function.

Although Milner's disorder, known as Ménière's disease, is rare, affecting just 12 out of every 1,000 people, inner ear difficulties are quite common. About one in three people experiences disturbing dizziness at some point in their life because of illness, injury or drug treatment. For most of us, these symptoms, while dramatic, will be short-lived. Either the inner ear recovers, or it retains sufficient function for the brain to adapt.

Yet for perhaps one eighth of those with severe inner ear injury, the changes are too great for the brain to fully compensate for the loss of function. These individuals experience chronic unsteadiness for the rest of their life. In addition, insults to the inner ear can add up over the years, leading to balance problems in 70 to 80 percent of the elderly, in whom falls are also the chief cause of fatal injuries. For the vast majority of individuals with chronic vestibular loss, there is no effective way to restore their lost function.

In fact, for many cases of vertigo the main treatments involve the exact opposite: shutting the system down. So about eight years ago my colleagues and I at the University of Washington set out to develop an inner ear prosthesis that might restore balance and a sense of orientation to patients such as Milner and others who have sustained damage to the vestibular system.

Inertial Guidance

The brain's vestibular network serves as the body's inertial guidance system. It takes information from several sensory modalities, including vision, touch and muscle sense (kinesthesia), and uses it to help the mind compute the body's physical place in the world. Its primary sensory structure is the vestibular labyrinth, which contains five organs that relay information about head motion to the brain. Three semicircular canals, which look like tiny Hula-Hoops oriented at right angles to one another, reveal the rotation of our head in three dimensions; two saclike otolith organs tell us how the head is oriented with respect to gravity and if it is moving linearly up, down or sideways.

If you turn in any direction, you will activate some combination of semicircular canals; if you lean to one side or move in a straight line, the otolith organs will spring to life. These organs are filled with fluid and contain receptor cells whose fine hairs project into a gelatinous tongue or layer (depending on the organ) within that fluid. When the head moves relative to the fluid or gel, the hairs bend, activating the receptor cells to which they are attached and sending signals to the brain.

All the hair cells in a given semicircular canal have the same orientation within the gelatinous tongue and so send identical directional information to the brain: they signal rotation in the plane of that canal [*see box on page 46*]. Any time you rotate your head, you trigger some combination of activation in the three canals on each side of the head, with the direction of motion coded in

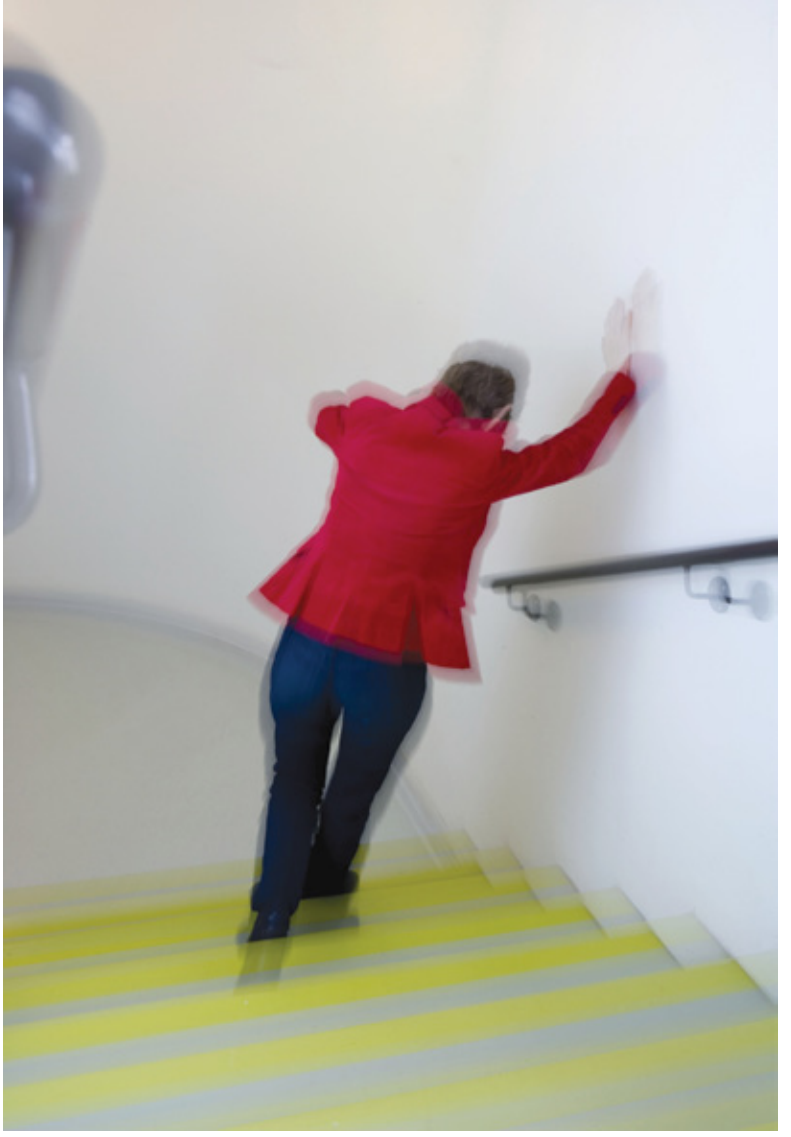
FAST FACTS

LOSING YOUR BEARINGS

1. One in three people experiences disturbing dizziness at some point in their life resulting from illness, injury or drug treatment.
2. Insults to the inner ear can add up over the years, leading to balance problems in up to 80 percent of the elderly, in whom falls are also the chief cause of fatal injuries.
3. An experimental inner ear prosthesis can restore balance and a sense of direction to patients who have sustained serious damage to the vestibular system.

PRECEDING PAGES: RICHARD SAINSBURY *Getty Images (man)*; RIAN HUGHES *Corbis (black-and-white circles)*

When something goes wrong with the organs of your inner ear, the world may spin or flip, vision may blur, and you may wobble or even fall. You also often vomit and become confused.



their relative signaling rates. So if you move your head up and then to the left to observe a passing butterfly, both your posterior canals will respond vigorously to the upward motion. At the same time, cells in both anterior canals will quiet down. Turning to the left will spur strong signals from your left horizontal canal and blunt the response from the right one.

The canals are oriented in complementary pairs in either ear, with any motion increasing the signaling rates from some canals and decreasing the signaling rates from the complementary canals in the opposite ear. The brain deduces the speed of the motion from the frequency of the signals from each canal. If you whip your head to the right, for example, the hairs in the canals in your right ear will bend dramatically, producing more frequent nerve signals from those canals and less frequent nerve signals from the canals in your left ear. These signals are sent to the brain, which has the job of making sense of them.

In the otolith organs, hairs from the receptor cells project up into a gelatinous matrix. At the top of the matrix are calcium carbonate crystals called otoliths. A tilt of the head causes the otoliths to fall to one side, as if they were fruit atop a pan of gelatin. The movement bends the "gelatin" and the hairs of the embedded hair cells. Moving the head vertically or horizontally moves the hair cells up and down or sideways under the crystals, which lag behind, again bending the gel and the hair cells. In this way, these organs detect linear motion and tilt.

In people who have no vestibular information, a condition typically caused by a drug that is toxic to hair cells, objects seem to move whenever the head moves, as if the person were looking at the world through a shaking video camera. Balance is severely compromised, causing these individuals to stumble as if they were drunk or to take short shuffling steps. In these cases, a simple task such as going to the mailbox becomes an almost insurmountable challenge. Because the vestibular system connects to parts of the brain that govern working memory and concentration, patients also may have trouble thinking clearly, focusing, or remembering events and locations. Each day is like floating in the ocean, with both thoughts and physical sensations similarly unanchored.

For these individuals, canes and walkers act like hearing aids, providing additional sensory input from touching the ground. The devices do not speed up or normalize their users' gaits, however, nor do they allay the sense of disorientation and physical detachment that often accompany the condition.

Lopsided damage to the vestibular system, which is the more typical consequence of disease or trauma, can be even worse, producing nausea and dramatic illusions of being in motion. Damage to just one ear also produces the extreme vertigo that people with Ménière's disease experience.

When we are motionless, the brain expects balanced vestibular information

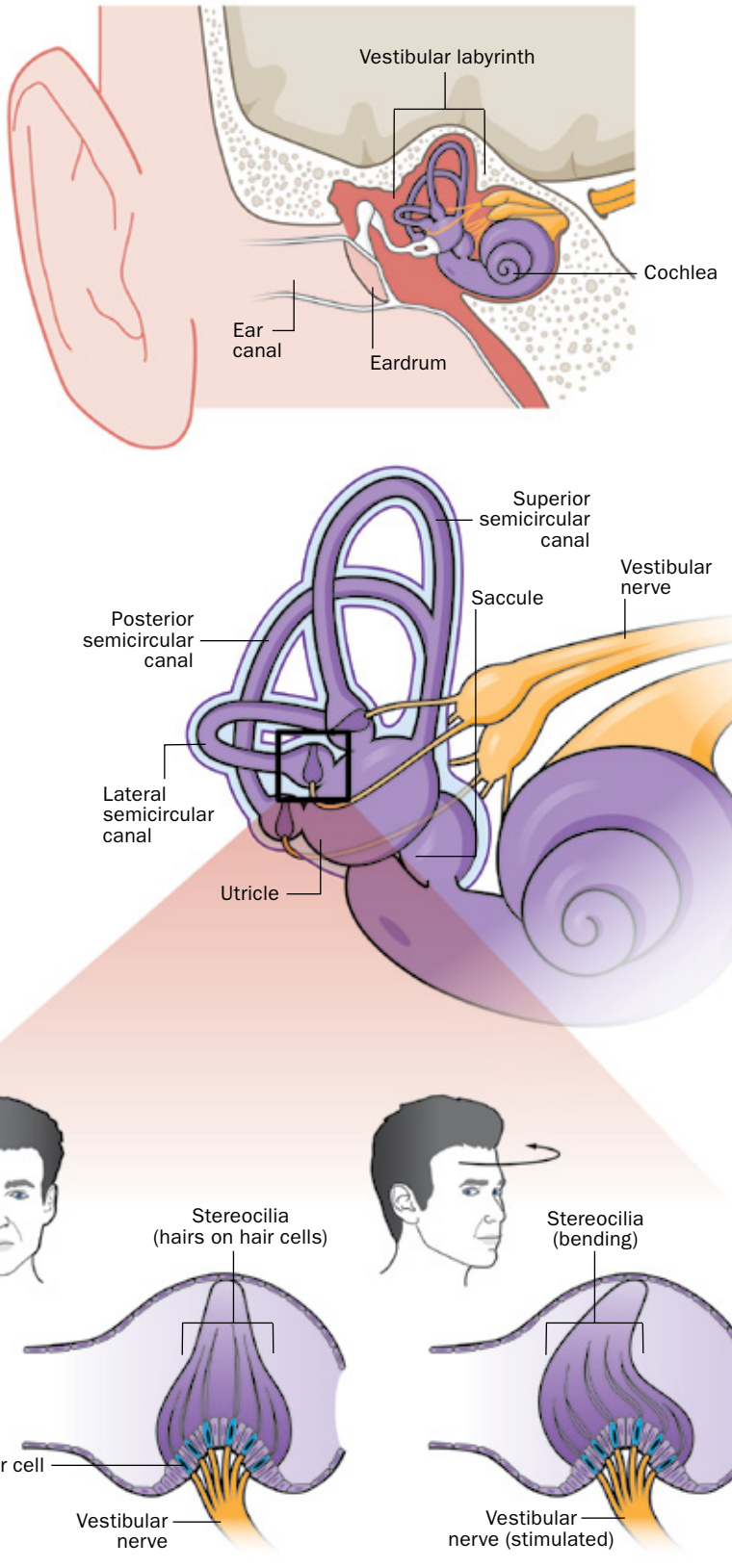
SCIENCE SOURCE

Knowing Which Way Is Up

Many people think the ears are only for hearing. But our ears contain organs that are critical to our ability to sense how we are oriented in the world, to see clearly and to balance. These structures make up the vestibular labyrinth. They are located near the cochlea, the hearing portion of the inner ear, but serve distinct functions.

Among these vestibular organs are three semicircular canals (superior, posterior and lateral), which sit at right angles to one another. Their job is to sense head rotation in three dimensions. When the head turns, fluid inside the canals moves and jostles a gelatinous substance into which the hairs (called stereocilia) from sensory cells project. The bending of the hairs then causes the hair cells to send signals through the vestibular nerve to the brain. Sensing head rotation is critical for vision: the eyes must compensate for such motion, or else our surroundings will appear to shake with every turn of the head.

The two other vestibular organs are the utricle and the saccule. These sac-like structures tell us how we are oriented relative to the pull of gravity; they thus allow us to detect head tilt and linear motion. In these organs, the hairs of the receptor cells are embedded in a gelatinous layer topped by calcium carbonate crystals. Tilting the head makes the crystals fall to one side, causing both the gelatinous layer and the stereocilia to bend. Lateral movement shifts the crystals horizontally or up and down, again distorting the stereocilia and eliciting a response from the sensory cells.



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from each ear. Motion toward one ear creates an imbalance, with more input coming from that ear and less from the other one. So when one ear goes virtually mute, the brain interprets the relatively larger input from the other ear as a rapid turning or tumbling in its direction. The illusion is impervious to reason. Even if you know you cannot possibly be moving, you still feel as if you are spinning or somersaulting through space. Meanwhile the brain activates reflexes that violently empty the stomach, in case you were poisoned, and hurls the body toward the affected ear to "save" you from your presumed fall in the other direction.

For Milner, disease did not so much destroy vestibular function on one side as cause it to fail intermittently. As fluid accumulated for unknown reasons, his inner ear membranes stretched and then ruptured, causing fluids to mix between different compartments. The mingled fluids wiped out the electrochemical gradients the hair cells need to send signals to the brain. At that point, the ear fell silent. For some, diet and diuretics can control the frequency and severity of these episodes. Surgery to lance a portion of the inner ear membrane may relieve the pressure, but its effects typically do not last. None of these strategies helped Milner. His only remaining option: chemical or surgical destruction of vestibular function—and often hearing—in the affected ear.

As the lawyer prepared for surgery in 2010, his surgeon told him about one other treatment strategy that was highly experimental. My University of Washington colleagues and I had just received approval from the U.S. Food and Drug Administration for the first clinical trial of an implantable nerve stimulator that would replace vestibular function. We offered Milner the chance to be one of our first 10 patients.

Artificial Dizziness

My colleagues and I had long dreamed of developing a remedy for the six million people with bilateral vestibular loss and the far larger number with uncompensated single-sided loss. In our clinic over the years, we had seen people born with a genetic disorder called Usher syndrome that leaves them with little or no vestibular function or hearing. These individuals at first use vision to regain some of their balance, only to lose their sight in adolescence. Other patients of ours had had chemotherapy or a course of antibiotics that had chemically killed all the vestibular hair cells in both ears. Their balance was extremely poor; they could not determine their body's position in the environment, and they experienced oscillopsia, in which the visual world gyrates wildly whenever the head moves. Still other patients had lesser damage that led to temporary vertigo but left them with a lasting unsteadiness and disorientation. Such amorphous symptoms also afflict many elderly patients with vestibular loss.

