SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS
November/December 2012
www.ScientificAmerican.com/Mind

SPECIAL ISSUE

THINK LIKE A GENIUS

How exceptional intelligence and creativity arise

Creativity on Demand

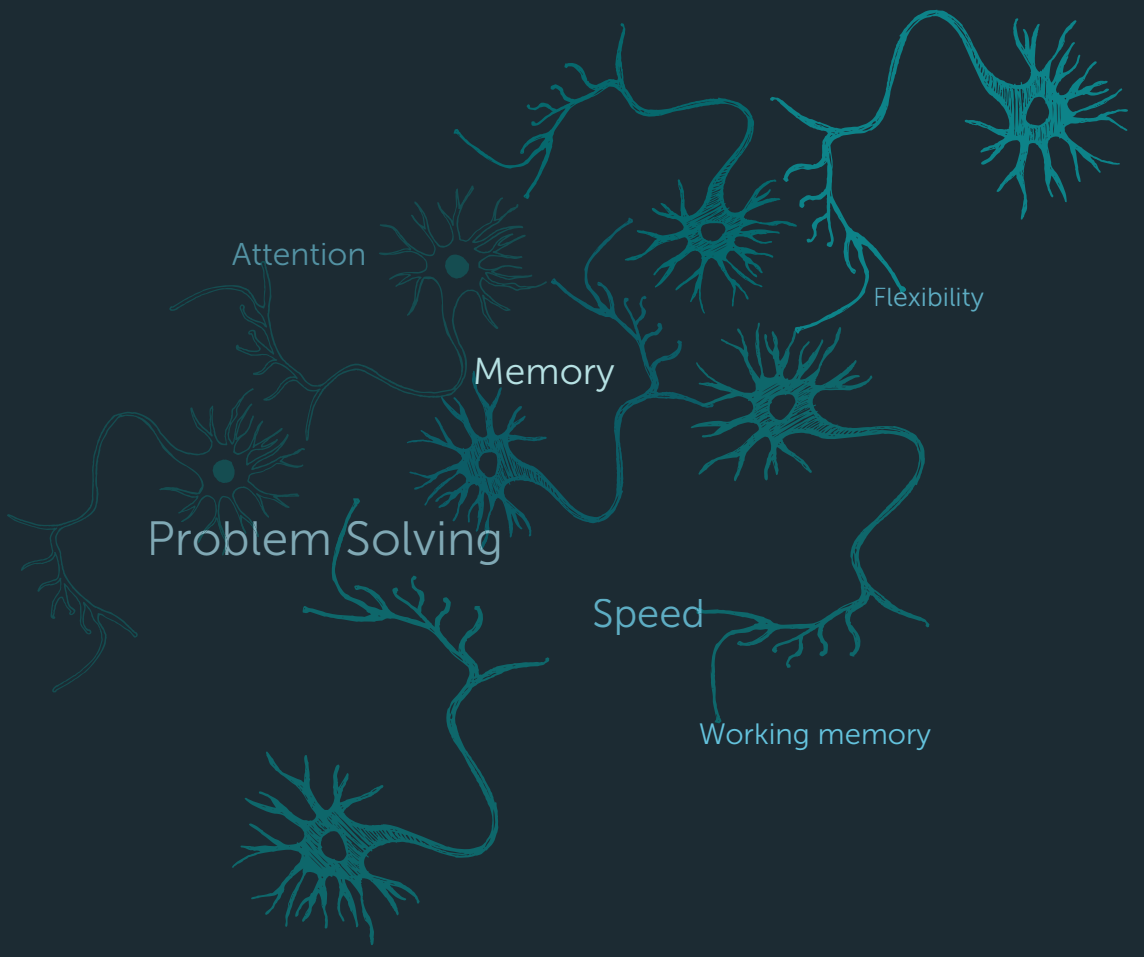
How to Brainstorm Your Next Big Idea

Meet the *Real* Evil Geniuses

Male versus Female Intelligence

How to Raise a Gifted Child

Animals: Smarter Than We Think



Help pioneer the understanding and enhancement of the human brain.

With **25 million users** worldwide and the **largest database** on human cognition ever assembled, Lumosity's platform enables **leading research collaborators** to understand human cognition at the next level.

Lumosity brings brilliant minds together, building tools that help everyone take charge of their brain health.

Unlock your potential. **lumosity.com**

lumosity

SCIENTIFIC AMERICAN
MIND™
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

Real Genius

"Imagine a world in which every work of genius was stripped away, a world without great literature, art, philosophy, science or even technology. We would be living in a very barren world, huddling in some cave, shivering in the cold."

So began a recent exchange with psychologist Dean Keith Simonton on the merits of studying genius. Few of us can be the best, I argued, playing devil's advocate, so why bother with the topic? Simonton countered that we can be proactive about encouraging genius, so that someday our present lives will look just as barren. In this special issue devoted to the topic of genius, we explore the cognitive components that make great works possible and ways to help brilliance bloom.

The first question most people ask about genius is how to define it. Singer-songwriter Beck offered this explanation: "Must have hair going everywhere." The iconic Albert Einstein hair, captured on our cover, implies irreverence and a touch of eccentricity. As Simonton writes in "The Science of Genius," starting on page 34, openness to peripheral ideas is common among highly innovative people. Their hobbies end up enriching their thought processes. Although it may sound like science fiction, in "Switching on Creativity," neuroscientist Allan W. Snyder and his colleagues describe an experimental brain stimulation technique they are developing for inducing such openness and creative insight. Turn to page 58.

Families can foster creativity, too, once they see its early signs. Artistic sensibilities and even passion can emerge as early as age two. See page 42 for more on how talent unfolds in "Predicting Artistic Brilliance," by psychologists Jennifer E. Drake and Ellen Winner. Exposing youngsters to a wide range of experiences increases the chances that a child will get inspired and start developing a new skill, as psychologist Rena F. Subotnik et al. write in "Nurturing the Young Genius," on page 50.

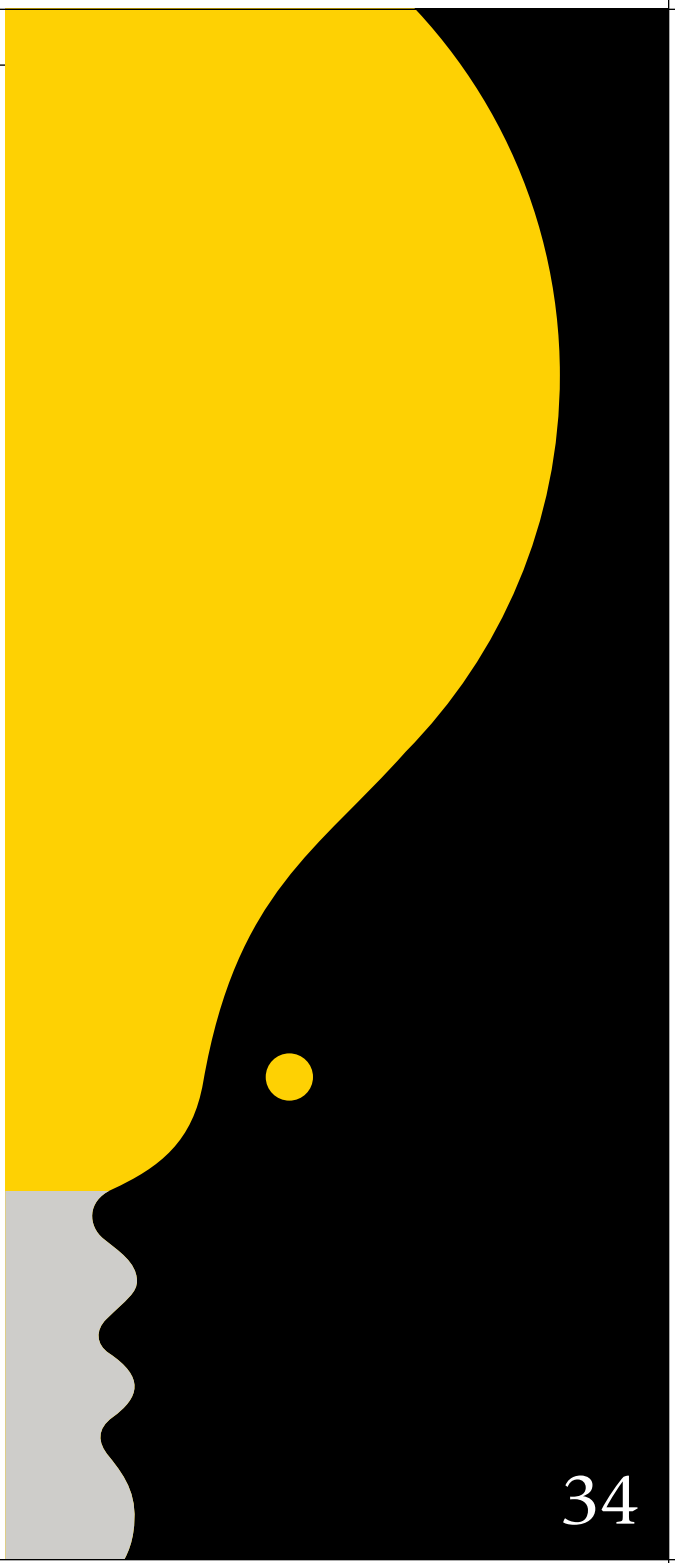
No crazy hair? No problem. Let our experts help you tap into your inner Einstein. Great minds really do think alike—and that is excellent news for the rest of us.

Sandra Upson
Managing Editor
editors@SciAmMind.com

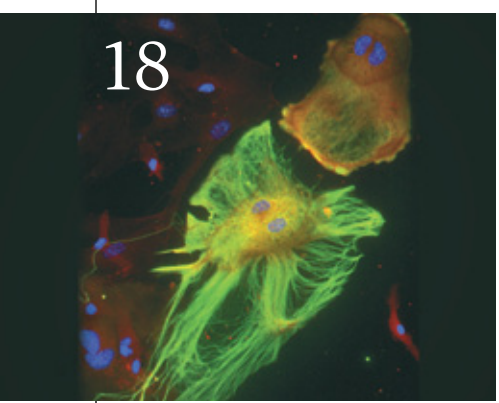
SCIENTIFIC AMERICAN MIND
Volume 23, Number 5, November/December 2012

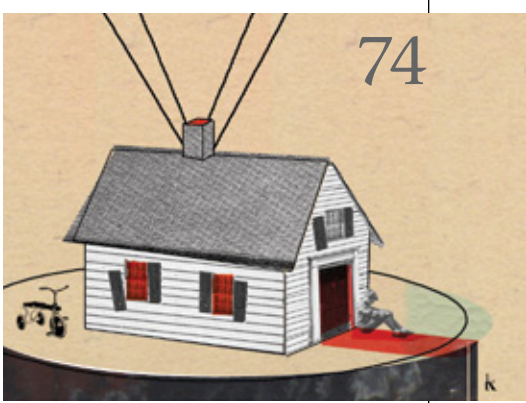
SPECIAL ISSUE: GENIUS

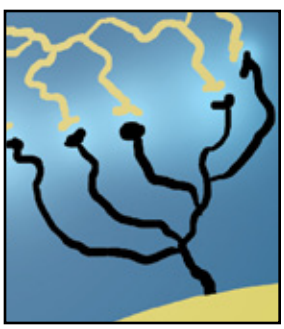
FEATURES



DEPARTMENTS







Scientific American Mind (ISSN 1555-2284), Volume 23, Number 5, November/December 2012, published bimonthly by Scientific American, a trading name of Nature America, Inc., 75 Varick Street, 9th Floor, New York, N.Y. 10013-1917. Periodicals postage paid at New York, N.Y., and additional mailing offices. Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40012504. Canadian BN No. 127387652RT; TVQ1218059275 TQ0001. Publication Mail Agreement #40012504. Canada Post: Return undeliverables to 2835 Kew Dr., Windsor, ON N8T 3B7. Subscription rates: one year (six issues), $19.95; elsewhere, $30 USD. Postmaster: Send address changes to Scientific American Mind, P.O. Box 3187, Harlan, Iowa 51537. To purchase additional quantities: U.S., $10.95 each; elsewhere, $13.95 each. Send payment to SA Mind, P.O. Box 4002812, Des Moines, Iowa 50340.
For subscription inquiries, call (888) 262-5144. To purchase back issues, call (800) 925-0788. Printed in U.S.A.

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

PRESIDENT: Steven Inchcoombe
EXECUTIVE VICE PRESIDENT: Michael Florek

VICE PRESIDENT AND ASSOCIATE PUBLISHER, MARKETING AND BUSINESS DEVELOPMENT: Michael Voss
DIRECTOR, ADVERTISING: Stan Schmidt
VICE PRESIDENT, DIGITAL SOLUTIONS: Wendy Elman
DIRECTOR, GLOBAL MEDIA SOLUTIONS: Jeremy A. Abbate
SALES DEVELOPMENT MANAGER: David Tirpack
PROMOTION MANAGER: Diane Schube
PROMOTION ART DIRECTOR: Maria Cruz-Lord
MARKETING RESEARCH DIRECTOR: Rick Simone
SALES REPRESENTATIVE: Chantel Arroyo

MANAGING DIRECTOR, CONSUMER MARKETING: Christian Dorbandt
ASSOCIATE CONSUMER MARKETING DIRECTOR: Catherine Bussey
SENIOR MARKETING MANAGER, ONLINE: David Courage
SENIOR MARKETING MANAGER/ACQUISITION: Patricia Elliott

DIRECTOR, ANCILLARY PRODUCTS: Diane McGarvey

HOW TO CONTACT US

FOR ADVERTISING INQUIRIES:
Scientific American Mind
75 Varick Street, 9th Floor
New York, NY 10013
212-451-8893
fax: 212-754-1138

FOR SUBSCRIPTION INQUIRIES:
U.S. and Canada: 888-262-5144
Outside North America:
Scientific American Mind
PO Box 5715, Harlan, IA 51593
515-248-7684
www.ScientificAmerican.com/Mind

TO ORDER REPRINTS:
Reprint Department
Scientific American Mind
75 Varick Street, 9th Floor
New York, NY 10013
212-451-8877
fax: 212-451-8252
reprints@SciAm.com

FOR PERMISSION TO COPY OR REUSE MATERIAL FROM SCIAMMIND:
Permissions Department
Scientific American Mind
75 Varick Street, 9th Floor
New York, NY 10013
212-451-8546
www.ScientificAmerican.com/permissions
Please allow three to six weeks for processing.

ANOTHER REASON TO HAVE KIDS

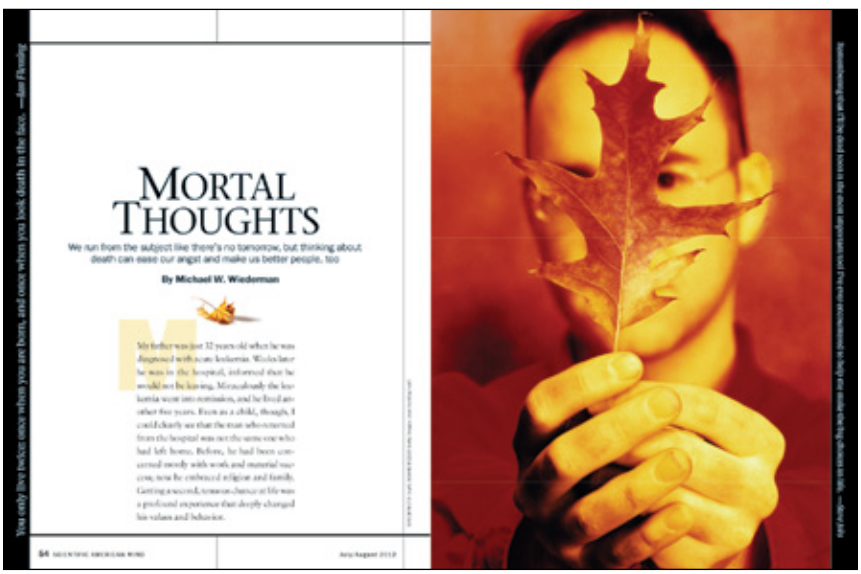
"Mortal Thoughts," by Michael W. Wiederman, raises an interesting question: Why did humans evolve such a strong fear of mortality in the first place? According to an article in the fall 2010 issue of *Biological Theory*, our awareness of mortality is a by-product of the evolution of consciousness (which has obvious fitness benefits). Yet natural selection was not finished: it then favored a fear of mortality, together with the amelioration of that fear through offspring production.

In other words, attraction to offspring production provided our ancestors with an important mortality anxiety buffer—a perception of being able to "leave something of oneself" for the future despite being terrorized by the uniquely human capacity to foresee one's own inevitable death. According to this hypothesis, children therefore represented vehicles for the transmission of self-identifying "memes," such as values and beliefs, which reside in the minds and behaviors of a parent. More important, this drive to reproduce also ensured genetic legacy: the transmission of genes to future generations, including genes that influence the expression of legacy drive and therefore also genes that promote mortality anxiety. Being afraid to die turned out to be in the best interests of our ancestors' genes.

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

INVITING BACTERIA IN

"Microbes on Your Mind," by Moheb Costandi, adds to a slew of great microbe theories getting recent notice. Others include the idea that humans and their bugs now represent a single superorganism and that the complex part of our immune system did not evolve to fight invading pathogens. That talent may have



Could our fear of death have evolved to inspire us to have more children?

been a lucky aftereffect of its more ancient role: managing the bugs our vertebrate ancestors "invited" in to help us better digest more kinds of food.

"The Mix–UAB"
commenting at
www.ScientificAmerican.com/Mind

HOW TO CONTACT US
For general inquiries or to send a letter to the editor:
Scientific American Mind
75 Varick Street, 9th Floor
New York, NY 10013
212-451-8200
editors@SciAmMind.com

PREHOMOSEXUALITY

Regarding "Is Your Child Gay?" Jesse Bering should be congratulated for the courage and wisdom to write an article that enlightens us on "sexual orientation and how it is influenced by environmental, biological and hereditary factors." This topic also raises an important question: How should boys and girls be raised?

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

HIGH ON ALL-NIGHTERS

I found "Tired and Amped," by Morgen Peck, to ring true. I work the overnight shift three days a week. In the mornings, I do catch a kind of "second wind," which allows me to make it through 20 hours of being awake. I can attest to feeling more hyper, silly and jumpy (it's better than being drunk) the longer I stay up. I also notice that after a while I completely go blank on anything that happened more than four to six hours earlier. Granted, I can eventually remember, but usually I have to sleep first.

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

CATCHING A MOOD

In Ask the Brains, Gary W. Lewandowski, Jr., responds to "Is a Bad Mood Contagious?" In my opinion, nothing could be more true!

Years ago when my husband developed diabetes and his blood sugar levels were out of control, he was in a constant bad mood. It definitely affected my ability to attempt to wrestle with his disease. Yet when I sought the cure for dealing with someone in a perpetual bad mood, there was no literature available.

On the other hand, there is nothing better than contagious enthusiasm. It's wonderful to stand in front of an audience with the perfect opening line. Upon delivery, the broad smiles and applause make everyone cheerful.

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

DRIVE MORE SAFELY

"Old and on the Road," by Wray Herbert [We're Only Human], offers a training method that seems like a really simple way to improve older drivers. It may work for younger drivers as well. I think anyone who sees his or her behavior from a third-person perspective can gain some real insights.