When we are motionless, the brain expects balanced information from each ear. When one ear goes mute, the brain interprets the relatively larger input from the other ear as rapid turning in its direction.

In 2006 I teamed up with several colleagues to develop technology to help the most severely afflicted patients. We wanted to treat patients who have little or no inner ear input or who, like Milner, receive dramatically fluctuating signals to which the brain cannot adapt. Our group, which included neuroscientists, biomedical engineers and an inner ear surgeon, applied to the U.S. National Institute on Deafness and Other Communication Disorders to build and test a device.

We were far from the first to float this idea. In fact, back in the 1960s neuroscientists Bernard Cohen and Jun-Ichi Suzuki, both then at Mount Sinai Hospital in New York City, had implanted wires in the inner ears of cats and monkeys and showed that by sending current through the wires, they could produce naturally appearing eye movements in different directions, similar to those seen during head movements. More recently, research teams at Harvard University and Johns Hopkins University had been working on small, fully implantable devices attached to motion sensors that stimulate the inner ear during head movement, but they were not yet ready to be implanted in people.

Like these other experimental prostheses, ours would stimulate the semicircular canals only. The hair cells in the otolith organs are positioned in a variety of orientations, leading to an array of signals encoding direction of motion that would be more complex to recapitulate. Our approach was different from the others in one important respect, however. Instead of building a device from scratch, we planned to adapt the robust and proved technology used in cochlear implants. Cochlear implants generate electrical pulses that activate the auditory nerve to restore hearing. Similarly, our device would stimulate the vestibular nerves to restore orientation and balance. The implanted stimulator would be identical to one that was already tested and approved in humans; we would simply change the electrodes and programming

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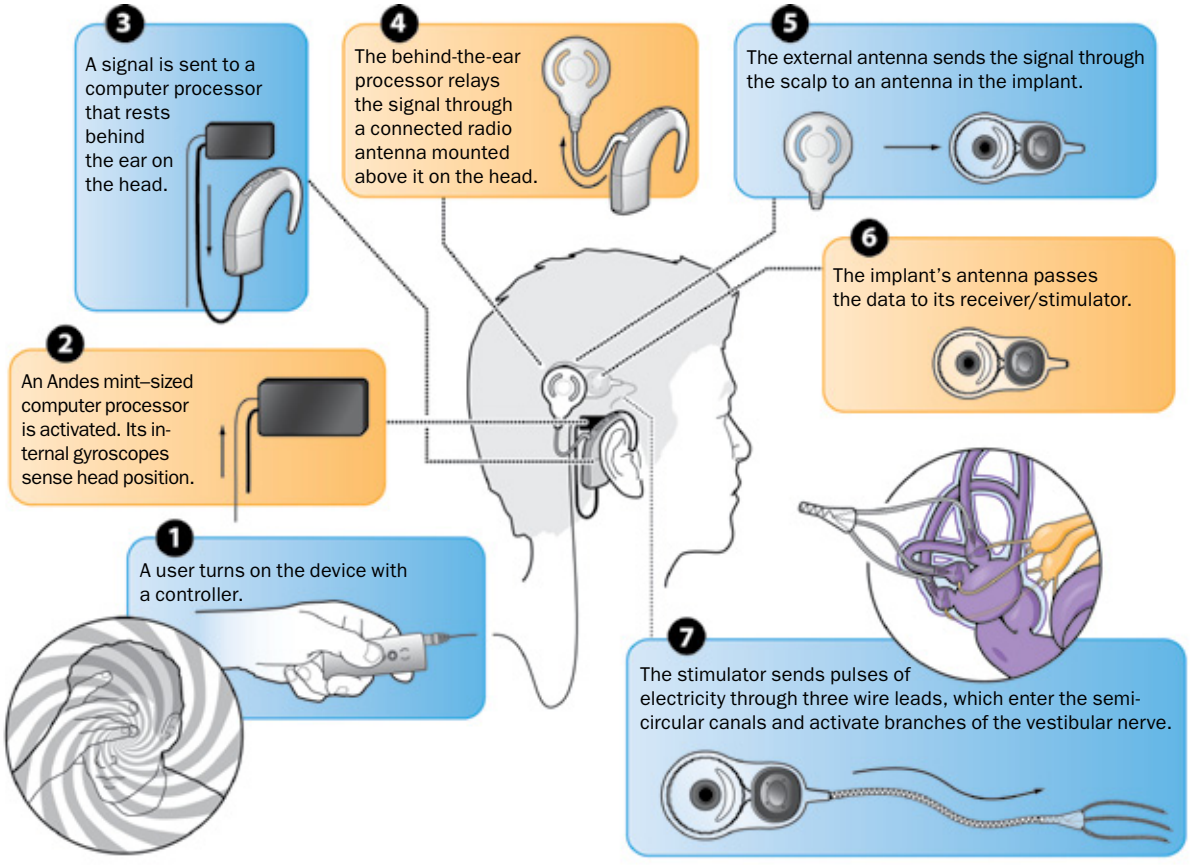
JAMES PHILLIPS is a research associate professor in the department of otolaryngology–head and neck surgery at the University of Washington. He is director of the Dizziness and Balance Center at the University of Washington Medical Center, director of the Clinical Oculomotor Laboratory at Seattle Children's Hospital and an affiliate of the Virginia Merrill Bloedel Hearing Research Center.

Electronic Ears

An experimental device can reduce vertigo and restore balance in those whose vestibular organs have been seriously compromised. Here's how the technology works.



of the device to suit its new application.

On August 1, with funding secured, we began working in earnest on the various parts of the device. A system of three tiny gyroscopes would align with the semicircular canals to sense head motion. These gyroscopes would sit outside the head, encased along with a computer processor in a box the size of an Andes thin mint. The processor's job would be to translate the information from the gyroscopes into radio waves, which it would transmit to the stimulator implanted behind the ear in the temporal bone of the skull. The stimulator would then send its signals through three leads, each of which would tunnel into a separate semicircular canal [*see box above*].

Our electrode leads had to be far tinier than those in the cochlear implant—narrower than one fifth of a millimeter and less than 2.5 millimeters long—to fit in the bore of each semicircular canal. We programmed our coin-sized stimulator to deliver pulses of electricity that would become more frequent as the head moved faster toward the implanted ear and slower as the head turned more rapidly away from that ear. Our program also varied the stimulation of the nerves from each semicircular canal by the plane of the rotation—its horizontal, or yaw (turning left to right), vertical, or pitch (nodding up and down), and lateral, or roll (tilting from shoulder to shoulder), components.

By the end of 2006 we had a prototype. We tested its fit and durability by implanting it in skulls from animal and human cadavers. In October 2007 we put it in a living monkey. We turned it on and watched the monkey's eyes. If the device worked, the eyes would move in the opposite direction of the movement encoded by the stimulation, triggered by the vestibulo-ocular reflex. To our disappointment, however, the monkey's eyes stayed put.

Then, in spring 2008, our surgeon, Jay Rubinstein, decided to subtly reposition the electrodes, shifting them just a few millimeters within the inner ear. When the switch was flipped, the monkey's eyes moved! We turned off the juice; the eyes stopped. We ramped it up, and the eyes moved faster. We changed which nerve received stimulation, and the eyes changed direction. In short, we successfully created all manner of artificial dizziness in this animal. We also did the opposite and made the monkey immune to vertigo. As the monkey spun around in a movable chair, as if in an amusement park ride, we turned on the prosthesis—and its eyes stopped moving,

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revealing that the monkey no longer sensed that it was spinning.

We saw similar success in six more monkeys. None of them lost their natural sense of balance, and most retained their hearing, so the implant seemed safe. And it kept working for more than 18 months in the first monkey. In October 2009 we applied to the FDA to put the stimulator in humans.

Bionic Balance

In 2010 we had the go-ahead from the FDA and began recruiting patients. In theory, the best candidates included those with no vestibular function. But the surgery to implant the stimulator would pose risks to these individuals, including possible hearing loss—and the benefits were largely unknown. In contrast, the implantation surgery might actually help people like Milner who had severe, intractable Ménière's disease. In these patients, after all, radical surgery to destroy one ear is their main last-resort treatment option. So we decided such patients were ideal candidates for our trial.

By the end of October 2010 Milner was having multiple attacks a week. After each one, he would take sedatives that shut down his inner ear; he also downed antiemetics to block the nausea. In a day, he would recover, as would his inner ear membranes—only to rupture again within a couple of days. Milner just wanted it to stop, as his life shut down every time his ear did. He volunteered to be our first patient. He hoped not only to get relief from his condition but also to help others who suffered as he did.

After six hours in the operating room, the surgeon stitched up Milner's ear. Milner recovered rapidly and went home the next day. A week later he returned to our laboratory for testing. We fastened a headband containing the external processor and strapped him to a clinic bench with a seat belt. We worried he would become nauseated or disoriented, hear loud sounds or feel facial pain. Then we turned on the stimulator for the first time.

We stimulated the horizontal canal on the right side—and Milner's eyes moved left. In the dark, he felt as if he were turning right. We toggled it on and off, and he alternately sensed turning and stopping. If we kept the pulses consistent and the current steady, Milner experienced spinning, as if on a merry-go-round. If we roused the anterior vertical canal, Milner felt as if he were tipping forward and to the side toward that ear. When the power was switched off, he sensed he was returning to an upright sitting position. The device was working!

We turned the device on and off, and our patient alternately sensed turning and stopping. If we kept the pulses consistent and the current steady, he experienced spinning, as if on a merry-go-round.

Milner did not feel sick. He was not in pain, and he did not hear phantom sounds. He experienced hearing loss in the implanted ear, but this outcome was the same as the alternative surgery would have produced. On other visits, we have asked Milner to walk, turn his head and balance on a wobbly platform. With the help of the device, his balance improves, and he is steadier as he moves. We have since implanted the device in three others with Ménière's, with similar results. This summer three additional patients will get the contraption. Although we are excited by the progress we have seen, only time will tell whether this new technology will provide a lasting therapy for vestibular loss. No one is sure yet how long each implant will remain effective or whether the brain will adapt fully to this new form of vestibular information. With the device, signals arrive synchronously from all the stimulated fibers in one ear, whereas naturally occurring signals arrive at different times and from both ears. But if the technology is proved safe and effective over long periods, it may provide relief to all those who suffer from chronic imbalance and disorientation—including people with partial vestibular loss who cannot adapt to their condition. With such implanted technologies, vestibular loss may no longer be incurable.

Milner has had his device for three years. Although our FDA-approved protocol does not permit him to use the still experimental device all the time, he turns it on if he starts to feel unsteady or dizzy. When he does, stability returns. His attacks are also less frequent now, most likely because the implantation surgery reduced his natural vestibular function. For both reasons, his life is vastly richer and easier than it was before he received his prosthesis. Earlier this year he sent us a digital photograph from a recent ski trip. He stood at the top of a run at his favorite ski resort. A sign in the picture noted the name of the trail: "Vertigo." M

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WHEN AROUSAL IS AGONY

SEXUAL DYSFUNCTION CAN EMERGE WHEN CERTAIN NERVES START MISFIRING. ARE SSRIS PARTIALLY TO BLAME?

By Cat Bohannon

A woman we'll call Sally lived in a small town deep in the heart of Texas hill country, a long, rippled patch of land wet with creeks and big oaks growing right out of the water. It's mostly middle class, mostly Christian, the sort of place where you don't have to lock your doors because you already know all your nosy neighbors. She lived with her husband and her kids were grown.

One day her husband took her out for a ride on his motorcycle. When they picked up speed, she was sucked off the back. Sally flew through the air, legs akimbo, and landed on her bottom. The doctors at the ER told her she had compressed a number of disks in her spine, broken her tailbone and snapped her wrist in three places. "Yeah, I messed myself up pretty good," she says.

After running a gauntlet of surgeries, drugs and physical therapy, her spine started to heal. Things were looking up. She was having some trouble with her bladder—"felt like I needed to pee all the time"—but doctors were taking care of that.

Then it happened.

Sally got really, really horny.

But she didn't want to be. Though she didn't know it at the time, Sally had restless genital syndrome (ReGS), a recently discovered, mysterious disease that causes maddening sexual arousal for thousands of men and women worldwide. It's not sex addiction. It has little to do with conscious desire. Though it causes psychological distress—many patients become suicidally depressed—ReGS is a peripheral wiring problem.

Triggered by some combination of physical trauma, medication and hormonal changes, the nerves of the pelvis send waves of unwanted and disturbing signals to the brain. For example, you might feel the need to masturbate for 12 hours at a stretch. You might feel a constant buzzing, tingling sensation in your crotch. You might have an orgasm because your jeans brushed you the wrong way in the supermarket. You might start to avoid both your jeans and the supermarket. Soon your life will be nearly impossible to manage.

The renowned sexologist Sandra R. Leiblum originally discovered ReGS in 2001. Though most scientists think the disorder is fairly rare, clinicians in the field say diagnoses are on the rise, at least in part because it is becoming better known. Irwin Goldstein, director of sexual medicine at Alvarado Hospital in San Diego, has seen hundreds of patients with ReGS in his practice. At national conferences, he will ask from the podium how many clinicians believe they have seen patients with ReGS, and two thirds of the audience will raise their hands. David Goldmeier, a sexologist at St. Mary's Hospital in London, conducted a survey at a walk-in clinic for sexual disorders and found that a full third of the women had some kind of spontaneous or persistent genital arousal. But far fewer of his subjects fully qualified for a ReGS diagnosis, and none of these tiny samples can tell us how many people really have it.

Like many patients with sexual dysfunction, Sally found herself deep in the American heartland with a startling realization: she was not entirely "in charge down there." But sexuality is not a top-down system. The brain doesn't just decide to become sexually excited and then send signals to the appropriate spots. The brain and the peripheral nervous system work together to build an individual's sexuality—and their rapid-fire conversation can become prickly when the two disagree.

Searching for a Diagnosis

Sally calls her husband a "trooper." In the beginning, he was very supportive, even as his wife alternated between crazed sexpot and withdrawn depressive, even though he didn't really—couldn't really—understand. He drove her to doctor after doctor, although driving was the worst. The low vibration of a car seat had become unbearable for her.

There are essentially four places in the world where doctors know the latest about ReGS: California, New Jersey, the U.K. and the Netherlands. Sally did not live in any of these places. Though eventually she would discover all the top names in this burgeoning field, the only doctor she knew at first was her urologist. She still felt like she had to pee all the time.