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

BE KIND TO YOURSELF

Self-compassion is a crucial aspect of emotional and mental health, as Marina Krakovsky writes in "Self-Compassion Fosters Mental Health" [Head Lines]. It is important, however, to also study and learn from our "negative" noncompassionate thoughts and feelings. Although they are often oppressive and can be demoralizing, they have a capacity to teach us how we were conditioned and reveal the hidden ideals we harbor about how we should live our lives.

"jeffrey rubin"
commenting at
www.ScientificAmerican.com/Mind

TELL US **YOUR** STORY

Have you ever used a tip from psychology you learned in our pages to solve a problem or improve your life? Share it with us at editors@sciammind.com

FACEBOOK REPARTEE

Readers discuss MIND articles at www.facebook.com/ScientificAmerican Mind:

We linked to "Why Sharing Is Tough for Tots," by Ruth Williams [Head Lines], and said:
A child's brain is still under construction, which explains why kids sometimes know better but nonetheless act in selfish ways.

You said:

Better Kid Care: This supports early educators and their developmentally appropriate practices with children.

Micaela Torregrosa-Mahoney: Just another reason to support techniques other than physical punishment when working with kids to improve sharing and other optimal behaviors.

We linked to "Right Hand, Right Choice," by Matthew Hutson [Head Lines], and said:
Here's a clear example of embodied cognition: our dominant side influences whether we prefer options on our left or right.

You said:

Ryan Harford: Is this evidence that training the weak side is more important than we thought before? Could being ambidextrous create a more balanced life?

Carlos Sosa: In my own experience, I'd say that's definitely true. I practice a type of juggling called poi (almost daily). It requires you to build muscle memory equally on both sides, which means that you're probably also building connections between the left and right hemispheres of the brain. I used to be left-brained, clumsy, uncoordinated, overweight, and anxious (basically, your typical wallflower) but after five years of poi I can't say I'm any of those things now. Learning any type of juggling will build ambidexterity, as long as you continue practicing over time (according to studies showing juggling is good for the brain).

Ryan Harford: Cheers! Yes, and juggling also develops spatial awareness. It is the best ambidextrous practice I've found.

SEAN JUSTICE *Getty Images*

>> NEUROSCIENCE

Changing Social Roles Can Reverse Aging

Old bees that start caring for young ones gain cognitive power

How many mothers have looked at their children and thought, "Ah, they keep me young"? Now we know how right they are.

Caring for the young may delay—and in some cases, even reverse—multiple negative effects of aging in the brain. Gro Amdam, who studies aging in bees at Arizona State University, observed tremendous improvements in cognition among older bees that turn their attention back to nursing. She has reason to believe that changes in social behavior could shave years off the human brain as well.

When bees age, their duties switch from taking care of the brood to foraging outside the hive. The transition is followed by a swift physical and cognitive decline. Amdam removed young bees from their hives, which tricked the older bees into returning to their caretaker posts. Then she tested their ability to learn new tasks. A majority reverted to their former cognitive prowess, according to results published in the journal *Experimental Gerontology*. "What we saw was the complete reversal of the dementia in these bees. They were performing exactly as well as young bees," Amdam says.

The ones that improved had higher levels of the antioxidant PRX6 in their brain, a protein that exists in humans and is thought to protect against neurodegenerative diseases. Amdam's theory is that when older individuals participate in tasks typically handled by a younger generation—whether in a hive or in our own society—antioxidant levels increase in the brain and turn back the clock. Youth, it turns out, may be infectious after all. —*Morgen Peck*

BIAS

Reasoning Is Sharper in a Foreign Language

We might be least rational about money in our native tongues

The language we use affects the decisions we make, according to a new study. Participants made more rational decisions when money-related choices were posed in a foreign language that they had learned in a classroom setting than when they were asked in a native tongue.

To study how language affects reasoning, University of Chicago psychologists looked at a well-known phenomenon: people are more risk-averse when an impersonal decision (such as which vaccine to administer to a population) is presented in terms of a potential gain than when it is framed as a potential loss even when the outcomes are equivalent. In the study, published online in April in *Psychological Science*, native English speakers who had learned Japanese, native Korean speakers who had learned English and native English speakers studying French in Paris all surrendered to the expected bias when they encountered the question in their native tongue. In their foreign language, however, the bias disappeared.

A second set of experiments tested another cognitive bias—we anticipate a personal loss will be more painful than an identical gain will be pleasant, so the benefit of winning must be disproportionately large for us to take a bet (such as gambling with our own money). Again, the foreign-language effect prevailed in two different experiments, one with native Korean speakers and one with native English speakers. The Koreans took more hypothetical bets in English than Korean, and the native English speakers took more real bets in Spanish than they did in English.

"When people use a foreign language, their decisions tend to be less biased, more analytic, more systematic, because the foreign language provides psychological distance," lead author Boaz Keysar suggests. Cognitive biases are rooted in emotional reactions, and thinking in a foreign language helps us disconnect from these emotions and make decisions in a more economically rational way. This study did not consider, however, the instances in which emotional engagement improves, rather than hinders, our choices: "We have an emotional system for a good reason," Keysar says.

—Jessica Gross

MEMORY

Learn Music While You Sleep

Hearing a song during the night might improve your playing

If you have been practicing a piece of music, hearing it again while you are sleeping could help you play it more accurately the next time, according to a study from Northwestern University published online in June in *Nature Neuroscience*.

Sixteen participants with a range of musical education learned to play two melodies by pressing keys in time with a sequence of moving circles, as in the video game Guitar Hero. During a 90-minute nap, one of the tunes was played over and over during slow-wave sleep, which is thought to be an important period for memory consolidation. When the participants awoke, they were better at both tunes, but their accuracy was especially improved for the tune they had heard (without knowing it) in their sleep.

"Memory processing during sleep happens, and it can be beneficial," says senior author Ken A. Paller. "The findings we have suggest that slow-wave sleep is a very important part of the process." Future research will focus on the memory mechanisms at work during this stage of the sleep cycle—and their practical implications.

—Jessica Gross

ISTOCKPHOTO (*left*); JOOS MIND Getty Images (*right*)

22 NUMBER OF BONES THAT MAKE UP A **HUMAN SKULL**

ISTOCKPHOTO

FETAL DEVELOPMENT

A Daily Glass of Wine Is Okay during Pregnancy

Moms' moderate drinking does not affect kids' cognition

Many pregnant women indulge in an occasional—or even regular—glass of wine and then worry that it might put their baby at a mental disadvantage. A new study of more than 1,600 Danish five-year-old children shows that these nonteetotaler moms can breathe a sigh of relief.

Kids whose mothers had up to eight drinks a week were just as smart as their peers born to abstaining moms, according to the study, which measured brainpower in several ways. Another common concern comes from moms who had a "last blast"—a binge of five or more drinks—before realizing they were pregnant. These women, too, can breathe easy; tots whose moms had a binge episode early in pregnancy performed just as well on the mental tasks.

Heavier drinking during pregnancy does handicap children, and some previous reports had suggested that even a little daily alcohol could potentially harm the child. "Intelligence, attention and executive functions [such as planning and reasoning] are often affected in children of alcohol-abusing mothers," says lead researcher Ulrik S. Kesmodel of Aarhus University in Denmark. Therefore, he and his colleagues expected to be able to detect the effects of small amounts of alcohol on these specific abilities, he says. Yet no such changes emerged when the researchers put kids to these tasks. The results appeared in June in *BJOG: An International Journal of Obstetrics and Gynaecology.* Expecting moms can relax, it appears, and have a drink now and then, guilt-free.

—Stephani Sutherland

CEDRIC PASQUINI *Redux Pictures (top)*; COURTESY OF CHRISTINA STARMANS *Yale University (bottom)*

44

Number of Nobel Prizes awarded to women—5 percent of the total

IDENTITY

Your Eyes, Your Self

We think the self resides in the eyes, not the head

Study participants judged the fly to be closest to this "alien" when it was nearest to the figure's eyes.

Three experiments published recently in the journal *Cognition* sought to locate our physical sense of self. Children and adults viewed several drawings of characters with an object and in each case judged how close the object was to the illustrated person. Results showed that participants tended to measure distance from the character's eyes, even when the object was not in the person's line of sight. The researchers took this to mean that we place the concept of self in the eyes. To make sure that people were not judging distance from the head, researchers included an alien with eyes on its chest in their study. "By moving the eyes off the head, we could test whether people were really drawn to the eyes or just the head in general," says study author Christina Starmans, a Ph.D. student at Yale University. Both children and adults still perceived the eyes as the location of the self.

—Tori Rodriguez

Think Clearly.

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

Cognizin®

For the evolution of your mind®

To learn more about Cognizin®
visit **www.cognizin.com**

Follow Cognizin®

***These statements have not been evaluated by the Food and Drug Administration. This product is not intended to diagnose, treat, cure, or prevent any disease.**

Look for Cognizin® Citicoline in these fine brands.

Ecological Formulas · GUNG HO · Healthy Origins® Healthy Value from Reliable Origins · Jarrow Formulas · Balance Your Life JoMar Labs amino acid source · LifeExtension · NSI Nutraceutical Sciences Institute® · nawgan® · Pathway To Healing · SomaLife · Swanson Health Products · TianChi® Brighten Your Mind

SCIENTIFIC AMERICAN Travel

BRIGHT HORIZONS™ 16

FEBRUARY 20–MARCH 5, 2013 ✷ PATAGONIA ✷ www.InsightCruises.com/sciam16

Explore the far horizons of science while living the dream of rounding Cape Horn. Gather indelible images of the uttermost ends of the Earth in the company of fellow citizens of science. Venture about South America's uniquely beautiful terrain with Scientific American Travel on the Bright Horizons 16 cruise conference on Holland America's Veendam from Santiago, Chile to Buenos Aires, Argentina, February 20 – March 5, 2013. An abundance of cultural, natural, and scientific riches await you.

Embrace the elemental suspense of Patagonia. Absorb the latest on neutrinos with Dr. Lawrence Krauss. Immerse yourself in oceanography with Dr. Gary Lagerloef. Survey South America's deep origins with Dr. Victor A. Ramos. Take a scientific look at beliefs, ethics, and morals with Dr. Michael Shermer. Ponder key questions about extraterrestrial life with Dr. Seth Shostak. See the world in a grain of soot and the future in nanotechnology with Dr. Christopher Sorenson.

You have pre- and post-cruise options to peer into the Devil's Throat at Iguazu Falls (a great wonder of the natural world), visit Easter Island or the Galapagos, or ascend Machu Picchu.

Savor South America with a friend. The potential of science beckons, and adventure calls on Bright Horizons 16. Please join us! We take care of the arrangements so you can relax and enjoy the natural and cultural splendor of South America. For the full details, email Concierge@insightcruises.com, or call 650-787-5665.

Cruise prices vary from $1,599 for an Interior Stateroom to $5,599 for a Deluxe Suite, per person. For those attending our SEMINARS, there is a $1,575 fee. Taxes, Port Charges, and an Insight Cruises fee are $336 per person. Program subject to change. **For more info please call 650-787-5665 or email us at Concierge@InsightCruises.com**

CST# 2065380-40 ™Scientific American, Inc.

THE EARTH FROM SPACE

Gary Lagerloef, Ph.D.

Earth From Space: A Dynamic Planet

The world's space programs have long focused on measurements of Earth. NASA has more than a dozen satellites collecting data on weather, climate change, the land, ocean and polar regions. They reveal Earth's dynamic biosphere, atmosphere, oceans and ice. Get a guided tour of an active and dynamic Earth with amazing and astonishing images and videos.

The Oceans Defined

Satellites have greatly enhanced the exploration & understanding of our oceans. From early weather satellite images detailing ocean currents to views of the marine biosphere, new satellite technologies have revolutionized our scientific understanding of the oceans. Find out what we can measure from space today, objectives of measurement, the amazing technology behind these abilities, and the latest compelling discoveries.

Climate Science in the Space Age

Climate variability and change are among the most important societal issues of our time. Signs of rising global temperatures are obvious in meteorology and oceanography. We'll discuss short, medium and long-term climate variability & change. You'll gain perspectives to effectively sort through contemporary debate about climate change.

The Aquarius/SAC-D Satellite Mission

Take an in-depth look at the Aquarius/SAC-D mission, an oceanographic partnership between the United States and Argentina. Get a behind-the-scenes look at the process of developing and launching a new satellite mission, a briefing on the core scientific mission, and a look at initial findings. Dive into a session that ties together mission, data, and applied science.

GEOLOGY

Speaker: Victor A. Ramos, Ph.D.

The Patagonia Terrain's Exotic Origins

Did Patagonia evolve as an independent microcontinent that fused with South America 265 million years ago? Dr. Ramos will give you the latest theory on the complex development of Patagonia. We'll look at the geologic evidence of Patagonia's close relationships with Antarctica, Africa, and South America, plus archaeological evidence suggestive of Patagonia's origins.

The Islands of the Scotia Arc

Delve into the dynamic nature of South Georgia and the South Sandwich and South Orkney Islands on the Scotia Plate, one of the youngest, and most active tectonic plates. Deepen your understanding of the geology, ecosystems, and history of the Scotia Arc, part of the backbone of the Americas.

The Andes: A History of Earthquakes and Volcanoes

Unfold deep time and learn how South America took shape. Get the details on how the Andes formed, how active Andean volcanoes are, the Andes as a unique climate change laboratory, and lessons learned from the Chilean earthquakes of 1960 and 2011. All certain to give you geologic food for thought on your voyage around the Horn.

Darwin in Southern South America

Darwin's voyage on the Beagle is an incredibly rich scientific and human adventure. Learn the highlights of HMS Beagle's mission in South America in 1833–1835, including Darwin's geological and biological observations. Gain a sense of South America's role in Darwin's life work, and an understanding of his contribution in the context of contemporary science.

PHYSICS

Speaker: Lawrence Krauss, Ph.D.

The Elusive Neutrino

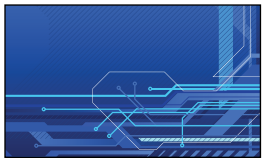
Neutrinos are the most remarkable elementary particles we know about. They are remarkable probes of the Universe, revealing information about everything from exploding stars to the fundamental structure of matter. Dr. Krauss will present a historical review of these elusive and exciting objects, and leave you with some of the most remarkable unsolved mysteries in physics.

The Physics of Star Trek

Join Lawrence Krauss for a whirlwind tour of the Star Trek Universe and the Real Universe — find out why the latter is even more exotic than the former. Dr. Krauss, the author of The Physics of Star Trek, will guide you through the Star Trek universe, which he uses as a launching pad to the fascinating world of modern physics.

Space Travel: Why Humans Aren't Meant for Space

The stars have beckoned humans since we first looked at the night sky. Humans set foot on the Moon over 40 years ago, so why aren't we now roaming our solar system or the galaxy in spacecraft? Dr. Krauss describes the daunting challenges facing human space exploration, and explores the realities surrounding our hopes for reaching the stars.



NANOSCIENCE

Chris Sorensen, Ph.D.

Fire, Fractals and the Divine Proportion

Physicist Chris Sorenson discusses the mysteries, beauties, and curiosities of soot. Take an unlikely journey of discovery of soot to find fractal structures with non-Euclidian dimensionality, networks that tenuously span space and commonalities among spirals, sunflowers and soot. Gain an appreciation for the unity of Nature, and the profound lessons in the commonplace as well as the sublime through soot!

Light Scattering

Take a *particle* physics perspective and ask: how do particles scatter light and why does light scatter in the first place? What are the effects of scattering on the polarization? How do rainbows, glories and sundogs work? How do light scattering and absorption effect the environment? Get the latest on scattering and see your universe in a new light.

Nanoparticles: The Technology.

Nanoscience has spawned a significant nanotechnology. Explore new nanomaterials such as self cleaning surfaces and fibers stronger yet lighter than steel. Then we'll do some informed daydreaming about far reaching possibilities like nanobots that could take a "fantastic voyage" inside your body or stealth materials for the invisible man. Enjoy reality science fiction at its best!

Nanoparticles: The Science.

What makes "nano" so special? Why does nano hold such great promise? Take a look at the clever chemistry that creates the nanoparticle building blocks of the new nanomaterials. Find out why physical properties of nanoparticles differ from larger particles. When this session is over, you'll understand why small can be better.

ASTROBIOLOGY

Speaker: Seth Shostak, Ph.D.

Hunting for Life Beyond Earth

Is Earth the only planet to sport life? Researchers are hot on the trail of biology beyond Earth, and there's good reason to think that we might find it within a decade or two. How will we find alien biology, and what would it mean to learn that life is not a miracle, but as common as cheap motels?

Finding E.T.

Life might be commonplace, but what about intelligent life? What's being done to find our cosmic confreres, and what are the chances we'll discover them soon? While most people expect that the cosmos is populated with anthropomorphic aliens aka "little gray guys with large eyes and no hair" you'll hear that the truth could be enormously different.

What Happens If We Find the Aliens?

One-third of the public believes that aliens are visiting Earth, pirouetting across the skies in their saucers. Few scientists agree, but researchers may soon discover intelligent beings sharing our part of the galaxy. Could we handle the news? What facts could be gleaned

immediately, and what would be the long-term effects such a discovery would have on us and our institutions, such as religion?

The Entire History of the Universe

Where and when did the cosmos begin, and what's our deep, deep future? The book of Genesis gives only a short description of the birth of the cosmos, but modern science can tell a more complex tale. How did the universe get started, and could there be other universes? And how does it all end, or does it end at all?

SKEPTICISM

Speaker: Michael Shermer, Ph.D.

The Believing Brain: From Ghosts and Gods to Politics and Conspiracies — How We Construct Beliefs and Reinforce Them as Truths

The brain as a "belief engine"? Learn how our brains' pattern-recognition and confirmation bias help form and reinforce beliefs. Dr. Shermer provides real-world examples of the process from politics, economics, and religion to conspiracy theories, the supernatural, and the paranormal. This discussion will leave you confident that science is the best tool to determine whether beliefs match reality.

Skepticism 101: How to Think Like a Scientist

Harvest decades of insights for skeptical thinking and brush up on critical analysis skills in a lively session that addresses the most mysterious, controversial, and contentious issues in science and skepticism. Learn how to think scientifically and skeptically. You'll see how to be open-minded enough to accept new ideas without being *too* open-minded.

The Science of Good and Evil: The Origins of Morality and How to be Good Without God

Tackle two challenging questions of our age with Michael Shermer: (1) The origins of morality and (2) the foundations of ethics. Dr. Shermer peels back the inner layers covering our core being to reveal complex human motives — good and evil. Gain an understanding of the evolutionary and cultural underpinnings of morality and ethics and how these motives came into being.

The Mind of the Market: Compassionate Apes, Competitive Humans, and Other Lessons from Evolutionary Economics

How did we evolve from ancient hunter-gatherers to modern consumer-traders? Why are people so irrational when it comes to money and business? Michael Shermer argues that evolution provides an answer to both of these questions through the new science of evolutionary economics. Learn how evolution and economics are both examples of complex adaptive systems. Get your evolutionary economics tools together.

SCIENTIFIC AMERICAN Travel HIGHLIGHTS

IGUAZU FALLS

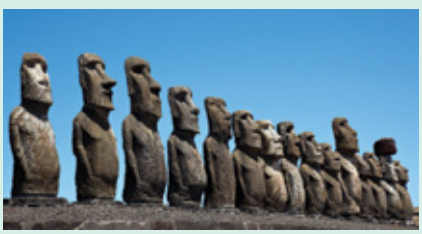
March 5–7, 2013 — Surround yourself with 260 degrees of 240 foot-high walls of water at Iguazu Falls. Straddling the Argentinian-Brazilian border, Iguazu Falls is split into about 270 discrete falls and at peak flow has a surface area of 1.3 million square feet. (By comparison, Niagara Falls has a surface area of under 600,000 square feet.) Iguazu is famous for its panoramic views and breath-taking vistas of huge sprays of water, lush rainforest, and diverse wildlife.

You'll walk Iguazu National Park's extensive and well-engineered circuit paths over the Falls, go on a boat ride under the Falls, be bowled over by the massiveness and eco-beauty, and take a bazillion pictures.

MACHU PICCHU

February 15–20, 2013 — Scale the Andes and absorb Machu Picchu's aura. Visit this legendary site of the Inca World, draped over the Eastern slopes of the Peruvian, wrapped in mystery. Whether it was an estate for the Inca emperor Pachacuti or a site for astronomical calculations, it captures the imagination. Visit Machu Picchu, and see for yourself the massive polished dry-stone structures, the Intihuatana ("Hitching Post of the Sun"), the Temple of the Sun, and the Room of the Three Windows. Iconic ruins, rich flora and fauna, and incomparable views await your eye (and your lens).

EASTER ISLAND



Februrary 16–20, 2013 — The moai of Easter Island linger in many a mind's eye, monumental statues gazing inland, away from the South Pacific. Join Bright Horizons on a four-day pre-cruise excursion to explore the mysteries of Rapa Nui. Visit archaeological sites, learn about the complex cultural and natural history of the island, and absorb the ambiance of one of the most remote communities on Earth. Come along on an adventure where archaeology and environment create memories and food for thought.

GALAPAGOS

February 12–20, 2013 — Enter an unearthly natural world in an eight-day pre-cruise excursion to the Galapagos Islands. "See the world in a grain of sand" and hone your knowledge of evolution with your observations in the Galapagos, a self-contained natural history laboratory. We'll tour Santiago, Chile, and straddle the Equator at the "Middle of the World" complex in Quito, Ecuador. Then off to the Galapagos for a four-day expedition on the mv Galapagos Legend. Accompanied by certified naturalists see the incredibly diverse flora and fauna up close. You'll have the opportunity to swim and snorkel, and photograph legendary wildlife and wild landscapes. Join Bright Horizons in the Galapagos for all the intangibles that communing with nature provides.

SCIENTIFIC AMERICAN™ Travel

BRIGHT HORIZONS™ 17

NORWEGIAN FJORDS, JULY 5–15, 2013

For information on more trips like this, please log onto **www.ScientificAmerican.com/Travel**

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

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

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

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

Neurobiology

Speaker: Robert Sapolsky, Ph.D.

The Biology of Memory

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

Sushi and Middle Age

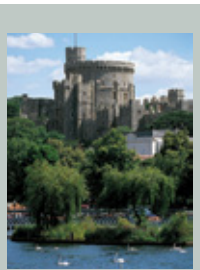
When was the last time you tried a really different, strange type of food, explored the work of a new composer, or made a substantial change in appearance? As we age, we get less interested in novelty and increasingly crave the familiar. Examine the neurobiology and psychology underlying this age-related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

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

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

The Biology of Aggression and Violence

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



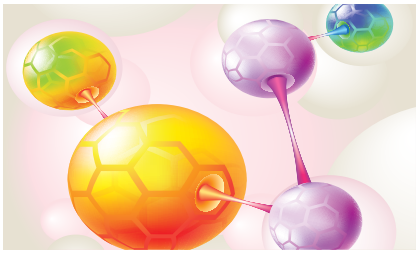
Hampton Court and Windsor Castle (July 2)

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

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

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

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



Chemistry

Speaker: Robert Hazen, Ph.D.

Genesis: The Scientific Quest for Life's Origins

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

The Diamond Makers

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

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

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

Chemical Bonding

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

Quantum Physics

Speaker: Benjamin Schumacher, Ph.D.

Private Lives of Quantum Particles

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

2π Is Not Zero (But 4π Is)

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

The Physics of Impossible Things

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

The Force That Isn't a Force

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

Archaeology

Speaker: Kenneth Harl, Ph.D.

From Old Europe to Roman Provinces

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

Great Halls and Market Towns in Viking Age Scandinavia

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

Ships and Ship Building in the Viking Age

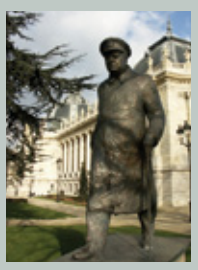
— European history records the effectiveness of the fearsome Viking longship; find out the features and technologies that made it so. Based on archaeological finds, learn about the multi-millennial evolution of the longship, from linden to oak, dugout to mast and sail. Gain an appreciation for the form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

Warfare in the Viking Age

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

SCIENTIFIC AMERICAN Travel HIGHLIGHTS

NORWEGIAN FJORDS
JULY 5–15, 2013

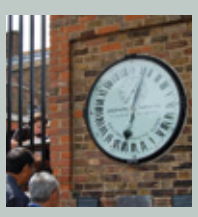


The Royal Observatory and the Churchill War Room/Museum (July 4)

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

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

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



Stonehenge and Bath (July 3)

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

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

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

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

>> MENTAL HEALTH

Treating Sleep Improves Psychiatric Symptoms

Sleep may be a critical link—and therapeutic target—in mental illness

People with depression or other mental illnesses often report trouble sleeping, daytime drowsiness and other sleep-related issues. Now a growing body of research is showing that treating sleep problems can dramatically improve psychiatric symptoms in many patients.

Much of the latest work illustrates how sleep apnea, a common chronic condition in which a person repeatedly stops breathing during sleep, may cause or aggravate psychiatric symptoms. In past years sleep apnea has been linked to depression in small studies and limited populations. Now a study by the Centers for Disease Control and Prevention strengthens that connection. The CDC analyzed the medical records of nearly 10,000 American adults with sleep apnea. Men diagnosed with this disorder had twice the risk of depression—and women five times the risk—compared with those without sleep apnea. Writing in the April issue of *Sleep,* lead author Anne G. Wheaton and her colleagues speculate that in addition to interrupting sleep, the oxygen deprivation induced by sleep apnea could harm cells and disrupt normal brain functioning.

Treating this disorder shows promise for reducing symptoms of depression, a recent study at the Cleveland Clinic suggests. In the experiment, patients went to bed wearing a mask hooked up to a machine that increases air pressure in their throat. The increased pressure prevents the airway from collapsing, which is what causes breathing to cease in most cases of this disorder. Using this machine, psychiatrist Charles Bae and his colleagues treated 779 patients who had been diagnosed with sleep apnea. After an average of 90 days of sleeping with the machine, all the patients scored lower on a common depression survey than before the treatment—regardless of whether they had a prior diagnosis of depression or were taking an antidepressant. The data were presented in June at the SLEEP 2012 conference in Boston.

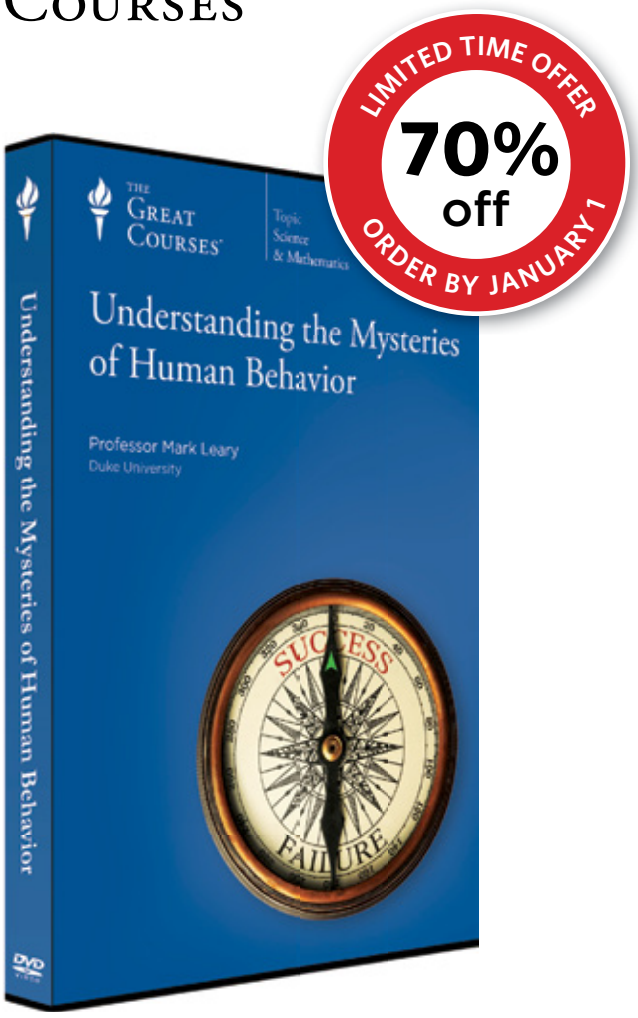
YE RIN MOK *Corbis*

Investigating their patients' sleep health might allow doctors to alleviate mental disturbances early—perhaps even before patients try psychiatric drugs. This treatment could be especially important for children, according to three new studies that show sleep is associated with mental disturbance at young ages. An August study in *Medical Hypotheses* reported that about 25 to 50 percent of children and adolescents with attention-deficit hyperactivity disorder experience sleep problems. A few months earlier in the journal *Pediatrics,* researchers found that of the 11,000 children in the study, those with disordered breathing in sleep (as reported by their parents) had 40 percent more behavioral difficulties at four years old and 60 percent more at age seven. Sleep disturbances affect moods, too—and not simply by producing crankiness. Adolescents who reported daytime drowsiness were also more likely to experience sadness, according to a March study in the *Journal of Mental Health Policy and Economics*.

Steven Y. Park, assistant professor of otolaryngology at the Albert Einstein College of Medicine, has long been advocating that sleep disorders are an underlying cause of many psychiatric disorders. "The way I see it," Park says, "you can't consider a psychiatric disorder without thinking about a sleep-breathing problem."

—David Levine

THE GREAT COURSES®



Why Do We Behave the Way We Do?

Where did your personality come from? Why do you have trouble controlling certain behaviors? Since the dawn of recorded history, people have sought explanations for why we behave the way we do. But it's only in recent decades that researchers can finally provide answers.

Join award-winning Duke University Professor Mark Leary, a preeminent force in social psychology and neuroscience education, on a fascinating journey into the complex heart of who you are with **Understanding the Mysteries of Human Behavior**. Using the latest research, these 24 lectures provide powerful insights on the provocative questions so many of us have about the fundamental—and sometimes puzzling—traits and idiosyncrasies of human behavior.

Offer expires 01/01/13

1-800-832-2412

WWW.THEGREATCOURSES.COM/8MIND

Understanding the Mysteries of Human Behavior

Taught by Professor Mark Leary
DUKE UNIVERSITY

LECTURE TITLES

1. Solving Psychological Mysteries
2. How Did Human Nature Evolve?
3. Where Do People's Personalities Come From?
4. How Can Siblings Be So Different?
5. Why Do People Need Self-Esteem—Or Do They?
6. Why Do We Have Emotions?
7. What Makes People Happy?
8. Why Are So Many People So Stressed Out?
9. Why Do Hurt Feelings Hurt?
10. Why Do We Make Mountains out of Molehills?
11. Why Is Self-Control So Hard?
12. Why Do We Forget?
13. Can Subliminal Messages Affect Behavior?
14. Why Do We Dream?
15. Why Are People So Full of Themselves?
16 Do People Have Psychic Abilities?
17. Why Don't Adolescents Behave like Adults?
18. How Much Do Men and Women Really Differ?
19. Why Do We Care What Others Think of Us?
20. Why Are Prejudice and Conflict So Common?
21. Why Do People Fall In—and Out of—Love?
22. What Makes Relationships Succeed or Fail?
23. Why Do People Blush?
24. A Few Mysteries We Can't Explain Yet

Understanding the Mysteries of Human Behavior
Course no. 1626 | 24 lectures (30 minutes/lecture)

SAVE UP TO $185

DVD ~~$254.95~~ **NOW $69.95**
CD ~~$179.95~~ **NOW $49.95**

+$10 Shipping & Handling
Priority Code: 65614

Designed to meet the demand for lifelong learning, The Great Courses is a highly popular series of audio and video lectures led by top professors and experts. Each of our more than 400 courses is an intellectually engaging experience that will change how you think about the world. Since 1990, over 10 million courses have been sold.

4 Number of people who possess more than one Nobel Prize: **John Bardeen** (physics), **Marie Curie** (physics and chemistry), **Linus Carl Pauling** (physics and peace) and **Frederick Sanger** (chemistry)

>> MENTAL ILLNESS

Did I Do That?

Schizophrenic patients might struggle with a poor perception of cause and effect

MARK GOLDMAN /*Stockphoto*

People with schizophrenia often experience the unnerving feeling that outside forces are controlling them. Other times they feel an illusory sense of power over uncontrollable events. Now scientists find these symptoms may arise from disabilities in predicting or recognizing their own actions. The findings suggest new therapies for treating schizophrenia, which afflicts an estimated 1 percent of the world population.

To see where this confusion might stem from, researchers tested two ways people are known to link actions and their outcomes. We either predict the effects of our movements or retrospectively deduce a causal connection. Healthy participants and schizophrenic patients were asked to look at a clock and occasionally push a button. Most of the time the button push was followed by a tone. The participants then told researchers what time they had pushed the button and when the tone had occurred.

Healthy volunteers reported later times for each button push if it was followed by a tone. This result suggests that awareness of a link between the two events causes people to perceive less time between them. Participants also tended to estimate later button pushes even in the few cases when no tone was emitted, revealing that the subjects were predicting they would hear the sound, says psychiatrist and cognitive neuroscientist Martin Voss of Charité University Hospital and St. Hedwig Hospital in Berlin.

This prediction effect did not appear in the schizophrenic patients' responses. Instead patients' subjective estimate of the time at which they hit the button was only delayed when the tone sounded and not when it was omitted. "It looked like they were only retrospectively constructing links between actions and effects instead of predicting them," Voss says. "They may have a fundamental problem with predicting the consequences of their actions." The researchers detailed their findings on July 18 at the Federation of European Neuroscience Societies conference in Barcelona.

Similarly, cognitive psychologist Janet Metcalfe of Columbia University found that schizophrenic subjects had trouble knowing how much control they had over their own actions. She and her colleagues had volunteers play a computer game in which they moved a cursor to touch falling Xs on the screen while avoiding falling Os. The scientists could distort player controls by introducing a lag into cursor responses or random turbulence into cursor motions. Although healthy volunteers knew when they were in control of their moves during the game, the schizophrenic patients apparently did not detect how lag or turbulence affected control of their performance. Yet "the patients' performance at the game was quite good, and they were good at judging how well they performed. The fact they have quite good mental function in those respects gives me hope that therapies can work," Metcalfe says. She and her colleagues described their results in the May 19 *Philosophical Transactions of the Royal Society B.*

This research suggests that exercising schizophrenic patients' awareness of themselves and their surroundings could improve their assessments of control, says cognitive neuropsychologist Sohee Park of Vanderbilt University, who did not take part in either study. "We're interested in seeing if teaching people to juggle improves symptoms of schizophrenia," she says. "Throwing a ball and catching it really involves awareness and predicting of what you and the ball are doing." Therapeutic approaches involving dance or yoga might also work.

—*Charles Q. Choi*

CanadaDrugs.com

1-888-909-0474
Call toll free. 24 hours a day. 7 days a week.

Everyday savings.

You'll save 40%-70% off your drug bill with Canada Drugs.

For over a decade, we've been saving our patients hundreds of dollars every month off their prescription drug bills. By ordering comparable generic medication from Canada Drugs, you'll save up to 70% on thousands of prescription drug products. That's money back in your pocket.

Call or visit us online for a quick no-obligation price quote on any of your current prescriptions. We will save you money, no plans, premiums, deductibles or complicated co-pays. Guaranteed.

Steven
Houston, Texas

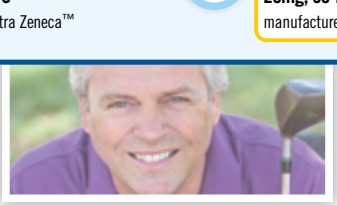
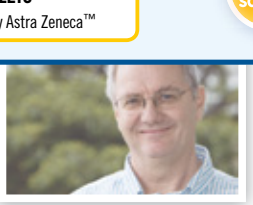
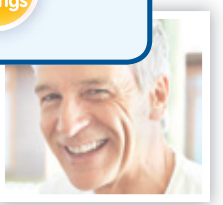
Savings of $128 a month!

WAS PAYING WITH U.S. RETAILER		WITH CANADADRUGS.COM		
CIALIS™ 20mg, 12 TABLETS manufactured by Lilly USA™	$267.84	CIALIS™ 20mg, 12 TABLETS manufactured by Eli Lilly & Co™	$139.65	47% savings

OTHER AVAILABLE PRODUCTS

CELEBREX™ 200mg, 90 CAPSULES manufactured by Pfizer™	$431.04	CELEBREX™ 200mg, 90 CAPSULES manufactured by Pfizer™	$130.50	69% savings
PLAVIX™ 75mg, 84 TABLETS manufactured by Sanofi-Aventis™	$556.92	PLAVIX™ 75mg, 84 TABLETS manufactured by Sanofi-Aventis™	$158.88	71% savings
VIAGRA™ 100mg, 12 TABLETS manufactured by Pfizer™	$260.16	VIAGRA™ 100mg, 12 TABLETS manufactured by Pfizer™	$144.42	44% savings
CRESTOR™ 20mg, 90 TABLETS manufactured by Astra Zeneca™	$453.24	CRESTOR™ 20mg, 90 TABLETS manufactured by Astra Zeneca™	$180.90	60% savings



SAVE 25%
on your first order

Call us today to SAVE 25% on your first order. Why Pay More?

Use this coupon code to save 25% on your first order with Canada Drugs. Not valid in conjunction with any other offer. **Expires March 31, 2013**

1-888-909-0474
Call toll free. 24 hours a day. 7 days a week.

CanadaDrugs.com

Coupon Code: **DCP267**

>> MEDICINE

Meditate That Cold Away

Practicing meditation or exercising might make you sick less often

To blunt your next cold, try meditating or exercising now. A new study from the University of Wisconsin–Madison found that adults who practiced mindful meditation or moderately intense exercise for eight weeks suffered less from seasonal ailments during the following winter than those who did not exercise or meditate.

The study appeared in the July issue of *Annals of Family Medicine.* Researchers recruited about 150 participants, 80 percent of them women and all older than 50, and randomly assigned them to three groups. One group was trained for eight weeks in mindful meditation; another did eight weeks of brisk walking or jogging under the supervision of trainers. The control group did neither. The researchers then monitored the respiratory health of the volunteers with biweekly telephone calls and laboratory visits from September through May—but they did not attempt to find out whether the subjects continued meditating or exercising after the initial eight-week training period.