Like many people suffering from ReGS, Sally described her symptoms with electrical metaphors—a "shock," "buzzing" or a "zap," that feeling of being right at the edge of an orgasm, the itchy, breathless *before*. It wasn't pleasurable, however. It was painful—and

FAST FACTS

BAD VIBRATIONS

1. Restless genital syndrome is a recently discovered, mysterious disease that causes maddening sexual arousal for thousands of men and women worldwide.
2. Many patients with restless genital syndrome link certain popular antidepressants—selective serotonin reuptake inhibitors—to the start of their symptoms. Injuries or hormonal changes may also play a role in some instances.
3. The brain and the peripheral nervous system work together to build an individual's sexuality. Trouble ensues when these two disagree.

PAGE 50: ERIK ASLA *Gallery Stock*; PRECEDING PAGE: ISTOCKPHOTO (*dagger*)

GETTY IMAGES

once it started, it wouldn't stop. It came in waves, sometimes for hours a day. If Sally had an orgasm, it only got better for a minute or two, and then the pain returned. "I couldn't think of anything worse to happen to a human being," Goldstein says. "To be at the throes of high arousal, almost anything pushes you into it, and [that] brief refractory period hoping you can get some respite, but you don't, it comes right back."

The accepted wisdom is that ReGS involves some malfunction of the pudendal nerve complex. Hooking onto the bottom of the spine, the pudendal nerve is a thick bundle of fibers that branches out to innervate the lower pelvis. One branch controls the anal sphincter, another the urethral sphincter and a third dorsal branch extends, in men, to the end of the penis and, in women, to the fat club of the clitoris. It's generally a well-liked part of the peripheral nervous system.

At Haga Hospital in the Hague, neuropsychiatrist Marcel D. Waldinger runs one of the world's only clinics specializing in ReGS. He noticed in 2008 that ReGS symptoms tended to occur together with an overactive bladder and restless legs syndrome—the persistent, nervous urge to twitch one's legs because they feel "strange" or "tingly." Thinking of the way the sacrum serves as a nerve hub for both the pelvis and the legs, Waldinger realized these disorders could be essentially the same problem: chronic aberrant neural activity around the sacrum, just referring to different places—the sciatic nerve for restless legs or the pudendal nerve complex for restless genitals or overactive bladders. Sally fit this profile: her bladder was what led her to a urologist in the first place.

Such academic discussions are all well and good, but the sciatic nerve doesn't challenge a woman's self-worth

IT CAME IN WAVES, SOMETIMES FOR HOURS A DAY. IF SALLY HAD AN ORGASM, IT ONLY GOT BETTER FOR A MINUTE OR TWO, AND THEN THE PAIN RETURNED.

quite the way the pudendal does. One quiet night in Texas, Sally did not know what was wrong with her yet. She had taken to drinking wine alone at home because it seemed to numb her a little. She also took pills to sleep. She remembers talking on the phone with her sister, drinking from the bottle, taking some pills, and then drinking more and taking more pills. Her sister was telling her to stop, to hang in there, that it wasn't worth it. Did she want to die? Maybe? Maybe. They found her in time.

Luckily, Sally's urologist had recently gone to a conference where she had heard Goldstein speak about his research on ReGS. Sally had her first glimmer of hope in years. Now she had a diagnosis that felt right to her—"I wasn't crazy. It was real. A real thing," she says. Finally she could find a doctor for what she was actually suffering from: not her bladder, but her nervous system. As for why her body went haywire, the accident wasn't the only culprit. It probably also had something to do with her uterus: Sally didn't have one.

The Many Lives of Serotonin

Sally had been artificially menopausal for many years before the accident. She had had a hysterectomy at age 27, with little in the way of hormone therapy since. Men and women both have a wide variety of sex hormones—estrogens, androgens and progestogens—in a sex-typical balance. In women, that balance changes with menopause. Women diagnosed with ReGS vastly outnumber men, with menopausal women forming the largest segment of ReGS cases. And Sally's body was in a kind of extreme menopause because she had neither a uterus nor ovaries.

One of the many roles of estrogens in the body is their influence on serotonin, a neurotransmitter that, among other duties, helps to regulate blood flow. Vasoregulation is incredibly important for sexual function. Just as it enables erections in men, the dilation of blood vessels in a woman's pelvis swells tissue in and around the vagina and spurs the production of lubricating mucus. The nerves of the genitals become extra responsive, and the entire area gets ready for coitus. In part through their actions on serotonin, the estrogens—especially estradiol—normally facilitate this process. In women of reproductive age, blood levels of estradiol correlate positively with serotonin levels. As estradiol decreases with menopause, the genitals can become less sexually responsive—not from any psychological predetermination, but because of what is essentially a plumbing problem.

THE TRANSMISSION OF SEXUAL SIGNALS ALONG THE DORSAL NERVE MAY BE TURNED ON, NOT OFF, BY DEFAULT.

Menopause is not the only way to manipulate serotonin levels, however. The most popular type of antidepressant, selective serotonin reuptake inhibitors (SSRIs), also targets serotonin. These medications can similarly diminish blood flow in the pelvis, thereby blunting sexual responsiveness. Erectile dysfunction and its analogue in women are such common side effects of SSRIs that some doctors are now in the habit of prescribing a cocktail of antidepressants and Viagra.

Many patients with ReGS link SSRIs to the start of their symptoms. Goldmeier and Leiblum published a paper on the link between SSRIs and ReGS in 2008; more papers have followed. In most cases, symptoms seem to start after either reducing dosage or discontinuing SSRIs. It has been known for some time that going off these drugs can cause negative side effects, including problems with mood, dizziness, headaches, digestion and sexuality. In 1996 the Eli Lilly company—flush with recent Prozac money—held a symposium on these issues. One study found that up to 80 percent of patients suffered from withdrawal symptoms, although after the symposium these were called "discontinuation syndrome."

SSRIs boost levels of serotonin at synapses (the junctions between neurons) by blocking neurons from corralling leftover serotonin after the neurotransmitter has done its job. The body may adapt to the excess by reducing sensitivity to serotonin overall. After a patient quits or lowers the dose of an SSRI, neurons can quickly scoop up the free-floating molecule, causing serotonin levels to drop even while the nervous system might still be less sensitive to serotonin—a double whammy. In patients who go on to develop ReGS, this change could lead to a vascular system that neither constricts enough nor dilates enough under the appropriate circumstances. The pelvic nerves may also go on the fritz, becoming chronically hyperstimulated. For some, ReGS will mysteriously go away after a month or two. For others, such as Sally, the disease gets progressively worse. Even more inexplicably, some patients get relief from taking an SSRI when their symptoms flare up.

As Waldinger describes it, ReGS is a kind of umbrella diagnosis: lots of different things can cause the neuronal misfiring associated with ReGS. No one knows for sure why Sally got it, but she had risk factors. Sally had once taken SSRIs for depression, but she was not on them when her ReGS symptoms developed; she had experienced dramatic hor-

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GALLERY STOCK

monal changes after her hysterectomy, however, and, of course, she had suffered severe trauma to the pelvis.

Finding the Code

Newly armed with a name for her disorder, Sally wasn't sure what to do. But she couldn't do nothing. She was tired of feeling like a "live wire."

Sally had already quit her job. Many ReGS patients lose their jobs. As she says, "You just can't function." Unfortunately, they are also unlikely to be eligible for disability benefits in the U.S. Although ReGS is now fairly well documented in the scientific literature, the disorder is not yet named in the current *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-5*) or the *International Classification of Diseases*. These two bibles of medical diagnosis—one for mental disorders, one for more general epidemiology—are the main points of reference for how American Medicare and insurance companies generate "codes" for claims.

In the *DSM-5*, a condition called "substance/medication-induced sexual dysfunction" mentions the SSRI fluoxetine, but the diagnosis refers to problems of diminished libido such as erectile dysfunction, not rampant, life-crippling sexual sensations. And, of course, ReGS is not always caused by medication.

Like any bible, the *DSM* is slow to change. The book still listed homosexuality as a pathological "sexual deviation" in 1973. Conditions based on physical neuralgias move a bit faster, but debates about sexual disorders tend to linger on a strange bridge between psychological and physiological, which could leave ReGS without an official stamp for some time. The result: insurance will not cover it. Instead some patients are diagnosed with interstitial cystitis—inflammation of the bladder, producing pain and the constant need to urinate.

Waldinger has a novel theory for why patients like Sally always feel on the verge of an orgasm. He thinks the transmission of sexual signals along the dorsal nerve to the lower spine may be turned on, not off, by default. House lamps work that way: once the lamp's cord is plugged in, electricity always runs between the wall and the lamp. The switch simply permits that energy to reach the bulb's filament. In this line of thought, your dorsal nerve may be, under normal circumstances, always ready to send signals to your spine that say, "Hey, orgasm incoming." Yet because of a complex inhibitory system surrounding the nerve, we only "hear" that signal at the right time.

Much of the human nervous system relies on complex arrangements of excitation and inhibition. One neuroscientist in Eric R. Kandel's laboratory at Columbia University estimates that roughly 20 percent of the neurons in the brain are inhibitory. For some patients with ReGS, Waldinger suspects that a specific kind of neuropathy—a problem with small fibers around the dorsal nerve—interrupts an inhibitory system, leaving the switch jammed on.

Whatever the underlying mechanism for the neural misfiring, dampening or interfering with that signal is the goal of every type of treatment available for patients like Sally. Every clinician in the know will prescribe a combination of psychotherapy to cope with the pain and

DRIVE IMAGES *Alamy*

SOME PATIENTS OPT FOR A $60,000-PLUS SURGERY IN WHICH A KIND OF PACEMAKER IS INSTALLED NEAR THE BUTTOCKS.

embarrassment, hormonal or neurotransmitter drug therapies to deal with the nerves, and sometimes mechanical intervention. Some patients receive anesthetic nerve blocks to mute the dorsal nerve or the pudendal complex overall, but these blocks tend to wear off over time, and the injections can be phenomenally painful.

Waldinger's practice has seen some success with TENS units, small boxes that send electrical signals down to nerves through the skin—in this case, wiring up women's genitals like something out of a steampunk magazine. ("TENS" stands for transcutaneous electrical nerve stimulation.) Goldstein sends some of his patients to a hospital in Michigan for a $60,000-plus surgery in which a kind of pacemaker is installed near the buttocks, sending controlled bursts of electricity down toward the sacrum. Both interventions are designed to interfere with, and thus impede, the errant nerve signal. Among other remedies, patients may try botulinum toxin, electroconvulsive therapy, or surgery to aspirate and seal cysts in the lower spine—a condition that behavioral neuroscientist Barry Komisaruk of Rutgers University has recently linked to ReGS.

Every patient's treatment is a bit of an experiment. No single intervention has been proved effective in the majority of cases, so doctors have to approach treatment for ReGS as trial and error, taking account of each individual's particular history and symptomatology.

Sally didn't have many options. Based on a recommendation from her urologist, she was starting to think a visit to Goldstein in San Diego sounded pretty good. She just wasn't sure she could afford it. Texas is a long way from California, and Goldstein's clinic is expensive. Yet his patients hold him in a kind of reverence. Of all the scientists and clinicians who work with ReGS, he is the most hopeful about treatment outcomes, and many patients of his have seen some

relief. Without insurance, however, trial-and-error treatments rack up significant medical bills. One woman took out a second mortgage on her home to afford it all.

"I Wish *My* Wife Had That Problem"

Shame is a huge barrier to more comprehensive clinical research into ReGS. Sally needed to be called "Sally" in this story, rather than her real name, because she lives in a small, conservative town. Other patients with ReGS have even stronger motivations to keep quiet. Goldstein says people could be fired: "A kindergarten teacher having sexual feelings in her classroom—can you imagine?" Women with the disorder often feel ashamed to come forward and speak with their (frequently male) doctors. Among those who have, many feel frustrated by the responses they receive. One physician Sally had consulted told her, "Gosh, I wish *my* wife had that problem."

Perhaps we can forgive that particular faux pas. His patient was a middle-aged woman, and people continue to conflate a woman's menopause—the cessation of her menstrual cycle—with the death of her sex life. Libido naturally decreases with age in many populations, but there is no evidence that it goes away entirely. Nor does it wane particularly in women, although many women expect it to. It is unclear whether this very belief—that they are not supposed to be aroused so often—is part of why women vastly outnumber men right now in the rank and file of ReGS. Maybe women are more likely to report their symptoms to their doctors. Men with the disease typically say they felt ashamed to go to the doctor with a complaint because sexual desire is supposed to be "manly." Even Sally's husband, who loved her deeply, struggled to reconcile his wife's illness with old ideas about women's sexuality. He worried, Sally says, that he "wasn't enough" for her, that maybe she just wanted to sleep with other people, that she was not taking care of him like a wife should. They were fighting a lot.

MOSTLY SHE WAS SCARED HER HUSBAND WOULD LEAVE HER AND TAKE THE CAR, AND SHE'D BE LEFT WITH NOTHING.

Sally wasn't sure why she took the car. She had reasons—she would need a car in California, planes were expensive—but mostly she was scared her husband would leave her and take the car, and she'd be left with nothing.

Sometimes you just make a decision in the middle of Crazy, and that decision anchors you. For Sally, that decision meant driving to California sitting on big bags of ice from gas stations to numb her labia and clitoris. She had a sister in California, a place to stay. It's a 26-hour drive, with two ways to do it: I-10, which takes you through western Texas badlands and the White Sands Missile Range, or up north to I-40 for Albuquerque and Flagstaff, just south of the Grand Canyon. The northern route takes a little longer, but it goes through more proper towns, and proper towns have ice machines. Sally went north. It took her four days.

Sally kept driving. The long, black throat of the road squeezing her little car forward, forward, through the desert, over mountains, one gas station after another, stopping only to pee, to barely sleep, her crotch numbed by an ice pack and still pulsing, still there, the anesthesia of the road dulling her brain, her husband on the phone, crazy with rage, Sally kept driving. Maybe he'd leave her. Maybe he wouldn't. Just drive. Her sister was waiting for her. That new doctor, waiting for her. Just drive. Drive.

Sally still has ReGS—or, as Goldstein calls it, persistent genital arousal disorder (PGAD), the syndrome's original name. Since becoming a patient at Goldstein's clinic, Sally has tried a number of treatments, including hormones, talk therapy and nerve blocks, with little success. She eventually got the surgery in Michigan, which helped greatly. Sex is still a trigger, but she can swim, do Zumba and even drive again without pain. Time will tell if the improvement lasts. For now, she is struggling with the medical bills—her husband is the breadwinner, and there isn't much bread to go around. M

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- **Prevalence of Sacral Spinal (Tarlov) Cysts in Persistent Genital Arousal Disorder.** Barry R. Komisaruk and Huey-Jen Lee in *Journal of Sexual Medicine,* Vol. 9, No. 8, pages 2047–2056; August 2012.
- General information on restless genital syndrome: **www.restlessgenitalsyndrome.com/en/index.html**

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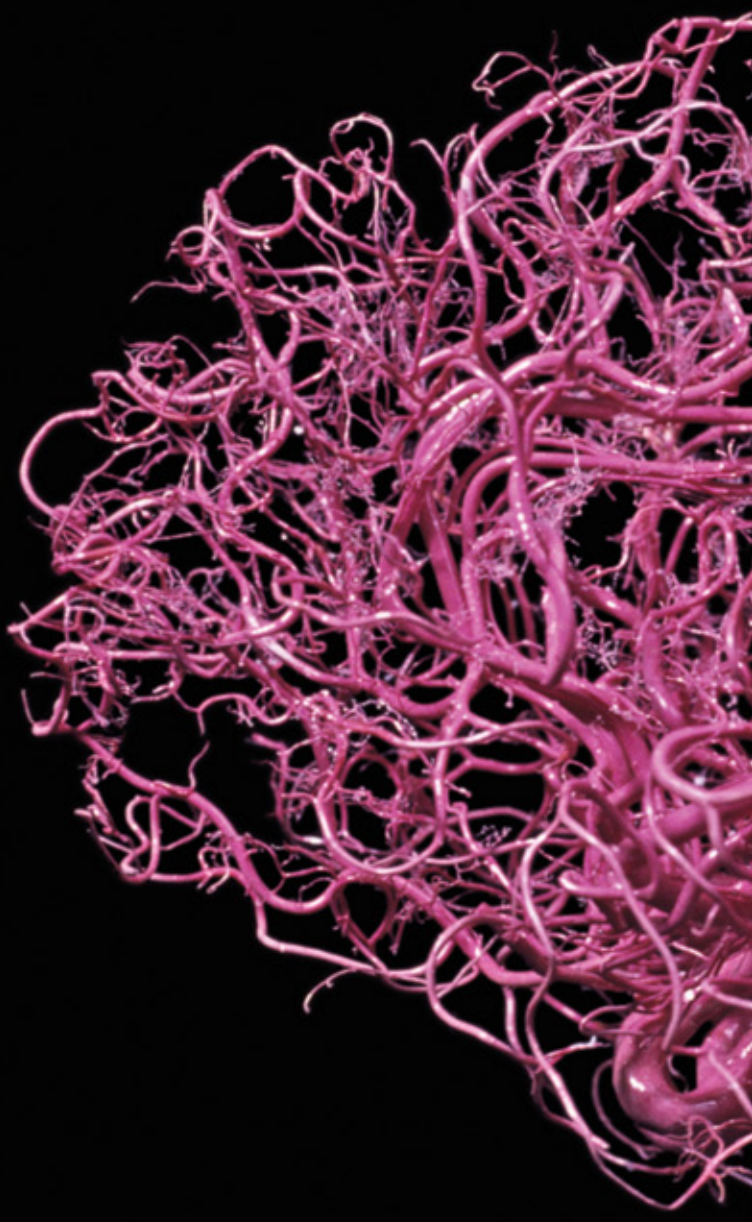
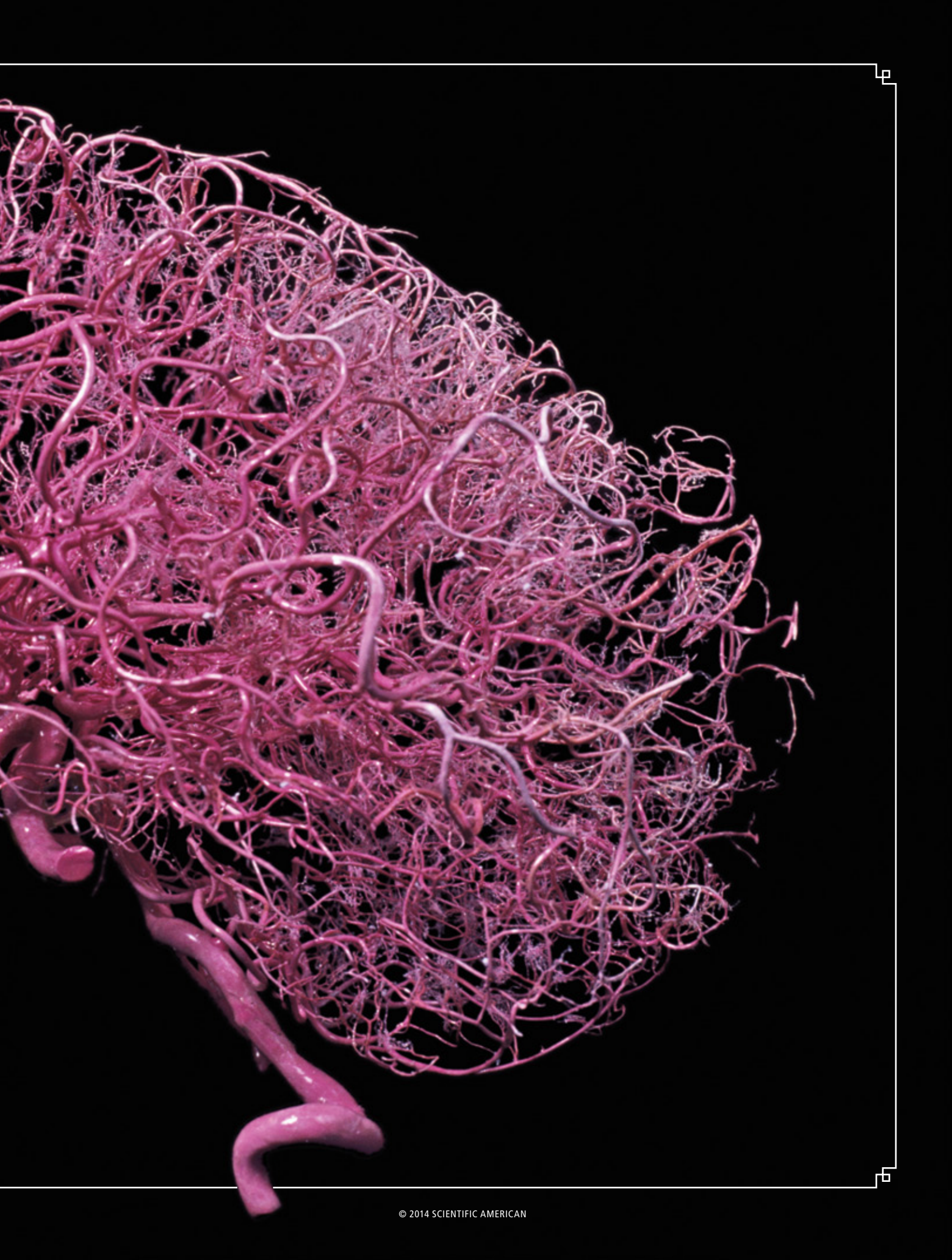
- **The Orgasmic Mind.** Martin Portner; April/May 2008.
- **Lust's Reward.** Kayt Sukel; November/December 2013.



OUT FOR BLOOD

THE NEURONS AND BLOOD VESSELS IN YOUR BRAIN ARE USUALLY TIGHTLY SYNCHRONIZED—BUT NOT ALWAYS. HERE'S WHAT CAN GO WRONG AND HOW WE CAN FIX IT

BY ELIZABETH M. C. HILLMAN



Your brain is an energy hog. It weighs less than 2 percent of your total weight yet consumes one fifth of your body's energy. The brain draws its fuel—oxygen and glucose—from blood delivered by a whopping 400 miles of blood vessels. Lined up end to end, all that vasculature would extend from New York City to Montreal.

These blood vessels are astonishingly dynamic. They tune the flow of blood to respond to the brain's needs from moment to moment. When certain brain areas work hard at something, more blood flows to those regions to help them refuel. Vessels do this by dilating near the spots that need a supply boost. This widening coaxes blood to reroute, much as customers in a busy store redistribute themselves whenever a new checkout line opens.

Fuel for neurons is limited, so your blood vessels must carefully choreograph every instant to sustain your brain. Yet what if the brain's blood vessels fall out of sync with their neurons? If the vasculature fails to deliver more blood when neurons need it, those cells might starve. In the short term, cognition could suffer. Longer term, entire networks of brain cells could wither away.

HISTORICALLY, NEUROSCIENTISTS HAVE SEEN BLOOD VESSELS IN THE BRAIN AS MUNDANE ROADWAYS, IRRELEVANT TO THE NEURONS THEY SUPPORT.

Historically, neuroscientists have seen blood vessels in the brain as mundane roadways, irrelevant to the neurons they support. Yet a city needs its roads. More than a simple conduit for noisy cars, transport infrastructure profoundly alters how we function. When Hurricane Sandy hit New York, for example, the rising water levels and power outages disrupted distribution networks for people, food and supplies, bringing the city to a standstill.

FAST FACTS
YOUR HUNGRY BRAIN

1. To power your brain, blood vessels deliver fresh oxygen and glucose to areas where neurons are hard at work.
2. Dysfunctional coupling between blood vessels and neurons could put brain health at risk.
3. New research suggests that endothelial cells, which make up the inner wall of blood vessels, are a key player in helping neurons summon more blood flow.

Blood flow is equally vital to brain function, and there are compelling reasons to think that dysfunction in one could impair the other. Brain scans have shown us that the brains of healthy individuals behave differently from those of people with Alzheimer's disease, attention-deficit/hyperactivity disorder, schizophrenia, depression, autism or multiple sclerosis, to name just a few conditions. The standard interpretation is that neuronal activity has deviated from a typical state.

There is a catch, though. Functional magnetic resonance imaging (fMRI), the technique most widely used for imaging brain activity, measures changes in blood flow as a proxy for neuronal activity. If the relation between blood flow and neurons has gone off the rails, fMRI scans will still deviate from the norm no matter what the neurons are up to. Scientists are left in the dark as to which brain disorders might solely affect neurons and which might also disturb cerebral blood flow.

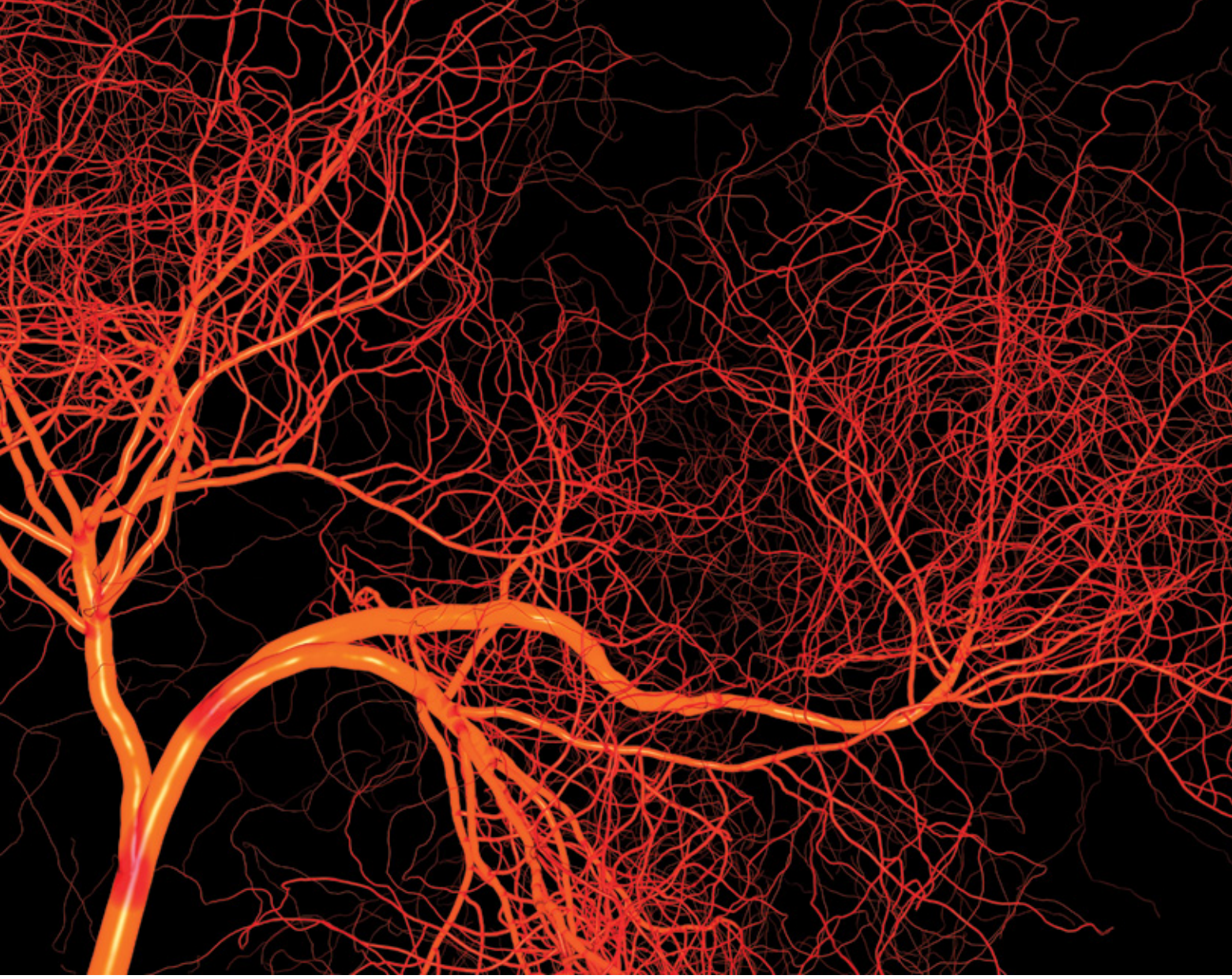
To get to the bottom of this, my laboratory has embarked on a mission to uncover how and when blood vessels and neurons might fall into discord. The evidence we have found suggests that this relation can indeed go awry and that it could contribute to—or even cause—neurological or psychiatric disorders. Fortunately, we might already possess the tools we need to correct the patterns of blood flow in the brain.

Written in Blood

Twenty years ago fMRI revolutionized the way that researchers study the human mind. This imaging technology can produce snapshots of the brain responding to a stimulus—a sound, a picture, a suggestion. Its magic comes from the unique properties of hemoglobin, the iron-rich protein in red blood cells that carries oxygen around the body.

Oxygen is invisible to an MRI machine as long as it is

PRECEDING PAGES: RALPH HUTCHINGS *Corbis*



The intricate branching of the vasculature delivers fuel to neurons in the form of oxygen and glucose.

bound to hemoglobin. Once the oxygen detaches, the deoxygenated hemoglobin left behind acquires a magnetic property that an MRI machine can detect. Oxygen is an essential fuel for neurons, and the general idea is that busy neurons need to replenish their energy supply by pulling oxygen from the blood vessels lacing through the brain. The process is the neuronal equivalent of nibbling on a sandwich to keep your energy levels up. But things get a little tricky because fMRI scans do not actually show oxygen getting consumed.

When activity in a certain brain region revs up, fresh oxygenated blood rushes in and flushes out the deoxygenated hemoglobin. This new overabundance of oxygen is interpreted by fMRI as a sign of neuronal activity. Rather than noticing that your neurons are nibbling on their sandwich, fMRI detects the delivery truck that is bringing you a huge portion of cake and ice cream for dessert.