Participants who had meditated missed 76 percent fewer days of work from September through May than did the control subjects. Those who had exercised missed 48 percent fewer days during this period. The severity of the colds and flus also differed between the two groups. Those who had exercised or meditated suffered for an average of five days; colds of participants in the control group lasted eight. Lab tests confirmed that the self-reported length of colds correlated with the level of antibodies in the body, which is a biomarker for the presence of a virus.

"I think the big news is that mindfulness meditation training appears to have worked" in preventing or reducing the length of colds, says Bruce Barrett of the department of family medicine. He cautions, however, that the findings are preliminary.

—*Harvey Black*

10

Percentage of people with **autism** who also exhibit savant abilities, such as outstanding memory or musical talent

>> VISIONS

Ghostly Glia

Swathed in green threads, this glial cell may hold clues for brain repair. The emerald fibers are chains of a protein called GFAP delta, which researchers suspect might be essential to the birth of new neurons.

ROBERT KOHLHUBER *Getty Images (top);* COURTESY OF MARTINA MOETON *Netherlands Institute for Neuroscience (bottom)*

COMPANIONSHIP

Pets Help Us Achieve Goals and Reduce Stress

Thinking of our dog or cat can make us more productive

The companionship of our furry friends may seem best suited for leisure time, but new research found that having one's dog or cat around—or even just in mind—helps people generate more goals, feel more confident about achieving those objectives and handle stress better.

INTI ST. CLAIR *Getty Images (left)*; MICHAEL CAVÉN *iStockphoto (right)*

1,022

Number of toys that Chaser, a border collie, could identify recently by name

In two related experiments published in the July *Journal of Research in Personality*, participants were assigned to one of three conditions. Either the subject had a pet nearby, simply thought about a pet or, in the control group, had no pet involvement. In the first experiment, participants were asked to come up with a list of goals and assess their confidence in attaining them. Those who had their pet in the room or on their mind identified more goals and felt more self-confident about them than the control group. In the second experiment, subjects performed a distressing cognitive task while their blood pressure was assessed. Both pet groups had lower blood pressure during the task than the control group. Simply picturing that sweet, slobbery face may be all you need to soothe your mind and boost productivity.

—Tori Rodriguez

>> SELF-REFLECTION

Why You Like to Watch the Same Thing Over, and Over, and Over Again

Reruns spark contemplation about personal growth

Sales of television show DVDs have exploded over the past few years. But why do viewers shell out so much cash for what are essentially reruns? A study in the August issue of the *Journal of Consumer Research* suggests that "reconsumption," as the researchers call it, is more complex than one might think. People use familiar entertainment to measure how their lives have changed in positive ways.

Cristel Antonia Russell, a marketing professor at American University, and Sidney J. Levy, a marketing professor at the University of Arizona, conducted interviews of 23 subjects, all of whom had recently "reconsumed" a book, movie or vacation spot. The researchers used open-ended questions to elicit long and descriptive first-person answers, then analyzed the transcripts for recurring themes and key phrases. The responses suggested that sometimes choosing to do something again was about reaching for a sure thing—the brain knows the exact kind of reward that it will receive in the end, whether it is laughter, excitement or relaxation. They also learned that people gained insight into themselves and their own growth by going back for a do-over, subconsciously using the rerun or old book as a measuring stick for how their own lives had changed. One woman, for example, rewatched the romantic Kevin Costner movie *Message in a Bottle* more than once: "It was helping her work through having an engagement that hadn't worked out," Russell says. Every time she watched that movie, it reminded her of her own failed relationship—and her reactions helped her see she was getting over it.

"I was very surprised," Russell says. "I thought that people reconsumed these things for nostalgia, to go back to the past. But they were actually very forward-looking and prospective." What about the boredom factor, you might ask? There was none to speak of. After all, Russell says, paraphrasing Greek philosopher Heraclitus: You never cross the same river twice—it's not the same river, and it's not the same you. —*Sunny Sea Gold*

>> COMMUNICATION

How to Use Your Ears to Influence People

Listen up: being attentive to others' needs allows you to wield more influence

We tend to think of smooth talkers as having the most influence on others. Although the gift of gab is indeed important, being a good listener provides even more of an advantage, according to new research.

In a study from the June *Journal of Research in Personality,* former work colleagues rated participants on measures of influence, verbal expression and listening behavior. Results indicate that good listening skills had a stronger effect on the ratings of influence than talking did. The authors suggest that listening helps people obtain information and build trust, both of which can increase influence. "Expressive communication has received the lion's share of attention in leadership work, but receptive behavior matters, too," says study author Daniel Ames of Columbia University. The research also found that being good at both is better than being better at one or the other.

For those who wish for better listening skills, here are a few ways to do it well: don't zone out or interrupt; be open to alternative points of view; incorporate details that someone said previously into a current conversation. Basically, pay attention.

—*Tori Rodriguez*

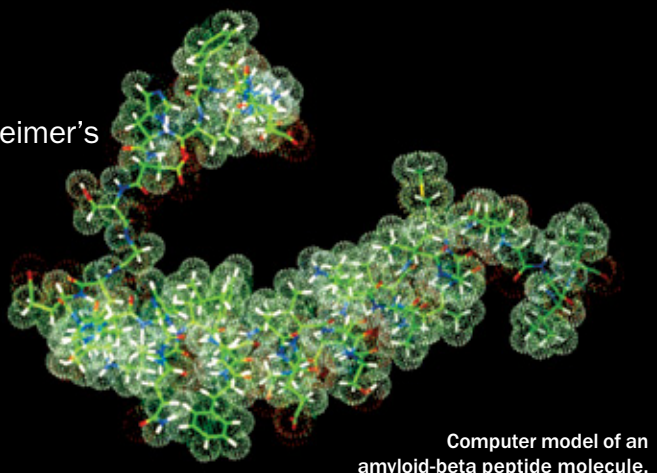
CHRISTOPH HETZMANNSEDER *Getty Images (left)*; GETTY IMAGES *(right)*

67,890 **Largest number of digits of pi ever memorized, a record held by Chao Lu of China**

>> DISEASE

Planting Seeds of Dementia

A cascade of misfolded proteins may trigger Alzheimer's



Computer model of an amyloid-beta peptide molecule.

LEONARD LESSIN *Photo Researchers, Inc.*

Researchers have untangled some of the neurological events that may ultimately lead to Alzheimer's disease. Two new studies show that a protein implicated in this form of dementia can infect other neurons to spread disease across the brain. These problematic proteins clump together, which can lead to cognitive problems.

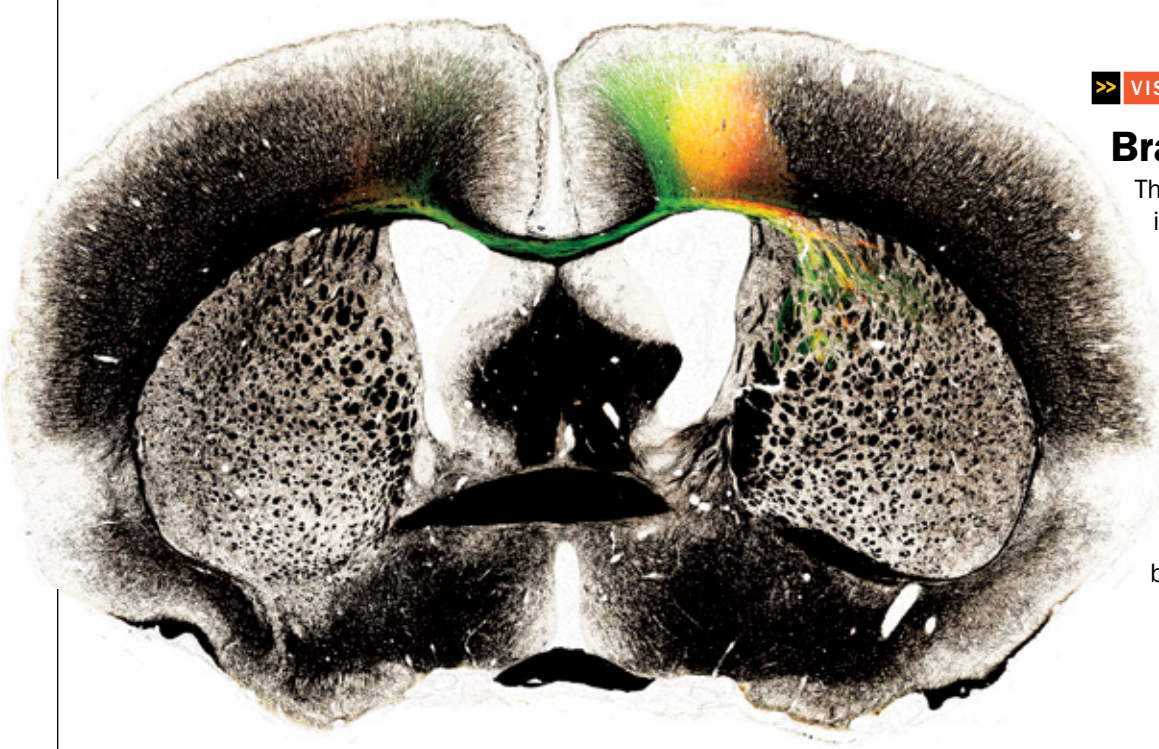
A protein's shape—the way its chains of amino acids fold—determines its function. If a protein misfolds, its structure and function change. In Alzheimer's, researchers have long suspected that misfolded versions of a protein called amyloid-beta might travel from cell to cell and cause more amyloid-beta proteins to take on a deformed shape.

To test this idea, biophysicist Jan Stöhr of the University of California, San Francisco, and his colleagues injected synthetic amyloid-beta proteins into the brains of mice and found that plaques began to form in less than six months. Even when the synthetic proteins were injected into only one side of the brain, over time plaques materialized throughout the organ, the researchers found. "If these aggregates are not cleared by the brain, they will start to recruit more amyloid-beta peptides into the diseased conformation, and the spread throughout the brain begins," Stöhr says. The results appeared in the June *Proceedings of the National Academy of Sciences USA*.

In a separate study using a cell culture, a team of researchers led by Martin Hallbeck of Linköping University in Sweden tracked amyloid-beta transmission from neuron to neuron for the first time. The results, published in the June 27 *Journal of Neuroscience,* also show that neurons containing misfolded amyloid-beta can cause neighboring, connected neurons to break down, eventually infecting the entire culture.

The current task for scientists is to figure out what other proteins and cellular machinery assist the infection process. Targeting these helpers may be an effective option for developing Alzheimer's therapies, Stöhr says.

—Carrie Arnold



>> VISIONS

Brain Atlas

The colorful glow in this mouse brain cross section comes from fluorescent proteins taken up by neurons in the motor cortex and transported along the brain's pathways. The image is part of a project to map the brain's connections.

18

Youngest age of a university professor. Harvey Friedman and Alia Sabur both received academic appointments just shy of their 19th birthdays; Friedman at Stanford University in 1967 and Sabur at Konkuk University in South Korea in 2008

>> FIRST IMPRESSIONS

Show Me Your Shoes

We can guess people's attachment style with a glance at their footwear

You know better than to judge a book by its cover. Sizing up a person by his or her shoes, however, might at times be justified. A new study found that people deduce certain characteristics of strangers with better-than-chance accuracy based solely on their footwear. One group of study participants completed a personality survey and provided pictures of the shoes they wear most frequently. A second group then viewed the pictures and rated the shoes' owners on various characteristics. Their guesses were accurate regarding age, gender, income and attachment anxiety. For instance, the volunteers perceived correctly that shoes with visible brand names most often belonged to men and stylish shoes to women with high incomes. They also figured out that people who provided pictures of the shoes on their own feet were more emotionally stable. The findings were published in the August *Journal of Research in Personality.*

But take heed: "Some shoe characteristics did correlate with the shoe owners' personality traits and personal characteristics, but observers picked up only on about half of these cues," says Angela Bahns, assistant professor of psychology at Wellesley College and one of the study authors. Shoes may help form a first impression, but avoid assuming too much—you might end up shooting yourself in the foot.

—Tori Rodriguez

Not agreeable

High income

Avoids attachments

COURTESY OF MOUSE BRAIN ARCHITECTURE PROJECT/PARTHA MITRA LAB (*brain slice*); ISTOCKPHOTO (*boots and high heels*); SUSAN DANIELS /*iStockphoto* (*sneakers*)

Afraid of Shadows

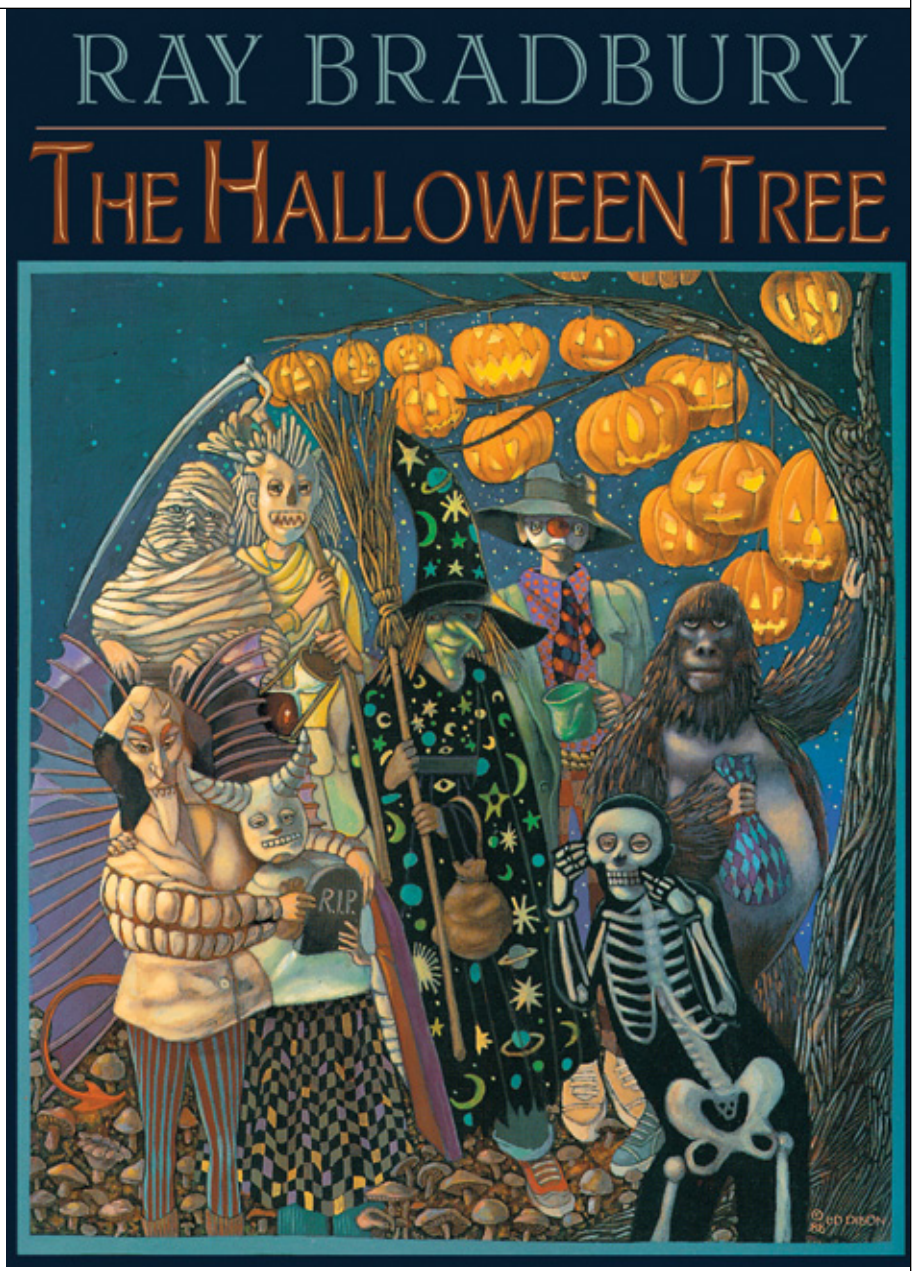
Spooky illusions trick and treat your brain

BY STEPHEN L. MACKNIK AND SUSANA MARTINEZ-CONDE

> "What difference do it make if the thing you scared of is real or not?"
>
> —Toni Morrison
> *Song of Solomon*

HALLOWEEN celebrates illusion. Even if we manage to ignore flights of fancy the other 364 days of the year, come October 31 we set out to enjoy trickery and pretense. We disguise ourselves, we carve malevolent expressions in bland, innocuous pumpkins and we do our best to suspend our disbelief as we enter supposedly haunted houses. We become illusion creators as well as willing victims. We seek fake fear. But costumes for our masquerades are not the only deceptions that Halloween brings you. Any emotion you experience, whether it be fright or delight, is real only in your mind. In a neural sense, all of us are afraid of "ghosts"; we all have irrational fears that are disconnected from fact (bugs and small spaces are some of our own personal phobias). With its harmless thrills and scares, Halloween pushes gently on the limits of the reality that our brain constructs. And one thing about limits, as Michael Jordan said in his Hall of Fame induction speech in 2009, is that "like fears, [they] are often just an illusion." M

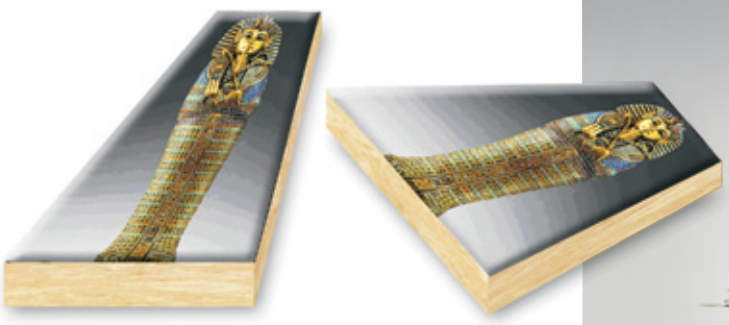
STEPHEN L. MACKNIK and SUSANA MARTINEZ-CONDE are laboratory directors at the Barrow Neurological Institute in Phoenix. They serve on *Scientific American Mind*'s board of advisers and are authors of *Sleights of Mind: What the Neuroscience of Magic Reveals about Our Everyday Deceptions,* with Sandra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



COURTESY OF RANDOM HOUSE

TRICK-OR-TREATERS

In *The Halloween Tree,* a 1972 novel by American horror, science-fiction and fantasy writer Ray Bradbury, eight children go trick-or-treating. Can you find them in the book's cover? In this ambiguous illusion, the costumed kids, their props and the tree in the background form the shape of a skull. Step back from the scene or squint your eyes if you have trouble seeing the skull. To identify the trick-or treaters, get close again, paying attention to the details in the image. When your perception of an ambiguous image flips back and forth between two possible interpretations, so does the underlying neural activity in the areas of your brain that are responsible for your experience.



THE CURSE OF THE MUMMY

"Wretchedness and death will befall to those who disturb the rest of the Kings!" Before you dismiss the Curse of the Twin Pharaohs as nonsense, take a careful look at the two sarcophagi and see if you can detect any signs of evil sorcery. The left sarcophagus appears longer and narrower than the one on the right, and the left mummy image is taller and skinnier than that of the other mummy. Or is this the case? Grab a pair of scissors and cut around the trapezoid shapes on top of each sarcophagus. Now rotate them and superimpose them. Both mummies and sarcophagi are exactly the same size. The effect is a variant of the classic Shepard tabletop illusion, in which two identical parallelograms with orthogonal orientations to each other appear dissimilar in shape. Images drawn inside the parallelograms, such as the mummies in the sarcophagi, are assimilated into the Shepard illusion, so that they, too, appear distorted.

WHAT LURKS IN THE SHADOWS

Gestalt psychologists famously asserted that the whole is different from the sum of its parts. British artists Tim Noble and Sue Webster's *Dark Stuff* agglutinates the bodies of 189 mummified animals, including 67 field mice, five adult rats, 42 juvenile rats, 44 garden shrews, a fox, a squirrel, a weasel, 13 carrion crows, seven jackdaws, a blackbird, a sparrow, a robin, a toad, a gecko and three garden snail shells. As anybody would agree, the outcome is so much more than the sum of its body parts.

SINKING FEELING

Acrophobia, or fear of heights, occurs even if the height is fake. According to neuroscientists Maria V. Sanchez-Vives of the August Pi I Sunyer Biomedical Research Institute in Barcelona and Mel Slater of University College London and the University of Barcelona, a virtual-reality pit (*near left*) and a real pit can generate comparable psychological and physiological reactions (such as changes in heart and respiratory rate). Psychologists have started to take advantage of this idea to provide safe, but highly effective, phobia-desensitization therapies consisting of exposing patients to photorealistic virtual-reality scenarios. Artists, such as Andrew Walker, just want to scare the shizzle out of us. Walker painted an elevator floor at the Southside Shopping Center in Wandsworth, London, to suggest a multifloor vertical drop (*far left*). The illusion advertised a thrill ride at the Alton Towers Resort theme park. See the alarmed Londoners' reactions at www.visualnews.com/2012/02/16/3d-elevator-illusion-shocks-london-shoppers.

TOP: COURTESY OF DANIEL PICON (*left*); COURTESY OF TIM NOBLE AND SUE WEBSTER AND BLAIN SOUTHERN (*right*)
BOTTOM: COURTESY OF ALTON TOWERS RESORT (*left*); COURTESY OF DEPARTMENT OF COMPUTER SCIENCE, UNIVERSITY OF NORTH CAROLINA AT CHAPEL HILL (*right*)

OUTRAGEOUS PUMPKINS

American sculptor Ray Villafane competed as one of four professional pumpkin carvers and bagged the Grand Prize in the Food Networks' Challenge Show, Outrageous Pumpkins in 2008, and Outrageous Pumpkins Challenge II in 2010. He has since carved pumpkins around the world, including in the president's White House quarters. For Halloween 2011 he established a new world record for carving the heaviest pumpkin ever documented. The beast, grown by Jim Bryson and his daughter Kelsey, weighed in at 1,818.5 pounds. Villafane sculpted zombies from a smaller pumpkin (weighing a mere 1,693 pounds) and staged them to create the illusion of the living dead bursting out of the colossal squash pod (*far left*). See the artist in action at www.visualnews.com/2011/10/29/halloween-worlds-largest-pumpkin-carving.

ALL IS VANITY

***All Is Vanity,* an 1892 drawing by American illustrator C. Allan Gilbert, draws on the 16th- and 17th-century European Vanitas painting tradition, in which still-life objects symbolize the transient and meaningless nature of earthly pursuits. The woman admiring herself in the mirror does not realize that her bottles of perfume, her makeup table (also called a vanity), her elegant gown, even her own youth and beauty, are fleeting illusions. Only death, represented by the skull engulfing the scene, is permanent and real. *Last Days of the Sun,* by British sculptor James Hopkins, puts a contemporary spin on the Vanitas concept. The seemingly casual arrangement of rock-star bling signifies the futility of ephemeral fame and riches. The skull emerging from the image provides the set of items with symbolic meaning.**

TOP: COURTESY OF VILLAFANE STUDIOS; BOTTOM: C. ALLAN GILBERT, 1892 (*left*); COURTESY OF JAMES HOPKINS (*right*)

(Further Reading)

- **Mind Sights: Original Visual Illusions, Ambiguities, and Other Anomalies, with a Commentary on the Play of Mind in Perception and Art.** R. N. Shepard. W. H. Freeman, 1990.
- **From Presence to Consciousness through Virtual Reality.** M. V. Sanchez-Vives and M. Slater in *Nature Reviews Neuroscience,* Vol. 6, No. 4, pages 332–339; April 2005.
- **Ray Villafane's Pumpkins.** R. Villafane. Gibbs Smith, 2012.

Unveiling the Real Evil Genius

Creative people are better at rationalizing small ethical lapses that can spiral out of control

BY INGRID WICKELGREN

Behavioral economist Dan Ariely of Duke University has probed the origins of dishonesty. Among his insights: creativity can contribute.

GABRIELA HASBUN *Redux Pictures*

IN 1940 Action Comics introduced a brilliant supervillain named Lex Luthor who tries to kill Superman to advance his plot to rule the world. These days news articles often portray Bernard Madoff as an "evil genius" because of his creative Ponzi scheme that siphoned some $20 billion from investors.

We think of an evil genius as someone who devises a clever plan for wrongdoing on a large scale. According to behavioral economist Dan Ariely of Duke University, however, the genius of the perpetrators often manifests itself not in elaborate planning of misdeeds but in almost the exact opposite: an unplanned escalation of a minor wrong they imaginatively have justified to themselves. I spoke with Ariely, author of *The (Honest) Truth about Dishonesty* (HarperCollins, 2012), about the true origins of evil genius.

SCIENTIFIC AMERICAN MIND: ***Creativity, or genius, is usually thought to be a positive attribute. What made you think it might have a dark side?***

ARIELY: There are two models of dishonest behavior. The economic model is one in which people do a cost-benefit analysis. You go by a store and ask yourself, "How much money do they have in the store, and what are the chances I'd be caught?" You then decide whether to rob the store or not. We found very little evidence that this is how people think.

What we do find is that lots of us are able to cheat a little bit and still think of ourselves as honest people. This suggests that dishonesty is all about rationalization. It's all about the small acts we can take and then think to ourselves, "No, this is not real cheating." Think about people who do accounting fraud. When they start, they say to themselves, "The rules of accounting are so unclear, is it really so bad?" Or they say, "I'll fix it in the next quarter." Or think about when Clinton said, "I did not have sexual relations with that woman, Miss Lewinsky." At the time, he likely redefined sexual relations, and in his mind he really didn't cheat.

So I wondered: What kind of people would be able to rationalize better than others? Creative people will be able to tell themselves better stories. Intelligence doesn't change anything, we found. It's not the smartness part. The creativity part lets you find all kinds of ways to convince yourself that what you're doing is actually okay.

Are all creative people more dishonest, or are other personality characteristics required?

It's very easy to think that dishonesty is only a function of the individual, but the reality is that the environment plays a big role. You cheat when the rules are flexible or not very clear and when you have a conflict of interest or a reason to have a biased perception of reality. Let's say you and I think of ourselves as honest people. But imagine we were on Wall Street in 2007, and we could get a $10-million bonus if only we could see mortgage-backed securities as a good product. With $10 million on the line, you could probably convince yourself these securities are quite good—or at least better than they are. But if the environment doesn't allow for dishonesty, creativity won't be such a big deal. If you put a creative person in a military academy, where he has no flexibility in his decisions, he will be perfectly honest.

When we think about evil genius, we imagine clever plots to take over the world. But most creative dishonesty isn't like that, is it?

It's important to distinguish between how acts of dishonesty start and how they end. I've been interviewing cheaters, people who are involved in all kinds of white-collar crime. I've tried to talk to Madoff—he refuses to talk to anybody—but I've talked to people who know him. He seemed like an incredibly smart guy. He took lots of money from people and yet didn't seem to think about the endgame. If you or I were going to steal $20 billion, wouldn't we find a nice island somewhere with no extradition rules and figure out how to get there when the time comes? I would speculate that when he started, he did not have a long-term plan. I suspect that in the first quarter, he said, "I'll just do this for one quarter, and then next quarter I'll make it up…." But then he fell more and more behind. I think evil geniuses start like all of us—they are maybe a little more creative, so maybe their acts are more frequent or extreme—but the vast majority get on a slippery slope, and at some point there's no way back.

What is the evidence that a creative personality can breed dishonesty?

In our first experiments, we took students and measured how creative they were using multiple methods. No matter the measure, we found that the more creative people cheated more on a math test.

Second, we tried to temporarily increase creativity in some people but not in others. There are all kinds of evidence that this works. [For tips on boosting creativity, see "Your Creative Brain at Work," by Evangelia G. Chrysikou; Scientific American Mind, July/August 2012.] Those in whom we increased creativity cheated a bit more. That's more causal, supporting the idea that creativity is the mechanism.

Then we went to a big advertising company and asked its employees questions that tested their moral flexibility in personal relationships, taxes, relationships with companies, and so on. If you were on a business trip, would you report a dinner you purchased after you got home on your expense report? We also asked the CEO which jobs have more or less creativity. The results showed that the more creativity in a person's job, the more moral flexibility the person reported in our survey.

How can the dark side of creativity be avoided or diminished?

Creativity is very helpful for lots of things, so we don't want to stamp it out. But if you take creative people and put them in a situation where they have a conflict of interest and where the rules are flexible, this is going to be a bad recipe. Wherever rationalization is easy, I would worry a lot about the rules, regulations and code of conduct—and then I would try to eradicate conflict of interest. In finance, you can make lots of money if you see reality in one way or another. In medicine, if a physician gets paid for prescribing a test or procedure, creativity can also play a big dangerous role. And there are cases where creativity exercises might not be beneficial. I would also worry about increasing creativity just before doing taxes or playing golf.

> Creativity exercises might not **always be beneficial**. I would worry about boosting creativity just before doing taxes or playing golf.

Are there instances in which lying is okay?

Not all dishonesty is bad. We all know about white lies and social politeness. Telling the truth all the time is a difficult thing to live with, which is why we often encourage some level of dishonesty. M

INGRID WICKELGREN is an editor at *Scientific American Mind* and author of the blog Streams of Consciousness, which can be found at ScientificAmerican.com.

(Further Reading)

◆ **The Dark Side of Creativity: Original Thinkers Can Be More Dishonest.** Francesca Gino and Dan Ariely in *Journal of Personality and Social Psychology,* Vol. 102, No. 3, pages 445–459; 2012.

Self-Awareness with a Simple Brain

Case studies suggest that some forms of consciousness may not require an intact cerebrum

BY FERRIS JABR

THOM LANG *Corbis*

THE COMPUTER, smartphone or other electronic device on which you may be reading this article, tracking the weather or checking your e-mail has a kind of rudimentary brain. It has highly organized electrical circuits that store information and behave in specific, predictable ways, just like the interconnected cells in your brain. On the most fundamental level, electrical circuits and neurons are made of the same stuff—atoms and their constituent elementary particles—but whereas the human brain is conscious of itself, man-made gadgets do not *know* they exist.

Consciousness, most scientists would argue, is not a shared property of all matter in the universe. Rather consciousness is restricted to a subset of animals with relatively complex brains. The more scientists study animal behavior and brain anatomy, however, the more universal consciousness seems to be. A brain as complex as a human's is definitely not necessary for consciousness. On July 7 of this year, a group of neuroscientists convening at the University of Cambridge signed a document entitled "The Cambridge Declaration on Consciousness in Non-Human Animals," officially declaring that nonhuman animals, "including all mammals and birds, and many other creatures, including octopuses," are conscious.

Humans are more than just conscious; they are also self-aware. Scientists differ on how they distinguish between consciousness and self-awareness, but here is one common distinction: consciousness is awareness of your body and your environment; self-awareness is recognition of that consciousness—not only understanding that you exist but further comprehending that you are aware of your existence. Another way of considering it: to be conscious is to think; to be self-aware is to realize that you are a thinking being and to think about your thoughts. Presumably human infants are conscious—they perceive and respond to people and things around them—but they are not yet self-aware. In their first years of life, children develop a sense of self, learning to recognize themselves in the mirror and to distinguish between their own point of view and the perspectives of other people.

Numerous neuroimaging studies have suggested that thinking about ourselves, recognizing images of ourselves, and reflecting on our thoughts and feelings—that is, different forms of self-awareness—all involve the cerebral cortex, the outermost, intricately wrinkled part of the brain. The fact that humans have a particularly large and wrinkly cerebral cortex relative to body size supposedly explains why we seem to be more self-aware than most other animals. But new evidence is casting doubt on this idea.

"Got a Towel?"

If this anatomical hypothesis were correct, we would expect, for example, that a man missing huge portions of his cerebral cortex would lose at least some of his self-awareness. Patient R, also known as Roger, defies that expectation. Roger is a 57-year-old man who suffered extensive brain damage in 1980 after a severe bout of herpes simplex encephalitis, an inflammation of the brain caused by herpesvirus. The disease destroyed most of Roger's insular cortex, anterior cingulate cortex and medial prefrontal cortex, regions near or at the front surface of the brain that are thought to be essential for self-awareness. About 10 percent of his insula remains and only 1 percent of his anterior cingulate cortex.

Roger cannot remember much of what happened to him between 1970 and 1980, and he has great difficulty forming new memories. He cannot taste or smell either. But he still knows who he is. He recognizes himself in the mirror and in photographs, and his behavior is relatively normal.

In a paper published earlier this year postdoctoral researcher Carissa L. Philippi of the University of Wisconsin–Madison and neuroscientist David Rudrauf of the University of Iowa and their colleagues investigated the extent of Roger's self-awareness. In a mirror-recognition task, for example, a researcher pretended to brush something off of Roger's nose with a tissue that concealed black eye shadow. Fifteen minutes later the researcher asked Roger to look at himself in the mirror. Roger immediately rubbed away the black smudge on his nose and wondered aloud how it got there.

The researchers also showed Roger pictures of himself, of people he knew and of strangers. He almost always recognized himself and never mistook another person for himself. He did sometimes have difficulty recognizing a photo of his face when it appeared by itself on a black background, without any hair or clothing.

Roger also distinguished the sensation of tickling himself from the feeling of someone else tickling him and consistently found the latter more stimulating. When one researcher asked for permission to tickle Roger's armpits, he replied, "Got a towel?" As Philippi and Rudrauf note, Roger's quick wit indicates that in addition to maintaining a sense of self, he adopts the perspective of others—a talent known as theory of mind. He anticipated that the researcher would notice his sweaty armpits and used humor to preempt any awkwardness.

In another task, Roger had to use a computer mouse to drag a blue box from the center of a computer screen toward a green box in one of the corners of the screen. In some cases, the program gave him complete control over the blue box; in other cases, the program restricted his control. Roger easily discriminated between sessions in which he had full control and times when some other force was at work. In other words, he understood when he was and was not responsible for certain actions.

Given the evidence of Roger's largely intact self-awareness, Philippi, Rudrauf and their colleagues argue that the insular cortex, anterior cingulate cortex and medial prefrontal cortex cannot by themselves account for conscious recognition of oneself as a thinking being. Instead they propose that self-awareness is a far more diffuse cognitive process, relying on many parts of the brain, including regions not located in the cerebral cortex.

Laughing without a Brain

In the new study, Philippi, Rudrauf and their co-authors point to a fascinating 1999 review of children with hydranencephaly, a rare disorder in which fluid-filled sacs replace the brain's cerebral hemispheres. Children with hydranencephaly are essentially missing every part of their brain except for the brain stem and cerebellum and a few other structures. Holding a light near such a child's head illuminates the skull like a jack-o'-lantern.

Although many children with hydranencephaly appear relatively normal at birth, they often quickly develop growth problems, seizures and impaired vision. Most die within a year; some live for years or even decades. Such children lack a cerebral cortex, but at least a few give every appearance of genuine consciousness. They respond to people and things in their environment. They smile, laugh and cry. They know the difference between familiar people and strangers. And they prefer some kinds of music to others. If some children with hydranencephaly are conscious, then the brain does not require an intact cerebral cortex to produce consciousness.

Whether such children are truly self-aware is more difficult to answer, especially as they cannot communicate with language. In the 1999 review one child showed intense fascination with his reflection in a mirror, but it is not clear whether he recognized his reflection as his own. Still, research on hydranencephaly and Roger's case study indicate that self-awareness—this ostensibly sophisticated and unique cognitive process layered on consciousness—might be more universal than we realized. M

Such children lack a cerebral cortex, but at least a few give every appearance of **genuine consciousness**.

FERRIS JABR is an associate editor at *Scientific American*. He is our guest columnist, filling in for Christof Koch, who writes Consciousness Redux and will return in January.

(Further Reading)

- **Consciousness in Congenitally Decorticate Children: Developmental Vegetative State as Self-Fulfilling Prophecy.** D. A. Shewmon, G. L. Holmes and P. A. Byrne in *Developmental Medicine and Child Neurology,* Vol. 41, No. 6, pages 364–374; June 1999.
- **Consciousness without a Cerebral Cortex: A Challenge for Neuroscience and Medicine.** B. Merker in *Behavioral and Brain Sciences,* Vol. 30, pages 63–81; 2007.
- **Preserved Self-Awareness following Extensive Bilateral Brain Damage to the Insula, Anterior Cingulate, and Medial Prefrontal Cortices.** Carissa L. Philippi et al. in *PLoS ONE,* Vol. 7, No. 8; August 2012.

THAT'S GENIUS!

The minds of exceptionally creative people hold answers for us all

TO CONTEMPLATE GENIUS IS TO CALL FORTH HISTORY'S MOST FASCINATING PEOPLE.

Take Leonardo da Vinci, whose artworks—*The Last Supper,* the *Mona Lisa*—shine like beacons across the centuries. His scientific writings secured his position as the quintessential Renaissance man. Other polymaths also stand out as exemplars of genius: René Descartes, Benjamin Franklin, Mikhail Lomonosov.

The patterns hidden in the names we summon are telling. The people we choose to venerate expose both the defining cognitive features and the circumstances that kindle exceptional creativity.

Created by Column Five Media

EARLY GENIUSES OFTEN DEMONSTRATED EXCELLENCE IN MORE THAN ONE AREA, AND TODAY'S LUMINARIES MAY SEEM LESS ACCOMPLISHED BY COMPARISON.

A few trends suggest that the era of big genius may be over, at least in the sciences: the average ages at which people win the Nobel Prize or earn their first patents have both increased over the years.

A contemporary genius, it seems, must climb higher to ascend to the shoulders of giants. Despite the need to specialize, pursuing broad interests remains a hallmark of a brilliant mind. Finding the time to do both can itself be an act of genius.

REACHING THE RANK OF GENIUS IS NOT A SOLITARY ENTERPRISE.

Ibn Khaldun, a great 14th-century Arab thinker, noted several mistakes that historians can make, among them a failure to place an event in its context.

A focus on individual accomplishment downplays the contributions of a vast supporting cast of family members, assistants and peers. Rather than lacking ability, these individuals may not have had the resources, freedom or desire to unleash their ideas on the world stage. A favorable genetic endowment creates the potential for greatness. Permissive life circumstances allow the rare individual to seize the chance to shine. Only now is the opportunity to excel at the highest levels becoming more widely available.

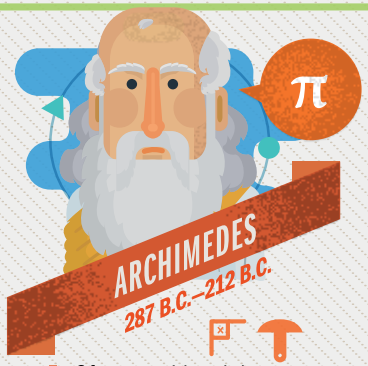
The thicket of cultural, social and genetic forces at humanity's intellectual summit holds important clues for the future. To reach our full potential as a species, we must cultivate an environment in which ingenuity thrives.