Scientists assume that these blood flow changes reflect what nearby neurons are up to. Those inferences come with large caveats. First, the blood flow response is slow—neurons fire within milliseconds, but a corresponding increase in blood flow peaks three to five seconds after the event. So neurons clearly do not need their cake and ice cream to activate.

A second major concern is that we do not yet know how neurons communicate with blood vessels. Researchers have only a rough understanding of how variation in neurons' signaling—differences in the amplitude, frequency and duration of their activity—might tweak blood flow. Third, neuroscientists have barely considered what might happen if the brain's blood

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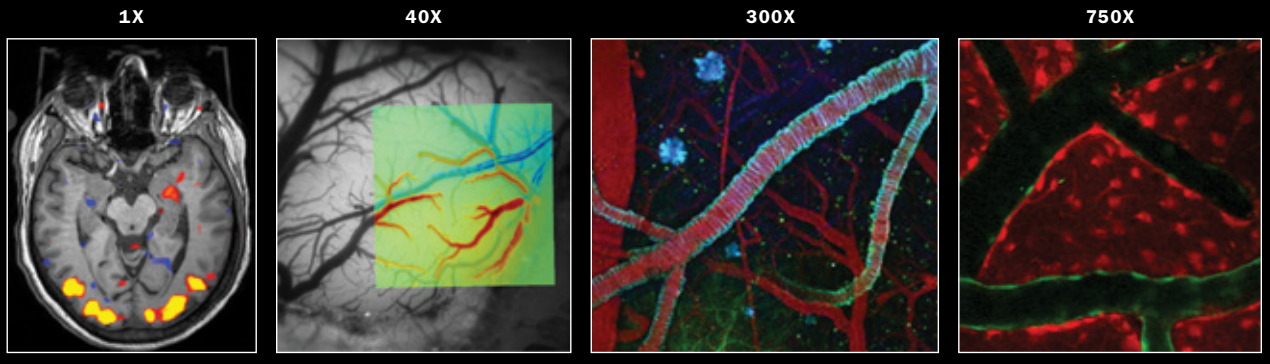
Deep Dive into the Living Brain



A functional magnetic resonance imaging brain scan (*far left*) identifies which areas in a brain are active at a given moment. It does so by using changes in blood flow as a proxy for neuronal activity. Imaging a rodent's exposed brain (*second from left*) reveals these blood flow fluctuations: stimulating a foot produces a local increase in oxygen-rich blood in veins (*red*). Observing a living brain under a microscope offers further insight into the blood vessels (*second from right*). This image reveals that beta-amyloid plaques (*blue*) coat the vessels of a mouse genetically modified to model Alzheimer's disease. Zooming in further (*far right*) unveils networks of astrocytes (*red*) grasping an artery and vein. The vessels are lined with endothelial cells (*green*), which may serve as a conduit for relaying signals upstream.

flow does not march in lockstep with the demands of neurons.

My colleagues and I believe that a mismatch might arise in numerous ways. The messages neurons send to alert blood vessels to their needs could get corrupted. The blood vessels themselves might lose some of their flexibility—constricting too easily, maybe, or dilating unduly. An acute brain injury, perhaps from a stroke or a head trauma, could also throw the vasculature and the affected region out of sync.

In short, the central premise of fMRI is that changes in the brain's blood flow are tightly coupled to specific neuronal events. If blood vessels fail to meet the demands of neurons, the implications could be enormous.

SOME DEVELOPMENTAL PROBLEMS MIGHT IN FACT STEM FROM ABNORMALITIES IN THE WAY THAT NEURONS AND BLOOD VESSELS SYNC UP AS THEY MATURE.

Strange Signals

To really be sure that it is the blood flow coupling that is broken, rather than the neurons themselves, you would need a way to measure both blood flow changes and the tiny electrical blips of neurons. This is easier said than done. If we had a robust way to map neuronal activity in the brain in real time, we would not need fMRI in the first place.

Electroencephalography (EEG) is one option. It can measure neuronal activity through electrodes placed on the scalp. Yet collecting clean EEG data inside the huge, electrically noisy magnet of an MRI machine is incredibly challenging. Researchers are still puzzling over the best ways to combine techniques to assess coupling in the human brain.

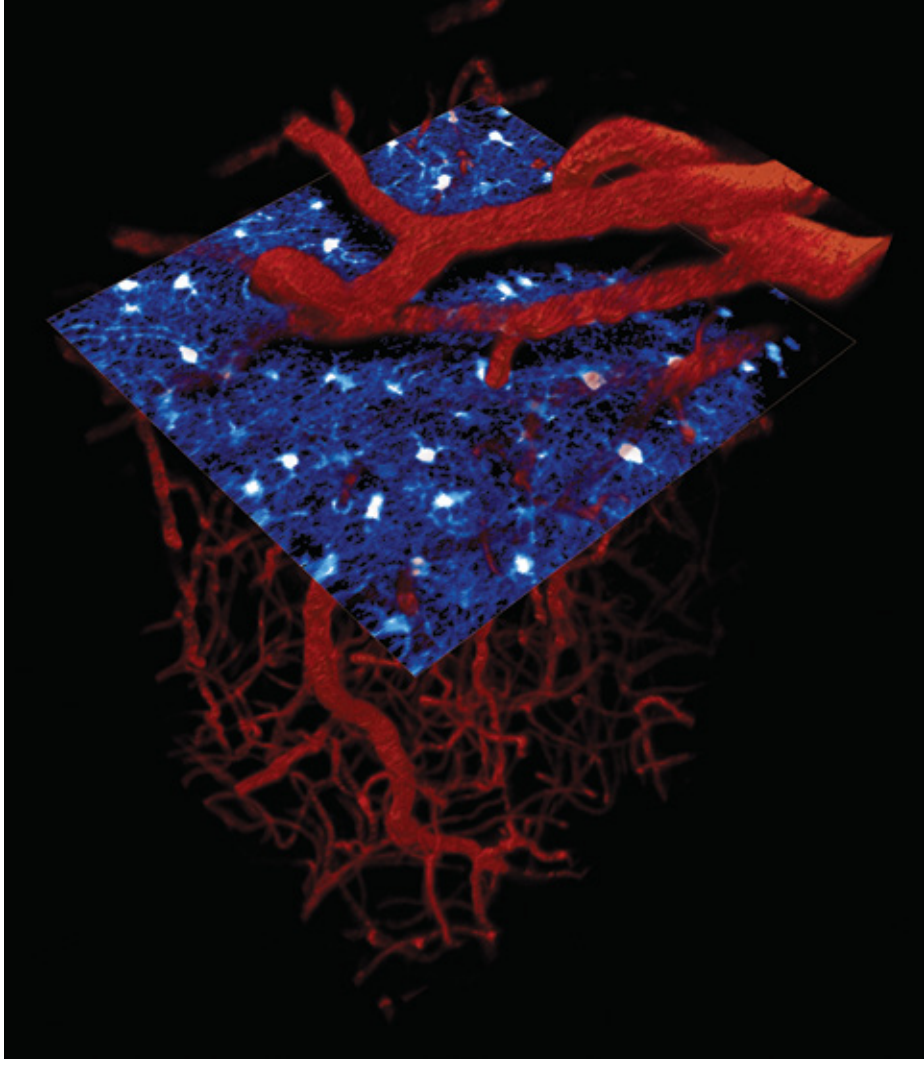
In my own work, we are using home-built microscopes that let us peer directly into the living rodent brain. In one study, published in 2013, we tackled a longstanding mystery in fMRI data. For almost as long as the imaging technique has been around, scans of the brains of infants and young children have looked very different from those of adults. In adults, an uptick in neuronal activity usually means an increase in the fMRI signal. In infants, many researchers saw a decrease in the signal.

My student Mariel G. Kozberg and I probed this oddity by observing blood flow in the brains of rodent pups during their first month of life. We took high-speed movies of the animals' exposed brain surfaces while we delivered mild zaps to their paws—comparable to a gentle touch. Our images showed us how this stimulus influenced blood flow in the brain area that corresponds to sensation in the paw. Subtle shifts in the color of blood also told us how much oxygen the blood was carrying.

We knew that neurons in the region were responding to the stimulation of the paw, yet in the youngest pups our videos revealed no increases in cerebral blood flow. In fact, we saw blood flow in the brain *decrease*. By observing rats of different ages, we discovered that over time the blood flow response gradually began to resemble that of an adult rat. This pattern suggested to us that the neurovascular system in a newborn brain has not yet synced up.

In more experiments, we found that when we delivered stronger stimuli, the blood pressure of the young rats spiked, equivalent to a startle reflex that makes a newborn cry or a sud-

COGNITIVE NEUROSCIENCE DIVISION, DEPARTMENT OF NEUROLOGY, COLUMBIA UNIVERSITY (*far left*); HILLMAN LAB, COLUMBIA UNIVERSITY (*second from left* and *far right*); FROM "DENDRITIC SPINE ABNORMALITIES IN APP TRANSGENIC MICE DEMONSTRATED BY GENE TRANSFER AND INTRAVITAL MULTIPHOTON MICROSCOPY," BY TARA L. SPIRES ET AL., IN *JOURNAL OF NEUROSCIENCE*, VOL. 25, NO. 1; AUGUST 3, 2005 (*second from right*)



Blood vessels weave and dive through a dense mesh of brain cells. One plane of cells is shown in blue.

HILLMAN LAB, COLUMBIA UNIVERSITY

den shock that gets your heart pounding. This increase in blood pressure caused blood to surge indiscriminately into the brains of the newborn pups. In a mature brain, a system known as autoregulation acts like a floodgate to protect against surges of blood. Our results suggest that this autoregulation system is also not mature in the developing brain.

This idea makes sense, of course—many aspects of the developing brain are in flux. We already know that after a baby is born new neurons continue to grow and that new connections form but also dissolve as the broad outlines of the brain's internal architecture take shape. Our group hypothesizes that the brain's mechanisms for deploying blood develop in tandem with these other processes.

That our neurovascular systems start out life incomplete raises a couple of concerns. First, fMRI might be blind during the early stages of brain development. Second, my colleagues and I have come to believe that some developmental problems might in fact stem from abnormalities in the way that neurovascular mechanisms mature. We are starting to explore this possibility by building new kid-friendly brain-imaging techniques to assess the emergence of vascular coupling in babies and young children.

Mind-Body Connections

Other important insights come from examining conditions known to affect both blood vessels and cognition. Take stroke, for example. During a stroke, a blocked or ruptured blood vessel causes a region of the brain to starve. If the vessels in that area cannot find a way to reroute the blood supply, neurons will begin to die.

Here again fMRI scans might be trying to tell us more than we once thought. Clinicians had hoped that brain imaging could help predict a stroke patient's recovery. The idea was that if brain scans show that the area affected by a stroke is responding to stimuli, the patient is on the road to recovery. Yet the data have turned out to be far too mixed to serve as an oracle. Some patients who showed promising fMRI activity did not recover well, whereas others whose brain scans were less encouraging ultimately regained function in that area.

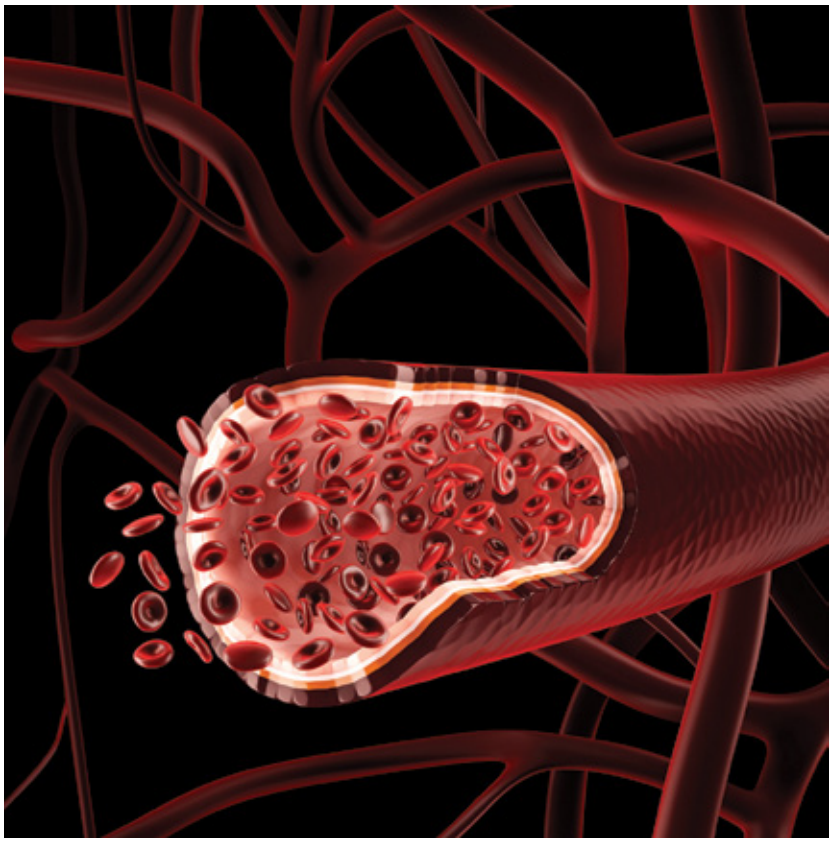
The problem is that when the vessels themselves are injured, blood flow routes might be blocked or damaged, and any number of biological mechanisms can come into play to try to save what is left. It seems almost impossible that the usual blood flow responses to neuronal activity would continue amid such catastrophe.

Yet we need not despair. Although the vasculature might not be speaking its usual language, fMRI can still listen. If we can learn to translate its messages, we might be able to understand how the brain tries to heal itself after a stroke—and better predict and guide recovery.

In the rest of the body, several disorders that afflict vasculature likewise affect the brain. Diabetes damages blood vessels and impedes memory and attention, as well as raising the risk of dementia. Similar cognitive troubles are seen in patients with heart failure. Hypertension and inflammation—risk factors for cardiovascular disease—increase a person's likelihood of developing Alzheimer's.

Physicians have circled these clues and connections for a number of years. We know, for example, that Alzheimer's has a blood flow component to it. In some patients, the brain receives less blood flow overall than it would in a healthy state. Such a deficit can make it harder to synthesize proteins crucial for learning and memory. Treatments for this aspect of Alzheimer's have focused on boosting blood flow brain-wide, but to little avail.

Those therapies might have missed an important clue. Perhaps the real problem is that the brain is not responding properly to local demands for fresh blood. One potential



Blood vessels transport hemoglobin, an iron-rich protein in red blood cells that carries oxygen around the body.

mechanism suggested by research is that beta-amyloid protein fragments—which form the characteristic plaques in Alzheimer's—may collect along parts of the vasculature. Beta-amyloid can trigger a chain of events that decreases the amount of nitric oxide available in the brain. Nitric oxide is a vital signaling molecule that instructs vessels to dilate. If the coupling of blood flow and neurons has indeed gone awry in Alzheimer's, improving the tuning of the blood supply (as opposed to simply ensuring higher overall flow) could offer a new strategy for treating some forms of dementia.