—The Editors

GENIUSES

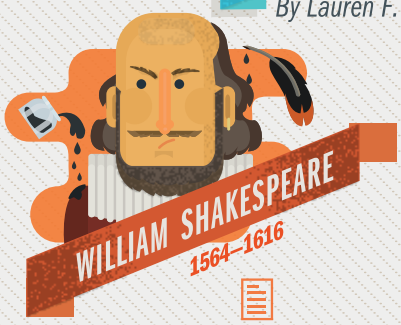
A TIMELINE

By Lauren F. Friedman



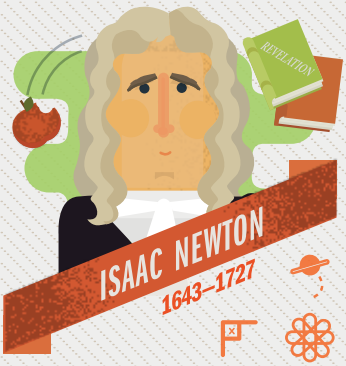
Often considered the greatest ancient mathematician, he is credited with discovering several geometric principles, including the volume and surface area of a sphere and the approximate value of pi.

In a quirky text called *The Sand-Reckoner*, Archimedes proved that the amount of sand in the world is not infinite, counter to prevailing wisdom.



The author of more than 30 classic plays and 100 sonnets, he pioneered new literary forms, helped to standardize grammar, and invented dozens of words and sayings.

Few records exist of Shakespeare's "Lost Years," the period between when his wife gave birth to twins and when he emerged in the London theater scene.



He described laws of gravity and motion and developed theories of color, cooling and the speed of sound. He also invented differential and integral calculus, along with Leibniz.

Newton wrote a 300,000-word interpretation of *The Book of Revelation*.

WHAT ABOUT BRILLIANT TEAMS?

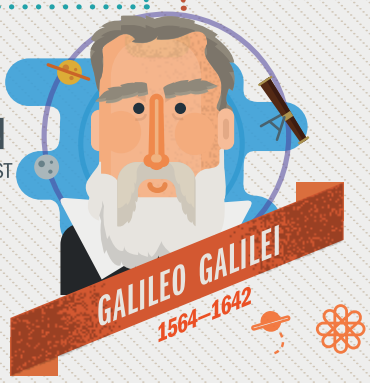
B.C. | 0 A.D.

ARISTOTLE
PHILOSOPHER & LOGICIAN
384 B.C.–322 B.C.

The famous painter also conceptualized inventions that were only developed centuries later, including concentrated solar power, the helicopter and the tank. This quintessential "Renaissance man" also made significant forays into mathematics, botany, cartography and astronomy.

Da Vinci was also a musician who dreamed up several innovative instruments, including a precursor to the piano.

FRANCIS BACON
STATESMAN & SCIENTIST
1561–1626



Often called the father of modern science, he pioneered astronomy using a telescope and discovered the law of free fall and also the timekeeping nature of a pendulum swing.

His two daughters lived in an impoverished convent, so Galileo maintained the convent clock.

IMHOTEP
ARCHITECT & PHYSICIAN
ABOUT 2650 B.C.

A LONE NON-WESTERN VOICE

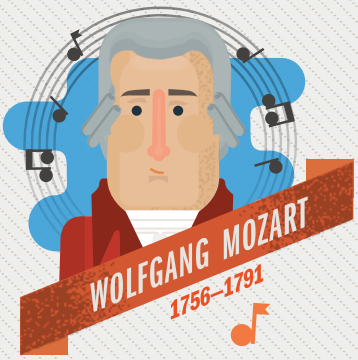
LAUREN F. FRIEDMAN is a staff editor at Psychology Today.

Created by Column Five Media

FIELD OF INTEREST KEY

Anatomy | Astronomy | Cartography | Satire | Business | Architecture
Engineering | Philosophy | Physics | U.S. Politics | Biology | Chemistry/ Science
Music | Art | Mathematics | Poetry & Playwriting | Mechanical Engineering | Computer Engineering

POLYMATH ALERT!



JOHANN WOLFGANG VON GOETHE

WRITER, BIOLOGIST, PHYSICIST & PHILOSOPHER

1749–1832

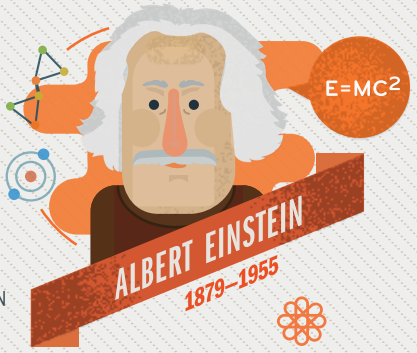
He lived only 35 years but composed more than 600 works, including the most renowned works in the Western canon, beginning when he was just five years old.

Mozart wrote a lot of dance music and was himself an enthusiastic dancer.

THOMAS EDISON

SCIENTIST & BUSINESSMAN

1847–1931



He developed the general theory of relativity and made significant advances in quantum theory, particle theory and photon theory. He is often considered the father of modern physics.

Einstein's brain was removed and preserved, without permission, by a doctor who hoped that neuroscientists might find in it an explanation for his genius.

NIKOLA TESLA

MECHANICAL & ELECTRICAL ENGINEER

1856–1943

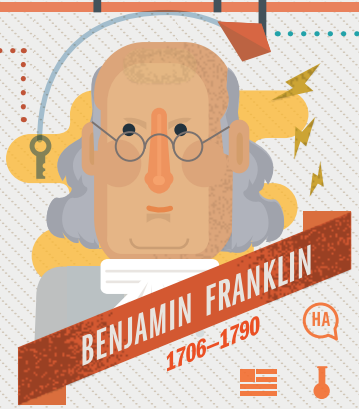
WHO'S NEXT?

2012

GOTTFRIED WILHELM VON LEIBNIZ

MATHEMATICIAN & PHILOSOPHER

1646–1716



One of the U.S. founding fathers, he developed many theories about optics, electricity and meteorology. He invented bifocals and lightning rods and was among the first to chart the Gulf Stream.

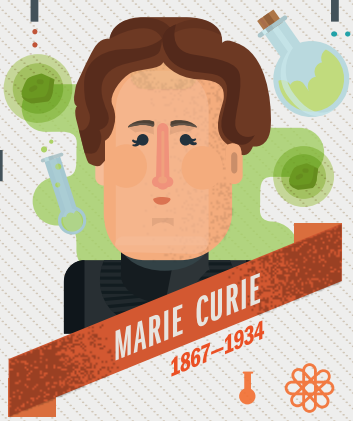
Franklin never patented any of his inventions, believing that because he himself had borrowed from others, people should be free to borrow and benefit from his work.

JANE AUSTEN

WRITER

1775–1817

NO MORE WOMEN?



She was the first person to win two Nobel Prizes, in chemistry and physics. Her groundbreaking work in radioactivity and radiation led to the discovery of radium and polonium.

Because of her high exposure to radioactivity, which unfortunately led to her demise, Curie's papers are still considered too dangerous to handle without protection.

STEVE JOBS

COMPUTER ENGINEER & BUSINESSMAN

1955–2011

TOO SOON TO TELL?

JOHN VON NEUMANN

MATHEMATICIAN

1903–1957

THE SCIENCE OF GENIUS

OUTSTANDING CREATIVITY IN ALL DOMAINS MAY STEM FROM SHARED ATTRIBUTES AND A COMMON PROCESS OF DISCOVERY

By Dean Keith Simonton

Identifying genius is a dicey venture. Consider, for example, this ranking of "The Top 10 Geniuses" I recently stumbled across on Listverse.com. From first to last place, here are the honorees: Johann Wolfgang von Goethe, Leonardo da Vinci, Emanuel Swedenborg, Gottfried Wilhelm von Leibniz, John Stuart Mill, Blaise Pascal, Ludwig Wittgenstein, Bobby Fischer, Galileo Galilei and Madame De Staël.

What about Albert Einstein instead of Swedenborg? Some of the living might also deserve this appellation—Stephen Hawking comes to mind. A female genius or two might make the cut, perhaps Marie Curie or Toni Morrison. And if a chess champion, Fischer, is deemed worthy, other geniuses outside the arts and sciences ought to deserve consideration—Napoleon Bonaparte as a military genius, Nelson Mandela as a political genius or Bill Gates as an entrepreneurial genius, to name a few candidates.

All these questions and their potential answers can make for some lively cocktail party conversations. What they reveal is how little we understand about the origins of intellectual and creative eminence. Explorations of this age-old debate have long sought to tease out the common features of geniuses working in disparate domains. The existence of unifying threads—including genetic factors, unusually broad interests and a link with psychopathy—suggests that the mind of a genius has a discernible shape and disposition.

Ultimately the goal is to explain how an eminent thinker arrives at his or her world-changing moment, or moments, of insight. Although such breakthroughs often seem to appear in a flash, the underlying mechanisms are likely to be much more orderly. According to one theory I helped to develop, a genius hunts widely—almost blindly—for a solution to a problem, exploring dead ends and backtracking repeatedly before arriving at the ideal answer. If this line of research bears out, we can start to investigate whether genius can be cultivated, unleashing a wealth of new ideas for the benefit of all.

The Meaning of Genius

The first hurdle in the study of genius is to settle on a working definition. The word itself harks back to ancient Roman mythology, according to which every male was born with a unique genius that served as a kind of guardian angel, and every female had a juno. Much later, after the Renaissance, the word became more exclusive in its application, with only a few people showing genius. Philosopher Immanuel Kant believed, for example, that a genius was someone who produced works that were both original and exemplary. The term did not acquire scientific meaning until the late 19th century, when psychologists came

ILLUSTRATION BY NOMA BAR

Psychologists often assess geniuses by their achievements, such as painting the Sistine Chapel, rather than by IQ scores.

FRANK HEUER *Redux Pictures*

to define genius in two distinct ways.

The first approach was to identify genius with exceptional achievement, as Kant did. These accomplishments elicit admiration and emulation from other experts in that field and often the world at large. Unquestioned examples of such works include Newton's *Principia*, Shakespeare's *Hamlet*, Tolstoy's *War and Peace*, Michelangelo's Sistine Chapel frescoes and Beethoven's Fifth Symphony. Even though this definition can be extended to encompass extraordinary leadership, such as military brilliance, and prodigious performance, including some chess grandmasters, most scientific research concentrates on outstanding creativity within the sciences or the arts, which will also be the focus here.

The second definition of genius coincided with the emergence of intelligence tests in the first half of the 20th century. A genius was someone who scored sufficiently high on a standard IQ test—usually landing in the top 1 percent, with a score above 140, as proposed by psychologist Lewis Terman, the formulator of one of the original intelligence tests. These two definitions have little in common. Many persons with superlative IQs do not produce original and exemplary accomplishments. One example is Marilyn vos Savant, who was once certified by the *Guinness Book of World Records* as having the highest recorded IQ of any living person. Her weekly "Ask Marilyn" column for a Sunday newspaper supplement did not inspire a new genre of science, art or even journalism. And many exceptional achievers do not attain genius-level IQs. William Shockley, for example, received a Nobel Prize in Physics for coinventing the transistor yet had an IQ score well below 140. Exceptional achievement, then, seems the more useful measure.

Too often in popular writing, genius is conceived as a discrete category—this person is a genius, but that person is not.

FAST FACTS

Genius, Defined

1» **Genius has been viewed two different ways: as achieved eminence and as exceptional intelligence. The former metric offers the more useful definition.**

2» **Genetics and life experiences both contribute to genius. Creative contributions can occur only after a domain has been mastered, but genetics can help a person improve faster and accomplish more with a given amount of expertise.**

3» **Genius can share certain potentially negative traits with the mentally ill, but when these traits are combined with specific positive attributes, the result is creativity rather than psychopathology.**

4» **A scientific genius has different expertise than an artistic genius, but all creative geniuses may depend on the same general process: blind variation and selective retention.**

Yet just as people can vary in IQ, they can also differ in the magnitude of their creative achievements, with either a single notable contribution or a lifetime of prolific work. One such "one-hit wonder" is Gregor Mendel, who attained lasting fame for a single paper that reported his classic experiments in genetics. Had Mendel never taken an interest in breeding peas, his name would be unknown today. Charles Darwin's fame, in contrast, rests on far more than *On the Origin of Species*. Nobel laureate Max Born once said that Einstein "would be one of the greatest theoretical physicists of all time even if he had not written a single line on relativity." Hence, Darwin and Einstein exhibited greater genius than did Mendel. Accordingly, much research is devoted to assessing relative degrees of genius—most often gauged by creative productivity.

Origins of Genius

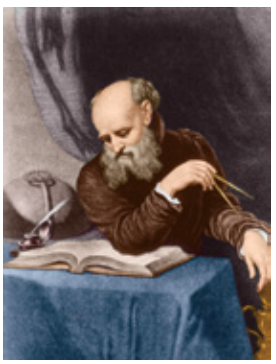
Finding the sources of consummate creativity has occupied the minds of philosophers and scientists for centuries. In 1693 English poet John Dryden wrote, "Genius must be born, and never can be taught." Two and a half centuries later French author Simone de Beauvoir countered, "One is not born a genius, one becomes a genius." The first scientific investigation devoted exclusively to genius concerned this precise issue. In 1869 Francis Galton published *Hereditary Genius,* in which he argued that genius is innate, based on his observations that geniuses tend to emerge from lineages that included other brilliant individuals. In response to criticisms, Galton later introduced the well-known nature-nurture issue. He conducted a survey of famous English scientists to discover some of the environmental variables involved in nurturing brilliance, and he examined factors such as birth order and education.

By the second half of the 20th century psychologists had moved to an extreme nurture position, in which creative genius rested solely on the acquisition of domain expertise. This idea was frequently expressed as the "10-year rule." Nobody can expect to reach the heights of creativity without mastering the necessary knowledge and skill because only experts can create—or so the thinking went. Indeed, Einstein learned lots of physics before he commenced his creative career.

GENIUSES ARE LIKELY TO EXHIBIT UNUSUALLY WIDE INTERESTS AND HOBBIES, OFTEN CONTRIBUTING TO MORE THAN ONE DOMAIN OF EXPERTISE.

This explanation cannot account for all the details, however. First, geniuses often spend less time acquiring domain expertise than their less creative colleagues. Studies have linked accelerated acquisition with long, prolific and high-impact careers. The 10-year rule is an average with tremendous variation around the mean. Further, major breakthroughs often occur in areas where the genius must create the necessary expertise from scratch. Telescopic astronomy did not exist until Galileo pointed his new instrument toward the night sky to discover what had never been seen before nor even expected. The moon had mountains, Jupiter had moons and the sun had spots!

Second, geniuses are more likely to exhibit unusually wide interests and hobbies and to display exceptional versatility, often contributing to more than one domain of expertise. This tendency was true not only in the era of Renaissance men but is also evident today. According to a 2008 study, Nobel laureates in science are more involved in the arts than less eminent scientists. Given that geniuses likely do not sleep any less than the rest of us, these extraneous activities would seem to distract from a dogged focus on a narrow field of interest. Einstein slept even more hours than the norm, but he still took time off to play Bach, Mozart and Schubert on his violin. At times these avocational activities inspire major insights. Galileo was probably able to identify the lunar mountains because of his training in the visual arts, particularly in the use of chiaroscuro to depict light and shadow.



To build the two-lens telescope he used to survey the skies, Galileo had to first learn how to grind his own lenses and discover the optimal lens combination.

The expertise acquisition theory also undervalues the genetic components that underlie a large number of cognitive abilities and personality traits that correlate with genius. In a recent meta-analysis, I found that at least 20 percent of the variation in creativity could be attributed to nature. For example, creative achievement is strongly associated with the personality trait of openness to experience, a highly heritable characteristic. The broad interests in art and music of many geniuses are clear manifestations of this trait. Many other predictors of achievement also have high heritabilities, such as cognitive and

(The Author)

DEAN KEITH SIMONTON is Distinguished Professor of Psychology at the University of California, Davis. He is author of more than 400 articles and chapters plus a dozen books, including *Great Flicks,* recently published by Oxford University Press.

MEASURING GENIUS

In 1926 Catharine Cox estimated the IQs of 301 eminent individuals. Using biographical data on early intellectual development, she and her collaborators calculated IQ using the formula IQ = 100 × MA/CA, where MA = mental age and CA = chronological age. Some representative results are shown here. (The actual scores are taken from a secondary analysis of her data that I recently published with Anna V. Song of the University of California, Merced.) These rankings illustrate the value of using achieved eminence, rather than intelligence test scores, as a measure of genius. Philosopher George Berkeley, for example, did not leave a greater mark on the world than Newton or da Vinci. Further, eight of these creative geniuses have IQs below the "genius threshold" of 140. —*D.K.S.*

IQs	Scientists	Philosophers	Writers	Artists	Composers
190s		Gottfried Wilhelm von Leibniz	Johann Wolfgang von Goethe		
180s	Blaise Pascal	John Stuart Mill	Voltaire		
170s	Pierre-Simon Laplace	George Berkeley	Samuel Taylor Coleridge		
160s	Isaac Newton	René Descartes	Charles Dickens	Michelangelo	
150s	Johannes Kepler	Baruch Spinoza	Michel de Montaigne	Leonardo da Vinci	Wolfgang Amadeus Mozart
140s	Charles Darwin	Emanuel Swedenborg	Molière	Peter Paul Rubens	Ludwig van Beethoven
130s	Nicolaus Copernicus	Jean-Jacques Rousseau	Robert Burns	Rembrandt van Rijn	Gioachino Rossini
120s			Miguel de Cervantes	Bartolomé Esteban Murillo	Cristoph Willibald Gluck

behavioral flexibility, along with a tolerance of ambiguity and change.

Nurture may still account for the lion's share of genius, and mastering a domain remains central. At the same time, genetics contributes heavily to the rate at which someone acquires the necessary skills and knowledge. Those with more innate talent can improve faster, launch their careers earlier and be more productive. In addition, genetics may help explain the different trajectories of equally well-trained individuals. Einstein did not know as much physics as many of his contemporary theoretical physicists, but what he did know went a long way. He could honestly say, "Imagination is more important than knowledge."

These influences are just a few of the ways genetics shapes the potential for genius. Let it suffice to note that I have probably understated the impact of genes on genius.

Madness and Magnificence

Researchers have long been tantalized by the question of whether the biological endowment of a genius also confers great setbacks. Greek philosopher Aristotle is reputed to have said, "Those who have become eminent in philosophy, politics, poetry and the arts have all had tendencies toward melancholia." This idea received wide currency in the 19th and 20th centuries at the hands of psychiatrists and psychoanalysts. Among the great writers, Virginia Woolf, Anne Sexton and Sylvia Plath all committed suicide. Vincent van Gogh did as well, and earlier he had cut off part of his ear to give to a prostitute. Newton sometimes suffered from extreme paranoia, and Galileo, possibly an alcoholic, was often bedridden with depression. Nevertheless, many psychologists have argued that such cases are the

WHEN HIGH IQS HANG OUT

"Genius" societies offer a social network for the top tier of test takers **By Lena Groeger**

Kevin Langdon is writing several books and designing an inside-out clock. Karyn Huntting Peters is organizing a global problem-solving network. Alfred Simpson juggles multiple Web-programming projects in his free time. These three people might not have much in common—except for their unusually high IQs.