Numerous studies have noted altered responses in the fMRI scans of patients with Alzheimer's, diabetes and some forms of heart disease. If these anomalies are a sign that blood flow regulation is faltering, it may be possible to intervene and rescue imperiled neurons before it is too late.

The Missing Link

A critical next step is to nail down how it is that neurons and blood vessels communicate. We have a lot to learn. For example, it is tempting to think that hungry neurons use up local oxygen supplies, triggering an increase in blood flow, but the reality is not quite that simple. Even when a rodent is inside a hyperbaric oxygen chamber, which saturates the brain with oxygen, the animal will still exhibit a surge of blood to an area where neurons are hard at work. The same thing happens when very high levels of glucose are available.

So the call for more blood involves something more than a simple "low fuel" alarm. The quest to identify this sequence of events has focused largely on the brain's support cells, in particular astrocytes and pericytes. Astrocytes, which are star-shaped cells, are interspersed with neurons and can be found clinging to blood vessels, wrapping their appendages around like ivy on an old drainpipe. Pericytes are known to spiral around the tiny capillary vessels of the brain. Recent studies suggest that pericytes may be able to squeeze and relax, giving them the power to fine-tune the flow of blood. Both cell types can alter blood flow in the brain, but the complete picture is not yet clear.

Recent work in my lab has focused on another component: the vessels themselves. The brain's vasculature is well organized, with large arteries and veins coursing along the surface. Smaller vessels branch off and dive into the brain tissue, routing blood through dense beds of tiny capillaries that weave among neurons. To observe exactly what series of events generates the signal seen in an fMRI scan, we used a high-speed camera to take pictures of the surface of a rat brain.

After stimulating the rat's paw, we first saw a rapid blush in the brain's sensory region as red blood cells became denser in the capillary beds below the surface. Within a fraction of a second, we saw small arteries dilate at the surface, followed by the larger arteries from which they branched.

Imaging more quickly, we spotted the wave of dilation traveling along the arteries, in many cases against the direction of blood flow. The wave moved faster and farther than could be explained by astrocytes and pericytes alone. With these data, we essentially had a baseball card with a list of performance stats. Could we scout a player (or team of players) who could run that fast and that far?

Our search did not take long. In fact, the answer was right in front of us. We stumbled across a paper on how blood vessels in the body's muscles send signals along a vessel at very high speeds, almost like a wire conducting electricity. The key is the vessel's innermost layer, a sleek mosaic of endothelial cells. In an artery (or smaller arteriole), this inner layer is wrapped in a chunky jacket of smooth muscle cells. The muscle cells are capable of squeezing to constrict the vessel or relaxing to let it di-

ISTOCKPHOTO

late. These tiny muscle cells can receive commands from cells around the outside of a blood vessel, or they can be directed from the inside by the endothelial cells. This inner layer of cells can whisper the instruction to dilate or constrict using a range of different signaling mechanisms.

The elegance of the system is that once one endothelial cell hears that blood is needed, it can broadcast this whisper far and wide along the length of the blood vessel. Each smooth muscle cell in the path of the signal will dutifully obey the order to dilate. The match between this picture and our baseball card stats was too close to ignore.

THE BEST WAY TO SHOW THAT THIS SECRET PATHWAY WAS AT WORK IN THE BRAIN WAS TO TRY TO BREAK IT. WE USED A REMARKABLY SIMPLE YET PRECISE TECHNIQUE.

The best way to show that this secret pathway was at work in the brain was to attempt to break it. We used a remarkably simple yet precise technique. We injected a special dye into the bloodstream. When hit by bright blue light, this dye produces oxygen free radicals that damage only the endothelial cells.

We chose an arteriole on the surface of the brain and shone a very thin line of light from a laser to effectively slice the vessel's endothelium at a specific point. The outer layers of the vessel remained intact. When we stimulated the paw again, we found that the disruption of this tiny section of the endothelium was enough to stop the dilation from spreading along the vessel.

Next we shone the laser on a large area of the brain's surface, which prevented all the arteries on the surface from dilating. By applying chemicals that we know should cause smooth muscle cells to relax and dilate, we were able to confirm that the vessels were not themselves irreparably damaged. These experiments told us that signaling within the endothelium is a critical component in generating blood flow increases in the brain.

Our finding has some intriguing implications. First, if we can discover exactly which signals tell the endothelium to start a wave of dilation, we may finally be able to say for sure what fMRI is showing. Also important is that mechanisms already known to regulate blood flow elsewhere in the body are also involved in the brain. This outcome might sound obvious, but until now many researchers have assumed that blood flow in the brain follows different rules. Now it seems possible that diseases affecting the cardiovascular system throughout the body could have a direct effect on brain health. The same mechanisms that lead a diabetic patient to develop a foot ulcer might also explain cognitive symptoms.

Fixing Blood Flow

Often scientists and physicians express frustration at the difficulty of developing drugs for brain disorders, for a simple reason—unlike the rest of the body, the brain has a protective wall, called the blood-brain barrier, that shields it from most molecules in the bloodstream. The endothelium *is* the blood-brain barrier, however, so it is closely exposed to chemicals in the bloodstream. This direct contact could be good or bad news.

The good news is that the endothelium is an accessible target for drugs aiming to treat a mismatch between blood flow and the demands of neurons. Whether neurovascular dysfunction is a cause or a symptom, drugs that act on the brain's vascular regulation could offer up treatments for conditions previously thought to be intractable.

A great many drugs already exist that target the vasculature, including analgesics and anti-inflammatories such as aspirin and ibuprofen. Antihypertensives such as angiotensin-converting enzyme (ACE) inhibitors also fall in this category. Even drugs like Viagra affect blood vessels. The bad news is that we do not yet know which of these drugs might have positive or negative influences on the carefully tuned regulation of brain blood flow.

Fortunately, we already have an exceptional tool for studying blood flow in the human brain: fMRI. We can use fMRI to hunt for signs of neurovascular dysfunction by looking for deviations from the normal patterns of responses in different disease states. If we find reliable signatures, fMRI could become a valuable clinical tool for diagnosing and monitoring neurovascular disorders and could help guide us to new treatments.

Our work suggests that we can no longer ignore the brain's vasculature as if it were mundane infrastructure. It is a critical partner in normal brain function. Scrutinizing the brain's vasculature, learning its language, and understanding how it develops, ages and responds to injury could finally bring us closer to untangling the mysteries of the human brain. M

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That [~~Lovestruck~~ ~~Fired-up~~ ~~Anxious~~ Missing] Feeling

Alexithymia, a little-known personality trait, reveals the profound power of emotional awareness over health

By Tori Rodriguez

It seemed like a textbook case of depression. The patient, a male in his late 30s, was in counseling for marital difficulties. He was socially withdrawn and had started drinking heavily. His speech and movements were slow. Yet even as he fought back tears in a session with his psychiatrist, Natasha Thomas, he could not describe how he felt. "When he would cry, I'd ask, 'How are you feeling?' and he would shrug," Thomas says. "I would give him words like, 'sad, hopeless, frustrated.'" Her patient would reply, "What do those things feel like?"

ILLUSTRATIONS BY BRIAN STAUFFER

Thomas's patient suffered from more than just depression—he also has alexithymia, a personality trait characterized by deficits in the ability to identify and describe one's emotions. People high in this trait also tend to think in concrete, utilitarian terms rather than in a way that emphasizes insight and internal experience, and they have a limited capacity for imagination, fantasies and dreams.

Although it may sound like a condition or disorder, alexithymia is actually a dimension of personality, akin to conscientiousness or neuroticism, and it tends to remain stable over time. About 10 percent of the population possesses the extreme characteristics of alexithymia, with the rest of us falling somewhere along a continuum. The trait's occurrence is influenced by developmental and cultural factors [*see box on opposite page*], but there is also a strong genetic component associated with alexithymia. Researchers at the Italian National Institute of Health have found that 42 percent of individual differences in alexithymia are ascribed to genetics.

Chances are we all know someone who meets the description of alexithymia, yet few people are familiar with the term. In part this is because the overlapping concept of emotional intelligence, or the capacity to understand, recognize and respond to emotions in others and oneself, has eclipsed alexithymia in the public awareness. Emotional intelligence, however, does not encompass the deficits in imagination and dreaming typical of alexithymia, suggesting the trait relates to a broader struggle with internally focused thinking. Communication scientist Colin Hesse of the University of Missouri believes many people fail to recognize the seriousness of this trait: "[They] don't really believe that some people honestly might be disadvantaged, on a neurological level, in understanding and communicating emotions."

People with alexithymia self-disclose less, give and receive less affection, and derive less joy from intimacy.

As recent research is now revealing, alexithymia has deep implications for numerous aspects of life. Beyond its association with several mental disorders, including anxiety and depression, alexithymia also can affect the quality of relationships and many facets of physical health. The good news is that emerging therapies show promise for helping people with alexithymia to develop an awareness of their emotions, enrich their inner lives and improve their overall well-being. Ultimately insights into this long-overlooked trait lay bare the intimate connection between mind and body. To ace life, you have to understand your emotions.

FAST FACTS

A TROUBLING TRAIT

1. Alexithymia is a personality trait marked by an inability to recognize internal emotional states and limited internal thinking.
2. People with alexithymia are at a higher risk for mood disorders, interpersonal problems and health problems.
3. Brain research is revealing that the neural processes supporting emotional awareness overlap with pathways that create awareness of inner states more broadly, such as stress and fatigue.

Soul without Words

Psychiatrists have long recognized that failing to get in touch with one's feelings extracts a physical toll. In the early 1970s the late psychiatrist Peter E. Sifneos of Beth Israel Hospital (now Beth Israel Deaconess Medical Center) in Boston noticed that

Origins of Alexithymia

Most people learn to differentiate between feelings in childhood, when caretakers teach children the words to name feelings. It is no surprise then that many researchers suspect developmental factors play an important role in alexithymia. In 2012, for example, physicians at the Erenköy Mental Research and Training Hospital in Istanbul found that emotional abuse and neglect could predict the emergence of alexithymia.

Culture, too, could play a part in the occurrence of alexithymia by de-emphasizing emotional experience. A 2013 study compared 388 Spaniards, who have a culture that is generally liberal and individualistic, with 537 Uruguayans, who hail from a more traditional and collectivist society. The Uruguayans reported placing less value on sharing personal emotions than the Spaniards. Similarly, multiple studies conducted by psychologist Andrew Ryder of Concordia University in Montreal have revealed that traditional Chinese culture de-emphasizes self-focused thinking, encouraging people to think more externally—that is, about others, objects and forces outside the self. Yet a collectivist culture need not breed alexithymia. Ryder found that despite an outward focus, emotional awareness remained intact in these societies.

Gender norms can add another layer of environmental influence. Traditional gender roles generally discourage men from paying attention or assigning importance to their emotions. This tendency has led researchers such as Ronald F. Levant of the University of Akron to coin the concept of "normative male alexithymia," in which society socializes young men to become emotionally stunted. He observes that men may develop a nonpathological variant of the alexithymia trait. Some data support this position: in 2008, for instance, Arizona State University psychologists found that Mexican-American men who exhibited more machismo—an outlook that endorses aggressive hypermasculinity—also had higher alexithymia scores.

Difficult circumstances can also produce temporary bouts of "state alexithymia." In such cases, trauma or a depressive incident triggers a sharp disconnect from emotional awareness. Compared with the stable and enduring "trait alexithymia" discussed in the main article, this state is even less researched and poorly understood. Fortunately, state alexithymia wanes with time. —*T.R.*

many of his patients with psychosomatic illnesses, in which a mental disorder manifests as physical illness or injury, were unable to understand or express their emotional experiences. Sifneos coined the term "alexithymia," from the Greek for "soul without words," to describe the phenomenon.

Researchers have since discovered that alexithymia is comorbid with multiple mental disorders, including obsessive-compulsive disorder and addiction. Rates of alexithymia are especially high among the chronically depressed. But as Sifneos suspected, alexithymia's damage goes beyond mental health. Diabetes, heart disease, hypertension and certain gastrointestinal disorders are all linked with the trait. A study of 101 patients with type 2 diabetes published in February in *Psychiatry Research* found that having the trait nearly doubles the risk of developing diabetes.

Another equally powerful factor is alexithymia's effect on interpersonal ties. A wealth of data backs the notion that strong social connections are vital to a healthy way of life. But alexithymia makes it harder to create and expand a supportive social network. Hesse has observed that alexithymia can hinder an individual's ability to begin, grow and maintain all kinds of close relationships. In 2010 Hesse found that after a 10-minute initial interaction, people were much less socially attracted to alexithymic individuals than nonalexithymic individuals. He has also shown that people with alexithymia are more likely to avoid and distrust others. When in relationships, people with this trait self-disclose less, give and receive less affection, and derive less joy from intimate interactions.

Heather Foran, a research psychologist at the Technical University of Braunschweig in Germany, believes that these relationship challenges cause negative emotions to persist longer than they otherwise might. In a study published in 2012 she and her colleagues discovered that measures of emotional intelligence and alexithymia could predict mood and relationship quality among 104 American couples. Foran found that without emotional disclosure, partners struggled to support each other, thereby increasing their risk of depression and dissatisfaction.

When Feelings Are Foreign

To understand how an emotional disconnect can create devastating physiological and interpersonal effects, scientists are looking to the brain. By stimulating the brain with magnetic pulses and observing how electric current then travels through neural tissue, researchers have found that people who are high versus low in alexithymia differ in the way their brain's two hemispheres communicate. Highly alexithymic individuals do not appear to transfer information between the two sides of the brain as well as people who rate lower in this trait. These individuals, therefore, may struggle to integrate various types of information, such as emotional cues.

Other brain-imaging studies indicate that people scoring high in alexithymia show reduced activity in brain areas associated with emotion regulation and self-related thoughts. For example, a 2013 study by researchers at three universities in Germany found that individuals with alexithymia have less gray matter in the anterior insula, which helps to govern emotions as well as interoception. This lesser-known sense encom-

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passes the perception of one's internal bodily states, such as hunger pangs or an accelerating heartbeat. The same neural processes that underlie interoception, it seems, can also explain the ability to detect and decipher emotions.

Other work bolsters the connection. In a study from 2011 Beate M. Herbert, a research scientist now at the University of Ulm in Germany, and her colleagues tested 88 women and 67 men for alexithymia and measured their interoception by asking them to count how many times their heart beat in a minute (people with poor interoception tend to fare worse on this task). The team confirmed that interoceptive sensitivity was inversely associated with all facets of alexithymia. Moreover, in March 2013 a Japanese research group found that neural pathways relating to awareness of both bodily and emotional states overlap, leading the authors to conclude that awareness of emotions requires interoception.