All three belong to exclusive high-IQ societies. Mensa International, whose members' test scores must land above the 98th percentile (or one in 50), may be the most popular, but it is just one option for the discerning test taker. The Triple Nine Society demands an IQ in the 99.9th percentile, whereas the Mega Society cuts off at the 99.9999th percentile (one in one million). The memberless Grail Society claims to accept one in 100 billion people—no one has applied so far.

Although members of IQ societies do not fit a single profile, they often join in search of a sense of belonging. "I've heard a lot of people refer to themselves as aliens until they found a group like this," says Peters, who serves as an officer of the

exceptions, not the rule. Some positive psychologists today consider creative genius a human strength or virtue.

My 2005 review of the literature, which summarized studies with varied methodologies, indicates that the association between genius and mental illness has considerable strength. Very creative writers tend to obtain higher scores on the psychopathology-related parts of the Minnesota Multiphasic Personality Inventory, a widely accepted personality test. A study using another instrument, the Eysenck Personality Questionnaire, found that extremely creative artists—and high-impact psychologists, for that matter—tend to receive elevated scores on the test's psychoticism scale, meaning that they are, among other things, egocentric, cold, impulsive, aggressive and tough-minded. Last, highly eminent scientists score higher on sections of the Cattell 16 Personality Factor Questionnaire that signify they are withdrawn, solemn, internally preoccupied, precise and critical. All told, top performers are not a very normal bunch.

Psychiatric studies bolster these results. The rate and intensity of certain psychopathic symptoms, such as depression and alcoholism, are noticeably higher in very creative individuals than in the general population. Research also suggests that these divergent thinkers are more likely to come from family lines at higher risk for psychopathology. Even if an extraordinary innovator is "normal," his or her family members may not be.

In line with these findings, in 2009 psychiatrist Szabolcs Kéri of Semmelweis University in Hungary found a genetic basis for both creativity and psychosis in a variant of the *Neuregulin 1* gene. In this study, Kéri recruited a group of highly creative individuals and found that the participants who had this specific gene variant, which is linked with an increased risk of developing a mental disorder, also scored higher on measures of creativity.

Out-and-out psychosis, however, can shut down creative genius. This tragic reality was dramatically illustrated in the 2001 film *A Beautiful Mind*, the biopic about Nobel laureate John Forbes Nash and his struggles with schizophrenia. The costs and burdens of psychological dysfunction are also immediately apparent in the art of the mentally ill, such as the works preserved in the Prinzhorn Collection in Heidelberg, done by psychiatric patients in the early 20th century. Few if any of these artworks show signs of genius. Quoting Dryden again, "wits are sure to madness near allied, and thin partitions do their bounds divide."

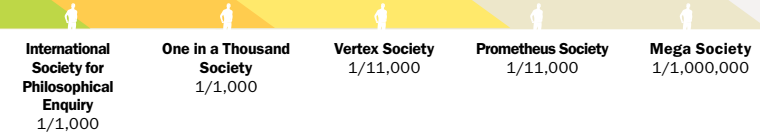
Recent research conducted by psychologist Shelley Carson of Harvard University and her colleagues has sought to identify these thin partitions. Creative achievement is positively associated both with cognitive disinhibition—openness to supposedly extraneous ideas, images or stimuli—and higher intelligence and greater working memory. These mental capacities can potentially ameliorate the negative effects of disinhibition and even channel them to more useful ends. This synergy may well constitute the cognitive basis for serendipity. Not everybody would be able to work out the profound

THE RATE AND INTENSITY OF CERTAIN PSYCHOPATHIC SYMPTOMS ARE NOTICEABLY HIGHER IN VERY CREATIVE PEOPLE THAN IN OTHERS.

Prometheus Society. "But get them all together, and they become extremely talkative—they're up until five in the morning." Langdon, who has founded or co-founded several high-IQ societies and now edits the journal of the Mega Society, also reports having joined to find people more like himself.

Others do it for the challenge. "I joined Prometheus just to see if I could," Simpson says. He now deals with the society's membership requests. He receives about two or three a week, although only three or four new members are accepted every year. The admissions process for these societies usually hinges on a score on an approved test, some of which have names such as Mega or Titan. Typical questions include analogies, the manipulation of complex three-dimensional shapes, or word problems that must be translated into equations.

Critics question whether IQ tests measure intelligence accurately, but "genius" societies rarely claim to represent true genius: the merging of intellect, creativity and outstanding achievement. Peters notes that her high-IQ colleagues are acutely aware of their own ignorance. Simpson concurs. "None of us consider ourselves a 'genius,'" he says. "Well, maybe there's this one guy, but he hasn't been in the society for a while now."



Lena Groeger is a science journalist based in New York City.

PABLO PICASSO'S CHAOTIC PROCESS

In his dozens of sketches for *Guernica* (*right*), Picasso explored numerous styles. A sampling of his drawings of the bull (*below*) reveal the breadth of his exploration. Hunting widely for answers, abandoning some ideas and backtracking to earlier concepts are hallmarks of a theory of creativity known as blind variation and selective retention.

11

15

19

22

26

27

implications of such humdrum events as water overflowing a bathtub or an apple falling from a tree. But Archimedes and Newton did. [For more on creativity and eccentricity, see "The Unleashed Mind," by Shelley Carson; Scientific American Mind, May/June 2011.]

Thinking Outside the Box

Archimedes and Newton both worked in scientific fields, raising the possibility that their brands of creativity may have been similar. A more revealing question might be to investigate how their route to original thought compares with that of a superlative writer or musician. A physicist's way of thinking has little, if anything, in common with that of a painter. For example, learning how to solve a differential equation has as much utility for a painter as learning linear perspective has for a physicist—zero in most cases. Yet the themes uniting geniuses, as discussed earlier, suggest that a common creative principle may exist. Domain expertise, such as the knowledge of advanced problem-solving strategies, supports thinking that is routine, even algorithmic—it does not inherently lead to the generation of novel, useful and surprising ideas. Something else must permit a person to go beyond tradition and training to reach the summit of genius.

According to a theory proposed in 1960 by psychologist Donald Campbell, creative thought emerges through a process or procedure he termed blind variation and selective retention (BVSR). In short, a creator must try out ideas that might fail before hitting on a breakthrough. Campbell did not precisely define what counts as a blind variation, nor did he discuss in any detail the psychological underpinnings of this process. As a result, his ideas were left open to criticism.

Using a mixture of historical analyses, laboratory experiments, computer simulations, mathematical models and case studies, I have devoted the past 25 years to developing BVSR into a comprehensive theory of creative genius in all domains. The blindness of BVSR merely means that ideas are produced without foresight into their eventual utility. The creator must engage in trial-and-error or generate-and-test procedures to determine the worth of an idea. Two common phenomena characterize BVSR thinking: superfluity and backtracking. Superfluity means that the creator generates a variety of ideas, one or more of which turn out to be useless. Backtracking signifies that the creator must often return to an earlier approach after blindly going off in the wrong direction. Superfluity and backtracking are often found together in the same creative episode. Exploring the wrong track obliges a return to options that had been originally cast aside.

The reflections of Hermann von Helmholtz, a prolific physicist with numerous creative breakthroughs to his name, capture this process of discovery:

> I had to compare myself with an Alpine climber, who, not knowing the way, ascends slowly and with toil, and is often compelled to retrace his steps because his progress is stopped; sometimes by reasoning, and sometimes by accident, he hits upon traces of a fresh path, which again leads him a little further; and finally, when he has reached the goal, he finds to his annoyance a royal road on which he might have ridden up if he had been clever enough to find the right starting point at the outset.

This account of venturing blindly into uncharted territory and retracing steps resonates with evidence from other eminent creators. As Einstein once said, "If we knew what we were doing, we wouldn't call it research."

To see superfluity and backtracking in practice, consider the sketches that Pablo Picasso produced in preparation for his 1937 *Guernica* painting. Among them are clearly "superfluous" sketches, which have a human head on a bull's body (for example, sketches 19 and 22 on the opposite page). Picasso soon discovered that this was a dead end and backtracked to an earlier bull's head drawing (15), before continuing to the final two sketches (26 and 27). Notice that the artist went too far in one direction in the last sketch, from which he backtracked yet again. Even more telling, after that last sketch Picasso largely reversed himself to a much earlier formulation (11), which shares the most unique features with the final version: the widely separated eyes, the thin-lipped open mouth with tongue, the menacing rather than inert visage and the Cubist rather than neoclassic style. These sketches are typical of blind variations both in the arts and in the sciences.

Only further research can expand the theory into a comprehensive, predictive model whose claims can be thoroughly tested. Even so, BVSR can help us make sense of certain quirks of the creative genius, including their personality traits and developmental experiences. Although they devote considerable time to achieving expertise, they also pursue other hobbies. Their openness to new ideas and their breadth of interests infuse them with seemingly irrelevant stimulation that can enrich blind variations.

As 19th-century German philosopher Arthur Schopenhauer said, "Talent hits a target no one else can hit; genius hits a target no one else can see." Exceptional thinkers, it turns out, stand on common ground when they launch their arrows into the unknown. M

COGNITIVE DISINHIBITION, HIGHER INTELLIGENCE AND GREATER WORKING MEMORY MAY CONSTITUTE THE BASIS FOR SERENDIPITY.

(Further Reading)

- **Scientific Talent, Training, and Performance: Intellect, Personality, and Genetic Endowment.** D. K. Simonton in *Review of General Psychology,* Vol. 12, No. 1, pages 28–46; March 2008.
- **Genius 101.** D. K. Simonton. Springer Publishing, 2009.
- **So You Want to Become a Creative Genius? You *Must* Be Crazy!** D. K. Simonton in *The Dark Side of Creativity.* Edited by D. H. Cropley, A. J. Cropley, J. C. Kaufman and M. A. Runco. Cambridge University Press, 2010.
- **Creativity and Discovery as Blind Variation: Campbell's (1960) BVSR Model after the Half-Century Mark.** D. K. Simonton in *Review of General Psychology,* Vol. 15, No. 2, pages 158–174; June 2011.
- **From Past to Future Art: The Creative Impact of Picasso's 1935 Minotauromachy on His 1937 *Guernica*.** R. I. Damian and D. K. Simonton in *Psychology of Aesthetics, Creativity, and the Arts,* Vol. 5, No. 4, pages 360–369; November 2011.

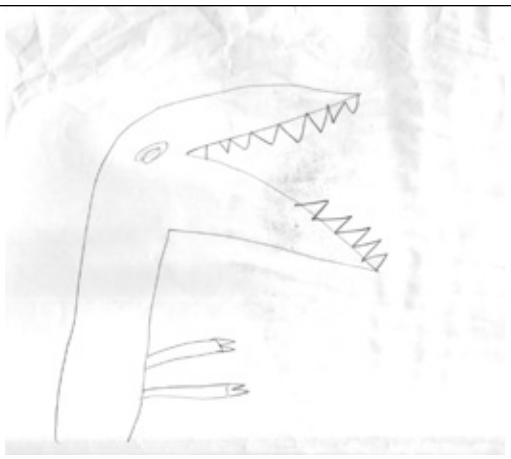
PREDICTING ARTISTIC BRILLIANCE

A "RAGE TO MASTER," AS OBSERVED IN SOME PRECOCIOUS YOUNG ARTISTS, MAY HELP DEFINE EXTREME VISUAL CREATIVITY

By Jennifer E. Drake and Ellen Winner

Arkin Rai, a seven-year-old child living in Singapore, draws dinosaurs with exquisite realism. At age three his dinosaurs were simple and schematic. A year and some months later, however, he created a complex drawing in which dinosaurs were layered one on top of the other, an image that bears an uncanny resemblance to a drawing of horses and a bull by the adult Pablo Picasso.

LUCY SCHAEFFER



age 3

age 4 years, 7 months

In one and a half years, Arkin Rai went from creating abstract, schematic drawings (*this page, left*) to learning several advanced techniques, such as occlusion (*this page, right*). His sketches (*opposite page*) show layering, foreshortening and linear perspective.

In Arkin's fanciful scene, the long, graceful neck of an *Apatosaurus*-like beast obscures the view of other dinosaurs. One of them is a *Tyrannosaurus rex*, drawn in profile with one leg mostly hidden behind another—an effect called occlusion, which most children discover at age eight or nine. In the ensuing months his drawings became shockingly realistic. He started using fluid contour lines to give figures shape. At age six he was depicting dinosaurs fighting and running, using various advanced methods to convey the distance between objects.

Most adults cannot draw anywhere near as realistically as Arkin can, and we are in awe of such technical virtuosity in a young child. Although we cannot know if Arkin will develop into a professional artist, his drawings and those of children like him are helping us study the emergence of artistic ability. By examining the artworks of gifted children and the early compositions of adult artists, we and other researchers have begun to predict who will display great visual creativity later in life. Our studies of young artists may also offer insight into the development of mastery more generally.

FAST FACTS

Motivated to Master

1» **Artistically gifted children may see the world differently than other youngsters do. They discover advanced compositional techniques many years before their peers.**

2» **These precocious children tend to be self-motivated and deeply interested in honing their skills.**

3» **These early signs and others are helping researchers to predict which children are likely to pursue art as adults.**

Exceptional realism, such as that displayed by Arkin, is one important sign, but it is not the whole story. Not all adult artists drew as convincingly as Arkin when they were his age, and some young children are now being discovered who show a skill for producing nonrepresentational art, rather than realistic works. We have identified five other characteristics that we believe foretell artistic creativity. A budding artist's drawings are often well composed and display either a decorative, colorful aspect or an expressive power. The child also has a hunger to look at art, possesses an enormous drive to create and wants to be original. Last, we contend that outstanding artists, and perhaps geniuses in all domains, not only possess innate talent but also are intrinsically motivated in a way that others may not be—something we call the rage to master.

Birth of a Skill

Scientists and educators have long sought to demystify the emergence of expertise, artistic and otherwise. Many researchers have argued that exceptional achievement can be boiled down simply to hard work—about 10,000 hours of it. Studies of eminent scientists in the 1950s supported this view by underscoring the individuals' capacity for endurance, concentration and commitment to effortful practice. Benjamin Bloom, a prominent education psychologist who studied mastery, wrote in 1985 that none of his subjects achieved expertise without a supportive environment and a long and intensive period of training. This education came first from encouraging instructors and later from demanding master teachers. A few years later psychologist K. Anders Ericsson of Florida State University conducted studies of experts in piano, violin, chess, bridge or athletics. The investigations revealed that a person's level of achievement correlated strongly with the amount of practice put in.

COURTESY OF DINESH RAI (*Rai family*); COURTESY OF ARKIN RAI (*dinosaurs*)

age 4 years, 7 months

age 6

age 6

These studies, however, have not been able to tease apart hard work and innate ability. The children with the most talent may also be the ones most interested in an activity, who begin to develop their skills at an early age and who work the hardest at it. Committing time and energy to a task likely is easier when advancement comes quickly but not when every step is a painful struggle.

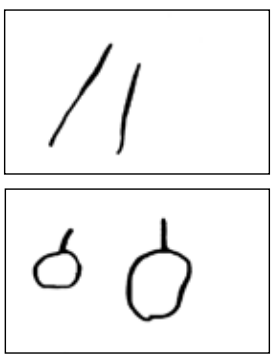
youngsters are abstractions: an apple is captured with a slash, a human body with a circle, a horse's body with a square. Precocious realists produce works that are much more optically convincing.

These children discover on their own how to create the illusion of 3-D using depth cues—foreshortening, occlusion, size diminution, shading to convey form and, the most difficult technique of all, linear

PRECOCIOUS ARTISTS BEGIN TO DRAW REPRESENTATIONALLY BY AGE TWO, AT LEAST ONE YEAR AHEAD OF MOST CHILDREN, WHO DRAW ABSTRACTIONS.

We have tackled this question by examining the earliest signs of artistic talent. Researchers have long assumed that the first inkling of it in humans, and especially in the young child, is the ability to portray the three-dimensional world realistically on a two-dimensional surface. Art historians have been struck by the realism of the cave paintings done by our Paleolithic forebears, leading many to assume that this style is the most natural form of art. Although most children's drawings are schematic, certain youngsters, including some with autism, can draw in a highly naturalistic fashion from a very early age, mirroring those paintings done by our ancestors. We refer to children who show an early ability to draw in this manner as precocious realists, and we now know a great deal about their developmental trajectory.

Precocious realists begin to draw representationally by age two, at least one year ahead of most children. The artworks of typically developing



A typical two-year-old's drawing of two apples uses two lines. A precocious two-year-old draws a circular line to capture contour.

perspective—years before most of their peers. In a comparison of typical and precocious artists published in 1995, psychologist Constance Milbrath, now at the University of British Columbia, observed that half of the children in the precocious group used foreshortening, in which lines not parallel to the picture plane are drawn shorter, in their artworks by ages seven and eight. Typically developing children reached comparable levels only by ages 13 and 14.

The ability to draw realistically at an early age marks the childhoods of many recognized artists. Artist and curator Ayala Gordon observed naturalism in the childhood compositions of 31 Israeli artists. Many famous artists' early drawings have been singled out for their advanced realism, too, including Picasso, John Everett Millais, Edwin Henry Landseer, John Singer Sargent, Paul Klee and Henri de Toulouse-Lautrec. Picasso recalled one of his first drawings in this way: "I was perhaps six.... In my father's

COURTESY OF ELLEN WINNER

THE DESIRE TO WORK SO HARD AT SOMETHING COMES FROM WITHIN. A CHILD'S INTEREST AND DRIVE CANNOT BE SEPARATED FROM THE TALENT.

See more drawings by precocious young artists at **ScientificAmerican.com/Mind/nov2012/gifted-artists**

house there was a statue of Hercules with his club in the corridor, and I drew Hercules. But it wasn't a child's drawing. It was a real drawing, representing Hercules with his club."

Different Way of Seeing

We set out to discover what cognitive differences might give these children their edge. Their skill is not a matter of intelligence. As we reported in 2010, we have observed no relation between realistic drawing ability and IQ. This finding is bolstered by the cases of autistic "savants" with low IQs, such as Nadia, a child discovered at age six who demonstrated phenomenal artistic prowess despite severe learning disabilities, and Stephen Wiltshire, a man with autism who could draw elaborate cityscapes from memory after only a brief exposure to a scene.

What we have found instead is that children who draw realistically at an above-average level differ in their perceptual abilities. They have strong observational skills and seem to be able to just see the shapes of things, including the distortions that occur as objects recede into depth and diminish in size. A typical child might see a road as having parallel sides because she knows that a road's edges are parallel, whereas an artistically gifted child overrides her knowledge about the road and sees its sides converging in the distance.

Early artistic aptitude is also strongly associated with the ability to focus on the parts of an object or scene rather than on the whole. To examine this idea, we used a visual and motor skills test called the Block Design Task. Children were asked to arrange red and white blocks to match a given pattern. We gave this task once in traditional format and once with the pattern segmented to reveal where the block boundaries should be. All participants did well on the segmented version. Children with realistic drawing ability, however, performed much better than other kids on the unsegmented version, presumably because they could mentally divide a complex form into its parts with ease.