Yet a failure of interoception does not mean that emotions do not exist. Psychologist Tom Hollenstein of Queen's University in Ontario believes that in alexithymia, the typical mental and physical responses to an emotional event have decoupled. In 2013 Hollenstein and his colleagues measured the heart rate and electrical conductance of skin—which varies as a person sweats—of participants giving an impromptu speech. They then compared these physiological measures with participants' self-reported feelings of self-consciousness, along with other observers' assessments of each speaker's mental state. The researchers found that people high in the trait failed to integrate their physical and mental reactions. "Alexithymics have emotions like everyone else, but they appraise them differently," Hollenstein says.

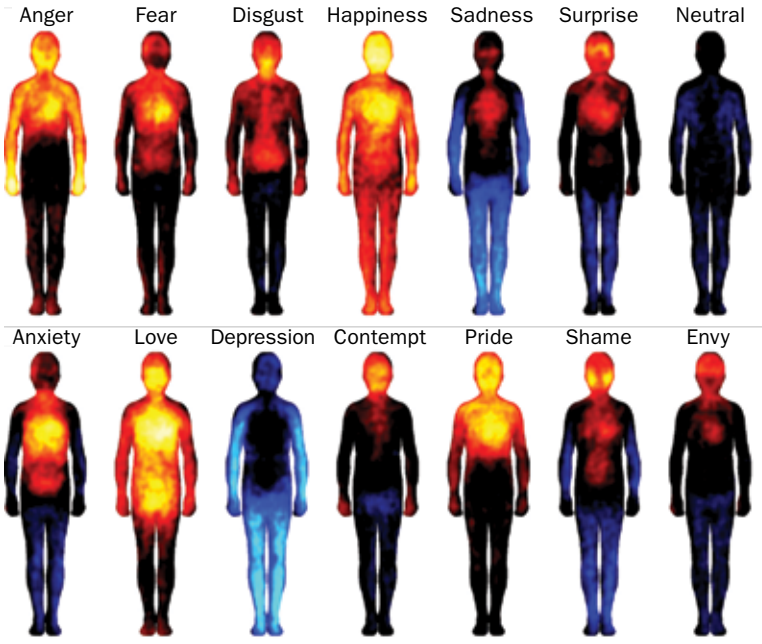
A failure to integrate bodily responses and emotional cues might explain why people with alexithymia are more prone to disease. If you cannot recognize your body's needs, maintaining a healthy lifestyle becomes difficult. Hans Thulesius, a physician at Lund University in Sweden, has proposed that individuals who struggle to discern their feelings may also be unable to assess symptoms such as fatigue, which can indicate changing blood glucose levels. And they may fail to regulate stress effectively by being slow to act when the body's fight-or-flight response kicks in. Maintaining an elevated stress response could exhaust the body and leave it vulnerable to sickness. Indeed, several studies have found that the diseases most closely associated with alexithymia—coronary heart disease, diabetes, hypertension and certain gastrointestinal disorders—also involve lower heart rate variability. This symptom is a marker of an unchecked stress response, which is exactly what researchers would expect to see if alexithymia and reduced interoception interfered with a person's ability to manage the body's needs.

For patients who struggle with mood and eating disorders, among whom alexithymia is common, basic emotion education is helpful.

Emotional Education

With mounting evidence that emotional awareness promotes healthier minds, bodies and relationships, finding ways to get in touch with one's feelings has become more important than ever. Given the limited malleability of personality traits, some experts have taken a pessimistic view of therapies. Fortunately, certain treatments have recently shown promise in not only reducing alexithymia but also improving related health and relationship outcomes. Social skills and emotional intelligence, for example, can be targeted through therapy. In a 2013 study in the *Asian Journal of Psychiatry,* alexithymic participants with dyspepsia, a form of chronic indigestion, received medication and underwent 16 weeks of group therapy focused on understanding and resolving interpersonal problems. Afterward, they had better health and lower alexithymia scores than patients who received only medical treatment for their dyspepsia.

Yet it remains an open question which of the many available psychotherapies work best. A randomized trial published



Psychologists at Aalto University in Finland and their colleagues asked participants to color parts of the body that experienced increased (*warm colors*) or decreased (*cool colors*) sensation after an emotional prompt. They found that emotions could be associated with the same regions of the body across cultures.

SOURCE: "BODILY MAPS OF EMOTIONS," BY LAURI NUMMENMAA ET AL., IN *PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES USA*, VOL. 111, NO. 2; JANUARY 14, 2014

in 2013 was the first to compare methods; its results indicated that a supportive approach, emphasizing an individual's strengths and teaching him or her social skills, was nearly twice as effective as a common interpretive treatment focused on identifying unconscious conflicts. The reason may be because the latter approach requires inward-thinking skills typically deficient in those with alexithymia.

Certain basic interventions can help people across the alexithymia scale. Therapies incorporating body-based techniques, for instance, can enhance a patient's awareness of and response to physical sensations and emotions. An example is progressive muscle relaxation, which entails paying close attention to the body while tensing and relaxing every muscle from head to toe.

For patients who struggle with mood and eating disorders, addiction and sexual trauma, among whom alexithymia is common, basic emotion education is often helpful. Typically the first step is to recognize the difference between thoughts and feelings. This can involve reviewing a "feelings list," which breaks down the nuanced variations of universal emotions. Using the list, patients pick out a feeling that seems like it might match a particular situation they have experienced and then "try it on" to decide whether it feels accurate. The therapist and client discuss how other people tend to feel in these situations and what physiological sensations accompany an emotion. It can be useful to refer to expressions such as "I had a lump in my throat," "butterflies in my stomach," "my heart dropped" or "I was steaming."

Some patients also benefit from having a therapist point their attention to bodily cues, such as the tense shoulders and constricted breathing typical of anxiety. As patients begin piecing together their emotional puzzle, they become more inclined to observe their internal experience. Mindfulness techniques, which emphasize nonjudgmental observation rather than pressuring patients to figure out or fix emotional states, can be invaluable at this stage. The success of these types of interventions may derive in part from the way they approach emotional awareness from the outside in.

Further gains may come from new efforts to create a "bodily map of emotions." In a study in 2013 in the *Proceedings of the National Academy of Sciences USA*, a group of researchers led by psychologist Lauri Nummenmaa of Aalto University in Finland asked 701 participants from Finland, Sweden and Taiwan to color the parts of the body that experienced a change in sensation in response to events such as watching a touching movie or observing certain facial expressions. The researchers discovered that across cultures, respondents consistently associated specific regions of the body with particular emotions. For example, people felt a sense of increased activation in the arms and upper body when angry, whereas happiness led to a flood of stimulation from head to toe. Teaching people to associate sensation in various regions of the body with a corresponding emotion could help them learn how to reconnect bodily responses with emotional reactions.

For those of us who do not struggle with recognizing emotion, research on alexithymia may be a reminder that this recognition is a gift. The same mechanisms that help us understand why we laugh, cry, reach for a snack or sit down for a rest also equip us to build relationships and keep tabs on our physical health. So listen to your inner chorus—what you hear might matter a great deal. **M**

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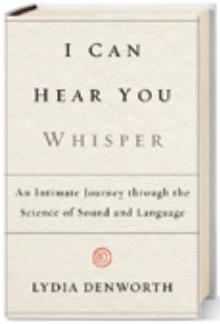
SOUND BARRIER

I Can Hear You Whisper: An Intimate Journey through the Science of Sound and Language

by Lydia Denworth. Dutton Adult, 2014 ($26.95)



Language, it is often said, is what makes us human. So what happens when the acquisition of language is impeded? Without language, how does one fully participate in the great drama of human life, let alone function in society?

These questions lie at the heart of Denworth's new book. Her youngest son, Alex, is nearly two when she discovers he has almost completely lost his hearing. The revelation prompts an avalanche of maternal anxiety. Can he have a normal life? What are the best ways to help him? And maybe most important, will he recover from the time he spent, unbeknownst to her, in near silence?

A former reporter and editor for *Newsweek* and *People,* Denworth attacks these questions as both mother and science journalist. The result is part memoir, part expository science writing and part history of the political intricacies of deafness. It is also, ultimately, a somewhat harrowing experiment.

Denworth finds she is racing against time. Although we continue to generate neurons throughout life, the brain undergoes a dramatic pruning process early on. Neural connections that are not used are deleted, whereas those that are retained become stronger. If the brain lacks sensory input early in life, not only may those connections fail to form, but regions normally used in, say, parsing auditory information may get co-opted for another job. Co-option is not necessarily problematic. There is some evidence, in fact, that deaf people who use sign language see better than hearing people do. A problem arises, however, if the brain-wide networks underlying language comprehension, be it sign or heard language, are not created at all.

Rather cruel animal experiments illustrate the underlying principle, which scientists often express as "use it or lose it." In one study, scientists sewed kittens' eyes shut and removed the stitches after three months. Despite having perfectly good eyes, the cats remained forever blind. Deprived of visual stimuli during a critical period of brain development, their visual cortices now failed them. Their eyes could see fine, essentially, but their brains could not. As with the kittens, the worry with any child who lacks sensory input is that without early-life stimulation, the neural networks that enable perception simply will not develop.

So Denworth chooses to give her son a cochlear implant in his completely deaf ear before age three—theoretically still within that window of neural malleability. This means surgically implanting wires in the spiral-shaped cochlea of the inner ear, which connect to a "receiver" under the scalp. That receiver communicates with a hearing device worn behind the ear. The implant works essentially as an artificial ear with a near-direct line to the brain.

You would think that the deaf community would embrace such technology. But as Denworth explains, the community views cochlear implants with great ambivalence. (The sign for the implants in American Sign Language—ASL—is two fingers stabbing the back of the neck, like a vampire's bite.) This antipathy stems in part from the historical view of deafness as a defect. In recent decades a deaf civil-rights movement has pushed back against these kinds of assumptions. The deaf aren't defective, the counterargument goes, just different. They don't need fixing. Indeed, just because you can't hear doesn't mean you can't have language. As sign languages make plain, sound is not required for the fundamental linguistic process of linking meaning with symbols.

Which brings us to the conundrum Denworth faces: Should Alex focus on pursuing membership, however marginal, in the hearing world? Or should he master ASL, a system that he may more fully inhabit but that may also limit the scope of his world?

Denworth ultimately decides on the former. After his implant—and a stint at a school geared toward the hearing impaired—Alex attends a hearing school in Brooklyn, where, with extra help, he does quite well. But Denworth also hedges; she and Alex eventually study ASL.

At the end of the book, Denworth's family moves to Hong Kong. Alex, now past his seventh birthday, is talking, reading and thriving. Everyone's hard work has paid off. In their willingness to strike off on adventure (which Alex insists on), a reader senses that the motherly anxiety evident at the book's outset has subsided somewhat. She seems to have absorbed the notion that perfect hearing is not required for a full, rich life.

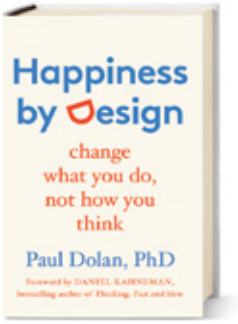
Denworth does a fine job interweaving the different elements of this historically fraught, scientifically complex and personally trying story. Major determinants of success among deaf and hard-of-hearing children include parents who care, access to resources and plenty of practice early in life. These fairly basic requirements highlight one way the deaf and hearing are actually more similar than different.

—Moises Velasquez-Manoff

FOLLOWING BLISS

Happiness by Design: Change What You Do, Not How You Think

by Paul Dolan. Hudson Street Press, 2014 ($25.95)



Are people happier in the Midwest or in southern California? Most folks point to the difference in weather and guess the latter. But in fact, the populations of these regions report roughly the same level of overall life satisfaction. That is because people quickly acclimate to weather, turning their attention to other aspects of their lives.

In *Happiness by Design,* behavioral economist Dolan suggests that once we accept how attention shapes experience, we can learn to shift our focus to what brings us the most joy. Dolan defines happiness as our experience of pleasure and purpose over time. He then draws on happiness data from the U.S. and Europe to reveal several general trends. Volunteering, for instance, tends to correlate with greater feelings of purpose in life and television with greater pleasure.

But one size does not fit all when it comes to happiness. Dolan proposes that monitoring our personal pleasure and purpose can tune us into what brings us contentment. From there, he offers ways to maximize those stimuli. For example, if you want more quality time with loved ones, simply turning off your computer or phone may help you be more present.

Although many of Dolan's suggestions may sound familiar—don't expect too much, surround yourself with people who make you happy, invest in experiences, not objects—he goes a step further by supporting these claims with recent research in behavioral and brain science. For example, before making a big decision, we are often told to "sleep on it." Neuroimaging research suggests that when we take a mental break, our brain continues to evaluate the situation and that this unconscious reflection often provides us with more clarity than if we overthink. One study found that subjects who made a decision after solving a puzzle were more content with their choice than people given extra time to actively pore over their options.

Overall Dolan gives a comprehensive overview of the science of happiness and useful tips to achieve it. In his quest to explain what makes us happy, Dolan touches on a powerful idea: happiness need not be pursued, simply rediscovered. In other words, sources of pleasure and purpose are all around us, if only one knows where to look. —*Daisy Yuhas*

MIXED METAPHORS

Sensation: The New Science of Physical Intelligence

by Thalma Lobel. Atria Books, 2014 ($26)

What if flipping a light switch could jumpstart your thinking? Or if giving a friend a sugary snack could make them "sweeter" company?

These situations may sound bizarre, but some psychologists suspect that our physical experiences—what we see, smell, touch, taste and hear—profoundly influence our mental states. In *Sensation,* psychologist Lobel explores the theory of embodied cognition, which posits that our body can direct our mind just as much as our mind directs our body.

Studies in embodied cognition reveal myriad ways in which our physical sensations unconsciously sway our thoughts and emotions. Holding a mug of hot tea may make you a warmer conversationalist, even when trying to be a tough negotiator, and washing your body may help clean your conscience.

The connections we make between body and mind are not random, Lobel says; many are actually ingrained early in life. For instance, after receiving a vaccination, a child may automatically come to associate a sharp sensation with an emotional pang and the cold temperature of the doctor's office with feelings of distress.

Being aware of these deeply ingrained associations can help us sidestep them or use them to our advantage, Lobel reveals. Researchers at Harvard University, the Massachusetts Institute of Technology and Yale University found that people prefer a job applicant whose résumé is attached to a heavy clipboard, viewing the candidate as having a more serious interest in the job. Perhaps, Lobel says, submitting résumés on heavy paper would give applicants a leg up.

Recently the idea that our body can be directing our brain rather than the other way around has met with serious criticism by researchers who have been unable to replicate findings. To her credit, Lobel acknowledges this debate, albeit briefly, at the book's end. Yet the controversy casts a shadow on much of the results and conclusions she discusses.

For readers interested in understanding an intriguing theory of how our physical experiences affect our mental ones, *Sensation* is a good place to start. But those looking for a more critical, nuanced look at the subject may be disappointed. Regardless, the book chronicles some of the quirky contributions of embodied cognition research and provides a nice reminder that the relation between mind and body is complex. —*D.Y.*

ROUNDUP

NATURE VS. NURTURE

Three books tackle whether talents are innate or cultivated

While watching the Winter Olympics this year, you may have pondered whether top athletes are born with incredible endurance and speed or whether such skills can be developed through years of intense training. According to sports psychologist Jim Afremow, raw talent isn't everything.

In **The Champion's Mind: How Great Athletes Think, Train, and Thrive** (Rodale Books, 2014), Afremow argues that getting an edge over the competition can boil down to mental preparation. He provides advice for how to thrive in high-pressured situations, such as avoiding comparing yourself with others and visualizing success (picture yourself at the finish line!).

Although the right mental and physical preparation does help, it is also clear that success depends heavily on our genes. In **The Sports Gene: Inside the Science of Extraordinary Athletic Performance** (Current Hardcover, 2013), *Sports Illustrated* writer David Epstein combs through the scientific literature to explain the complexities of the nature versus nurture debate. "Even at the most basic level, it's always a hardware *and* software story," he writes. But for some, no amount of dedicated training will do the trick. One study revealed that a chess player reached the master level after only 3,000 hours of training, whereas others had not progressed to that level after 25,000 hours.

According to Malcolm Gladwell, however, we often underestimate people because "we have a definition in our heads of what an advantage is—and the definition isn't right." In **David and Goliath: Underdogs, Misfits, and the Art of Battling Giants** (Little, Brown, 2013), Gladwell proposes that traits that seem valuable may not always work in our favor, and vice versa. He bolsters this claim with scientific research and real-life examples. For instance, he explains how a basketball team with little technical skill made the finals by playing to their one strength—defense. Although Gladwell sometimes cherry-picks data or suggests causation when none exists, he always offers a compelling way of understanding ourselves and our capabilities. —*Victoria Stern*

THINKSTOCK

Can you experience déjà vu of a place or situation you've never encountered?

—Ellen Smucker-Green, Nashville, Tenn.

Alan Brown, professor in the department of psychology at Southern Methodist University, Dallas, responds:

Déjà vu is a startling mental event. The phenomenon involves a strong feeling that an experience is familiar, despite sensing or knowing that it never happened before. Most people have experienced déjà vu at some point in their life, but it occurs infrequently, perhaps once or twice a year at most.

Although déjà vu often feels supernatural or paranormal, glitches in the brain might be to blame. One possibility is that a small seizure occurs in brain regions essential for memory formation and retrieval—the hippocampus and parahippocampal gyrus, areas deep in the middle of the brain. When you see your grandmother, for example, spontaneous activity in these regions creates an instant feeling of familiarity. With déjà vu, a brief synaptic misfiring might occur in these areas, creating the illusion that the event has occurred before. In support of this idea, studies show that some individuals with epilepsy have a brief déjà vu episode prior to a seizure, with the focal area of the seizure often falling in the hippocampus and parahippocampal gyrus.

Other phenomena might also help explain déjà vu, such as inattentiveness. Because we often navigate the world on autopilot, we take in much of our surroundings on an unconscious level. People who text on their cell phones while walking are only superficially aware of the shops and pedestrians they are passing. Perhaps an episode of déjà vu begins during such a moment. When we emerge into full awareness, we might do a perceptual double take. We are struck by a strange sense of familiarity because we saw the scene just moments before, unconsciously.

In a recent study, Elizabeth Marsh of Duke University and I investigated this idea. We showed participants dozens of unique symbols. Some of them were flashed too quickly for participants to consciously detect before they were revealed for longer viewing. Our participants were significantly more likely to identify a novel symbol as familiar if they had subconsciously glimpsed the image before.

A third possibility is that we have forgotten the prior experience. The psychology literature is replete with stories of adults visiting a notable place, such as a castle, and becoming overwhelmed by an uncanny sense of having been there before. Their parents, however, clued them in: they had been to the castle as a very young child. Similarly, television and photographs can breed a false sense of familiarity later on. For example, having watched a documentary on a castle a decade ago might lead to a sense of déjà vu when you visit it.

So, yes, it is possible to experience déjà vu related to a completely new place. Our brain is always searching for connections. As a result, we can sometimes make links that simply aren't there.

What processes in the brain allow you to remember dreams?

—Emma Poltrack, Virginia

Deirdre Barrett, author of *The Committee of Sleep,* replies:

Dreams are notoriously difficult to recall. In fact, if a dream ends before we wake up, we will not remember it. The processes that allow us to create long-term memories largely lie dormant while we sleep, which is why most dreams are forgotten shortly after waking. For instance, an important neurotransmitter for remembering, norepinephrine, exists at very low levels during dreaming, as does electrical activity in areas key to long-term memory, such as the prefrontal cortex.

As the brain awakens, it starts to turn on processes needed for long-term storage. Thus, if we wake straight out of a dream, we have a greater chance of remembering it. A 2011 study showed that people who have more theta brainwave activity in their prefrontal cortex after waking from REM sleep have better dream recall. Theta activity indicates a slower-paced, more relaxed brain state, and greater theta activity has been linked to enhanced memory while awake.

The emotional content and logical consistency of a dream also affect how much of our dreams we remember. One study found that less coherent dreams were harder to recall than ones with strongly felt content and organized plot lines. The dreams we are likeliest to retain—nightmares and other vivid, emotional dreams—are accompanied by greater arousal of brain and body and are therefore more likely to wake us up.

Certain techniques can help increase dream recall. Anything that captures our attention immediately after waking interferes with dream recall, so just as you are falling asleep, keep reminding yourself that you want to remember your dreams. Let it be your last thought as you are drifting off. Keep a notepad and pen by the bed. When you first wake up, do not jump up or turn your attention to anything. Even if you do not think you can remember a dream, take just a minute to see if there is any feeling or image you can describe. Following these simple steps may cause an entire dream to come flooding back. M

JAMIE CARROLL /*Stockphoto*

1 SENTENCE SNAKE

The stacked sentence below contains the lines that will complete the following rhyme. Start with the correct letter and move letter by letter in any direction (up, down, sideways and diagonally). (Hint: There are two null letters that do not appear in the lines.)

As Hans was walking up the Alps,
A vision turned his head.
With Mother on his handlebars
Along the road Fritz sped.
They hit a curve!

H	E	O	K	E	J	U
S	P	O	L	E	T	S
A	H	K	O	C	N	O
N	S	N	O	M	A	H
B	B	D	I	A	S	E

2 RECONSTRUCTION

Each of the following words is missing multiple instances of the same letter. What are the reconstructed words?

PRMAT **RHARS**
TNAGR **FORSR**

3 THESE LETTERS HAVE FLOWN

Fill in the blanks to find the names of birds.

L _ _ W I _ _
P _ _ _ E _
_ R _ B _
_ A _ _ I _ A _

4 AGE DIFFERENCE

Allan is twice as old as Gloria was three years ago. In three years, Gloria will be as old as Allan is now. How old are Allan and Gloria now?

5 PROVERB PUZZLER

A variation on a proverb is coiled in the grid below. To spell it out, start with an "I" and move to the adjacent letter in any direction. All letters will be used exactly once. (Hint: The number of letters in each word is 2, 2, 5, 3, 3'1, 7, 3, 9, 9.)

D	G	N	H	R	T	S	T	N	I	F
I	F	I	T	Y	D	U	O	D	R	T
F	E	R	E	S	E	C	O	U	S	A
T	N	E	M	O	E	C	Y	T	F	I

6 CONFOUNDING COMPOUNDS

Place the same three-letter word in each blank below to make four common words.

_ _ _ **TEEN**
_ _ _ **KER**
_ _ _ **INE**
_ _ _ **OE**

7 ANAGRAM

Rearrange the letters below into as many English words as you can, using all five letters in each word. (Hint: We found six words.)

A C E R S

8 HORSEPLAY

Each definition below applies to a word that begins with the name of a different animal. Find all three words.

Poor poetry: _ _ _ _ _ _ _ _ **(8 letters)**
Religious building: _ _ _ _ _ _ _ _ _ **(9 letters)**
Major fight: _ _ _ _ _ _ **(6 letters)**

9 MAGIC SQUARE

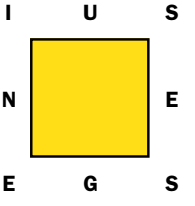
Complete the word square below by inserting the nine letters into the grid, one per square, to create the same words reading across and down.

A A E E N N P P T

H	O	B	S
O			
B			
S			

10 REVOLVER

A word is spelled out around the box below. Find it by beginning with the correct letter and moving clockwise or counterclockwise around the box, using each letter only once.



Answers

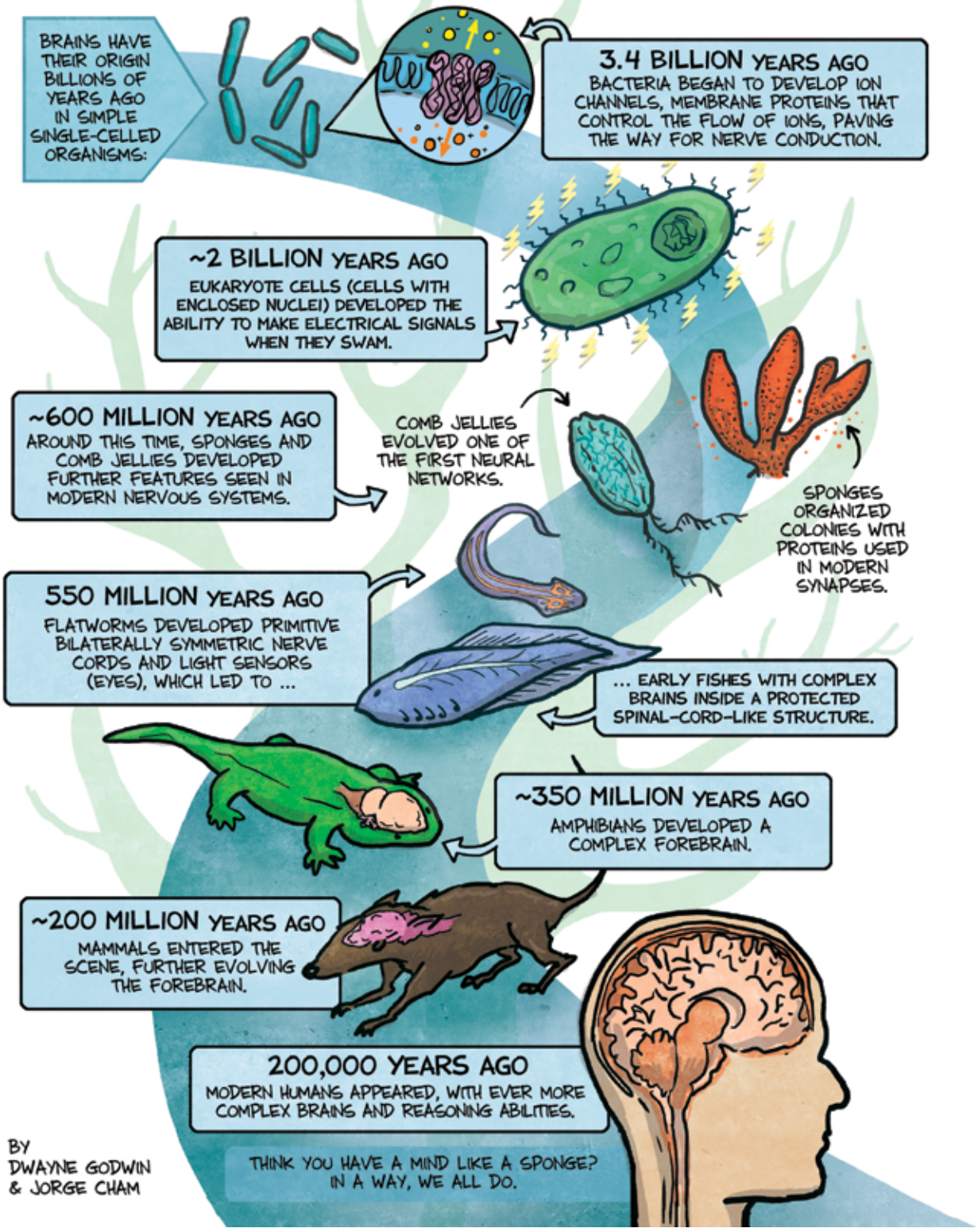
1. HE SPOKE JUST ONCE. "LOOK, HANS, NO MA," HE SAID.
2. PERMEATE, REHEARSE, TEENAGER, FORESEER.
3. LAPWING, PLOVER, GREBE, CARDINAL.
4. Allan is 12; Gloria is 9. Use the formula G + 3 = 2(G – 3).
5. IF AT FIRST YOU DON'T SUCCEED, TRY SOMETHING DIFFERENT.
6. CAN. 7. ACRES, CARES, CARSE, RACES, SCARE, SERAC. 8. DOGGEREL, CATHEDRAL, BATTLE.
9.

H	O	B	S
O	P	E	N
B	E	T	A
S	N	A	P

10. GENIUSES.

BRAIN EVOLUTION

WHERE DID OUR BRAINS COME FROM?



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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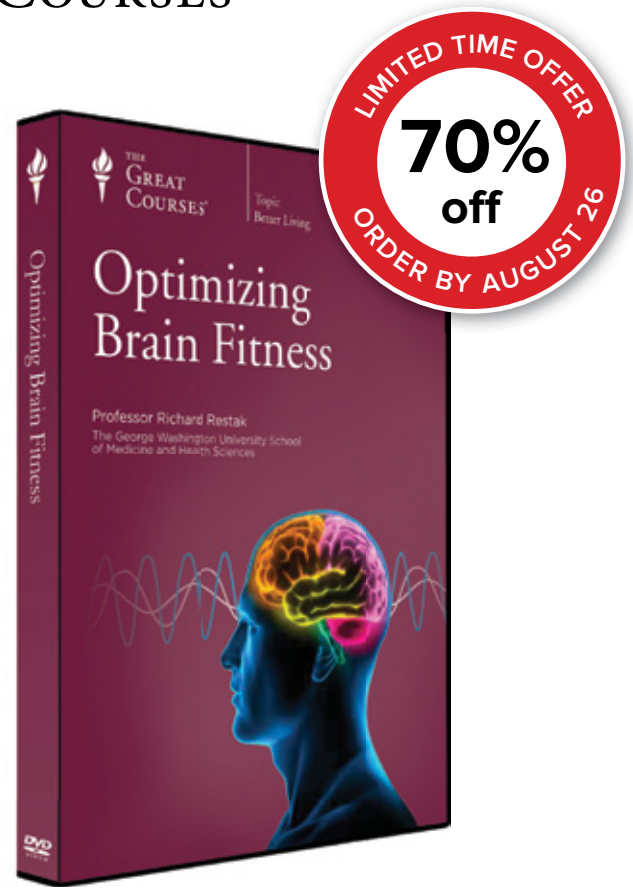

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