They also performed better on a task in which they were asked to detect small shapes hidden within figures, a skill that requires analyzing a form by its elements. We hypothesize that a focus on component parts characterizes the process by which realistic artists draw. They may create a complex drawing not by first sketching the global outline but by building up their drawings part by part. Thus, they may both process and generate a scene with a more local focus than do nonartists.

This local-processing bias is also seen in children with autism. In 1993, for example, psychologists Amitta Shah, now a consultant, and Uta Frith of University College London found that autistic children performed equally well on both versions of the Block Design Task. Although a local-processing bias is commonly thought of as a characteristic of autism, our work has found that this proclivity is predicted not by the presence or absence of autism but only by the ability to draw realistically.

Nonrepresentational Painters

We suspect, however, that producing works in a naturalistic style is not the only way to demonstrate artistic brilliance. Although most Western children identified as gifted in drawing have come to our attention by virtue of their precocious realism, some talented children have mastered a nonrealistic style instead. Psychologist Claire Golomb of the University of Massachusetts Boston has described these children, whom she called "colorists," as showing an awareness of form and quality

An avid 12-year-old naturalist, Joel Gibb displays artistic talent but may be using drawing as a tool to understand nature. He may become a scientist instead.

COURTESY OF JOEL GIBB

and a concern with decorative and expressive aspects of color, texture and design. These artists are more difficult for an untrained eye to spot because their drawings may look similar to the charming, nonrealistic paintings of typical preschoolers.

We have recently discovered a child, whom we classify as artistically gifted, whose paintings are entirely nonrepresentational. His process does not resemble that of his peers, nor do his works. Several days shy of his second birthday, Arrian began to create colorful abstract drawings on large, 18- × 24-inch pages using Crayola markers, concentrating intensely. He usually works on each drawing for a day and a half to two days. He fills the entire space densely and meticulously. As his mother describes it:

> One session for Arrian is typically a cycle through whatever set of markers he is using at the time. So, if he has a set of 24 he will systematically go through each marker one by one.... He often begins with some circles all over the page and long flowing lines.... Once he has his basic drawing he colors it in systematically—almost in quadrants.

A few months later his mother noted:

> Ari is obsessed with making circles—he tries for hours to make the smallest, tightest, thinnest circles he can do. He tries all kinds of ways of holding the marker ... experiments with putting his face really close to the page. He likes to dangle the marker to get a thin feather line but then tries with his fist to get a tighter circle—to hold it properly to gain control, and ultimately [he] seems to want to achieve some combination of all three to get the look he wants. He's been doing this all day for a week—sometimes with just one or two colors.

When Arrian turned three, he discovered viewfinders. For two weeks he carried around a comb through which he inspected the world. He also started drawing people at this time, right on track with typical development. Notably, he was not ahead of the curve in representational skill. He was, however, advanced in intensity: after drawing one face—a circle with eyes—he went on to draw about 400 more smiling visages, all in one sitting. The systematicity, intensity, focus and meticulous care with which Arrian draws set him apart from the typical two-year-old scribbler. None of the precocious realists we have studied show anything like Arrian's behavior—they progressed rapidly to representational drawings and showed no interest in nonrepresentational art.

At age two years and three months, Arrian (*shown above*) worked for five days to create this 18- x 24-inch painting. He used Crayola markers to fill the page with small marks, sometimes drawing with the right hand and sometimes with the left.

A Rage to Master

Arrian draws constantly and compulsively. So do the precocious realists. This kind of rage to master cannot be taught, cajoled or forced. The children we study often have to be dragged away from their preferred activities to eat, sleep, go to school or be sociable. The desire to work so hard comes from within, and it almost always occurs when a child can achieve at high levels with relative ease. The interest and drive cannot be separated from the talent.

Most gifted child artists do not become artists as adults, of course. Many individuals have displayed skill in their early work as great as that of Picasso, yet only one person became Picasso. The age at which extreme realism emerges is also not predictive: Klee's drawings at age six were less realistic than those of some of the children whose work is reprinted in this article, yet he is among the greats.

Gifted individuals may choose not to pursue art for many reasons, but one explanation might have to do with the child's underlying motivation. Some precocious realists seem more interested in understanding nature—drawing is their tool. Roc-

(The Authors)

JENNIFER E. DRAKE is a postdoctoral fellow at Boston College. ELLEN WINNER is professor of psychology at Boston College and senior research associate at Project Zero at the Harvard Graduate School of Education.

COURTESY OF ARRIAN AND REBECCA SMITH (*abstract drawing*); COURTESY OF BRANDON SMITH (*Arrian*)

TALENTED TODDLERS?

Parents sometimes believe that their two-year-old is a prodigy because they notice the similarity of their child's painting to that of an abstract expressionist master. Gallery owners, too, have been fooled by such paintings. In 2011, for example, four-year-old Aelita Andre had an exhibit in New York City and was touted as a genius on a par with Jackson Pollock and Wassily Kandinsky. These works, however, are age-typical, and we cannot yet call their maker artistically gifted—even if we find the paintings pleasing and superficially similar to works by abstract expressionists. (The film *My Kid Could Paint That,* directed by Amir Bar-Lev, asks whether parents and gallery owners are fooling the public into thinking these works are signs of genius.)

Other children, however, truly are precocious artists. Parents can nurture such giftedness when it exists. In the early years parents can encourage art-making behavior, provide high-quality art supplies, and take the child to museums and expose him or her to the range of styles in which artists have worked. Given the lack of attention and time devoted to art education in most schools, the opportunity to study art formally outside of school very likely is critical if the child is to go on to become an artist. In 2011 curator Ayala Gordon reported that almost all the 31 Israeli artists whose childhoods she studied had begun taking art lessons outside of school with artist-teachers by age 10. It was in these classes that they began to identify themselves as artists and to discover others like themselves. *—J.E.D. and E.W.*

AMAURY MILLER *Redux Pictures*

co Roth and Joel Gibb exemplify this mind-set. Both boys pore over nature encyclopedias and field guides. Rocco, currently six years old, is passionate about insects, seeds, leaves and vegetables. He collects specimens and then draws and labels every one. Joel, who is 12 years old, has memorized the *Kaufman Field Guide to Birds of North America* and makes meticulous copies of these drawings. These children may eventually become scientists rather than artists.

Beyond a realistic drawing skill, we have identified five other commonalities that are likely to be predictive of becoming an artist. The child's drawings have an interesting, arresting composition and decorative, aesthetic features or expressive power. The child shows a hunger to look at art, whether in museums or books, and hence manifests a deep interest in art. The young artist also has enormous drive—a rage to master. Finally, and perhaps most important, the child has a desire not just to make excellent art but to be original and innovative.

We can even speculate that realistic drawing skill might not be necessary. Because so few nonrealistic child prodigies have been identified, we do not yet know the answer to this question. Children who paint abstractly may be more unconventional and playful. They may more readily think out of the box and are thus perhaps more likely than the realists to think like true artists.

As art historian Ernst Gombrich wrote in *Art and Illusion,* a classic text on the history of art from a psychological perspective, realism is only one thin slice of the art that humans have produced over the centuries. There may be more than one route to a career in art—one that begins with a striving toward realism and another that emerges from a nonrepresentational exploration of form and color. As studies of children gifted not only in art but also in math, science, languages, chess and athletics have shown, what really predicts high achievement is the lucky combination of an ease of learning, an obsessive focus and a deep motivation to pursue an activity. M

(Further Reading)

- **Normal and Anomalous Representational Drawing Ability in Children.** Lorna Selfe. Academic Press, 1983.
- **Eytan: The Early Development of a Gifted Child Artist.** Claire Golomb in *Creativity Research Journal,* Vol. 5, No. 3, pages 265–279; 1992.
- **Gifted Children: Myths and Realities.** Ellen Winner. Basic Books, 1996.
- **"Autistic" Local Processing Bias Also Found in Children Gifted in Realistic Drawing.** Jennifer E. Drake et al. in *Journal of Autism and Developmental Disorders,* Vol. 40, No. 6, pages 762–773; June 2010.
- **Children Gifted in Drawing: The Incidence of Precocious Realism.** Jennifer E. Drake and Ellen Winner in *Gifted Education International.* Published online May 18, 2012.
- Watch Arrian, a precocious nonrepresentational artist, draw in this video: **www.youtube.com/watch?v=hyJB0shXoD0&feature=feedu**

SO YOU WANT TO BE A GENIUS

When it comes to cultivating genius, talent matters, but motivation may matter more **By Daisy Yuhas**

Got motivation? Without it, the long, difficult hours of practice that elevate some people above the rest are excruciating. But where does such stamina come from, and can we have some, too? Psychologists have identified three critical elements that support motivation, all of which you can tweak to your benefit.

Autonomy

Whether you pursue an activity for its own sake or because external forces compel you, psychologists Edward L. Deci and Richard M. Ryan of the University of Rochester argue that you gain motivation when you feel in charge. In evaluations of students, athletes and employees, the researchers have found that the perception of autonomy predicts the energy with which individuals pursue a goal.

In 2006 Deci and Ryan, with psychologist Arlen C. Moller, designed several experiments to evaluate the effects of feeling controlled versus self-directed. They found that subjects given the opportunity to select a course of action based on their own opinions (for example, giving a speech for or against teaching psychology in high school) persisted longer in a subsequent puzzle-solving activity than participants who were either given no choice or pressured to select one side over another. Deci and Ryan posit that acting under duress is taxing, whereas pursuing a task you endorse is energizing.

Value

Motivation also blossoms when you stay true to your beliefs and values. Assigning value to an activity can restore one's sense of autonomy, a finding of great interest to educators. In a 2010 review article, University of Maryland psychologists Allan Wigfield and Jenna Cambria noted that several studies have found a positive correlation between valuing a subject in school and a student's willingness to investigate a question independently.

The good news is that value can be modified. In 2009 University of Virginia psychologist Christopher S. Hulleman described a semester-long intervention in which one group of high school students wrote about how science related to their lives and another group simply summarized what they had learned in science class. The most striking results came from students with low expectations of their performance. Those who described the importance of science in their lives improved their grades more and reported greater interest than similar students in the summary-writing group. In short, reflecting on why an activity is meaningful could make you more invested in it.

Competence

As you devote more time to an activity, you notice your skills improve, and you gain a sense of competence. In 2006 psychologists at the Democritus University of Thrace and the University of Thessaly in Greece surveyed 882 students on their attitudes and engagement with athletics during a two-year period. They found a strong link between a student's sense of prowess and his or her desire to pursue sports. The connection worked in both directions—practice made students more likely to consider themselves competent, and a sense of competence strongly predicted that they would engage in athletic activity. Similar studies in music and academics bolster these findings.

Carol S. Dweck, a psychologist at Stanford University, has shown that competence comes from recognizing the basis of accomplishment. In numerous studies, she has found that those who credit innate talents rather than hard work give up more easily when facing a novel challenge because they assume it exceeds their ability. Believing that effort fosters excellence can inspire you to keep learning.

The next time you struggle to lace up your sneakers or park yourself at the piano bench, ask yourself what is missing. Often the answer lies in one of these three areas—feeling forced, finding an activity pointless or doubting your capabilities. Tackling such sources of resistance can strengthen your resolve. The choice, of course, is yours.

Practice makes perfect, but finding the personal wherewithal to start can be daunting. Proved techniques can help build motivation.

KRISTEN GERACI *Getty Images*

Daisy Yuhas is a science writer based in New York City.

SPECIAL ISSUE: GENIUS

NURTURING THE YOUNG GENIUS

RENEWING OUR COMMITMENT TO GIFTED EDUCATION IS THE KEY TO A MORE INNOVATIVE, PRODUCTIVE AND CULTURALLY RICH SOCIETY

By Rena F. Subotnik, Paula Olszewski-Kubilius and Frank C. Worrell

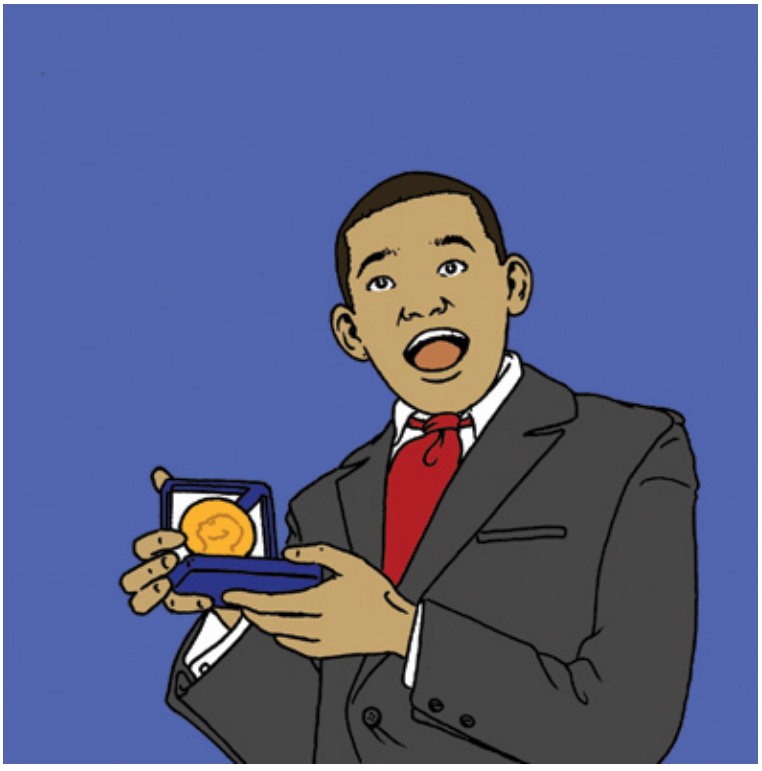
In 1957, when Sputnik took the world by storm, the Ford Foundation was several years into a project for talented students based on early college entrance. An evaluation of that program from the Fund for the Advancement of Education read: "There are those who argue that it is psychologically unsound and politically undemocratic for one child to proceed faster or to have a richer academic diet than another.... But what is too often ignored is the greatest risk of all—the risk of adhering stubbornly to a clearly imperfect set of practices which are frustrating the development of young talent at a time in history when this nation urgently needs to develop its human resources to the full."

The authors argued that focusing on the *most* able students is critical in a democracy for nurturing a cadre of capable leaders, among other advantages. The resulting infusion of attention and resources to talented youths through the National Defense Education Act led to a boom of innovation and scientific productivity in the U.S.

Today researchers, policy makers and teachers pay little to no attention to high-achieving students. School-based gifted education receives scant state or

ILLUSTRATIONS BY MARK NERYS

CHAD BAKER/RYAN McVAY Getty Images



Providing more opportunities for gifted children will boost our supply of future leaders, creative thinkers, and inspiring performers and will thus greatly improve our lives.

federal funding. Only four states currently fully fund their mandates to identify and serve gifted students. Many such students spend their days in school unchallenged—relearning material they have already mastered. The failure to develop their talents means that fewer of them will become future innovators of products and services; creative thinkers to solve major social, economic and environmental problems; leaders to tackle national priorities; or performers to entertain, inspire and soothe our souls.

FAST FACTS

Fast-Tracking Talent

1» **Abilities matter. They are malleable, however, and need to be cultivated.**

2» **Society needs to provide opportunities for intellectual enrichment to all students to ferret out hidden talents.**

3» **Psychological strengths such as persistence, social skills and strategic risk taking are determining factors in the successful development of talent.**

America's neglect of its talent is showing, particularly where math is concerned. As economist Eric Hanushek of Stanford University and his colleagues reported in 2010, 30 of the 56 countries that participated in the Program for International Student Assessment (PISA) study, which tests the reading, science, and math skills and knowledge of 15-year-old children, had larger percentages of high-achieving math students than the U.S. did. New Zealand, Canada and Australia have nurtured at least twice the proportion of mathematically advanced students that the U.S. has.

We think a renewed commitment to gifted education is critical for expanding the pool of individuals who can make pathbreaking discoveries and creative contributions to our society. The first step is to train teachers and others to spot giftedness, which may show up in a child's IQ score but could also surface as aptitudes in specific areas such as number sense or musical ability. Social and emotional qualities that can be developed through training, such as persistence, grit and passion, are also important contributors to later success.

Offering young children a wide palette of activities could spawn new interests and enable a greater diversity of talents to surface. Once an exceptional aptitude emerges, we need programs in place, including accelerated classes and psychological coaching, that can nurture its development as early and vigorously as possible. The chief goal of these efforts is preparing young people for outstanding achievement.

Talent

For nearly a century scholars have sought to understand, measure and explain giftedness. To some, the term is a misnomer for the result of endless practice or social advantage. We believe, however, that extraordinary abilities do exist and do matter. Giftedness implies an ability to perform at the extreme upper end of the distribution in a certain area. Early on it is determined and largely defined by potential, followed by demonstrated achievement and, later, by eminence. In elementary schools, it is often equated with IQ. Students who score above the 95th percentile (although cutoffs vary) on an intelligence test are often classified as gifted.

IQ is generally predictive of achievement in school, but new research shows that narrower academic assessments can help forecast the likelihood of adult contributions to, say, literature or physics. In 2005 psychologist David Lubinski of Vanderbilt University and his colleagues reported that scores on the math and verbal parts of the SAT measured around age 13 in high-achieving students (as well as tests of

student interests) can indicate whether an adolescent will choose to later pursue the humanities or a math or science field as a career. Even differences within the 99th percentile of mathematical ability—the top 1 percent—are associated with variations in outcomes, such as income level, number of patents and the likelihood of obtaining a doctorate.

In recent years educators have begun to look beyond IQ scores to measure giftedness. Specialized schools or programs for science or the arts admit students based on achievement test scores, essays and projects. Elementary school programs may ask teachers to complete checklists that reveal a student's commitment to learning. As we discover how to better identify the core abilities associated with each domain of knowledge and skill, these methods will become more valid and reliable.

EVEN DIFFERENCES WITHIN THE TOP 1 PERCENT OF MATHEMATICAL ABILITY ARE ASSOCIATED WITH VARIATIONS IN INCOME LEVEL, NUMBER OF PATENTS AND LIKELIHOOD OF OBTAINING A DOCTORATE.

The nonacademic domains are more advanced on this front. For example, New York–based choreographer and ballet dancer Eliot Feld, who has had years of experience building dance troupes and educating novice performers, identifies those with potential around the age of eight using indicators of flexibility, body proportion and physical memory. Characteristics such as pitch perception and audiation—a way of cognitively processing music—have been associated with musical performance. In response to a survey, voice teachers identified intonation, timbre, musicality and pitch control as important factors related to singing talent.

Our ability to identify and assess the aptitudes that matter varies, however. In athletics, dance, music and chess, experts have developed visible benchmarks of talent at various ages. In academics, so far only in mathematics do we have reliable ways to detect potential talent early on.

Commitment

To achieve greatness in any realm requires more than talent. It also demands extraordinary creativity, grit, passion and social skills. Creativity, the ability to come up with novel, useful and elegant ideas or ways of doing things, has a long historical association with giftedness. It may depend on relevant skills and knowledge, but at its essence are mental processes such as metaphorical thinking, tolerance for complexity, and flexibility in problem solving. [For more on creativity and how to cultivate it, see "Your Creative Brain at Work," by Evangelia G. Chrysikou; Scientific American Mind, July/August 2012.]

Precursors of adult creativity may include independent thinking, a willingness to entertain different perspectives and views, and the creation of projects and products that are novel when compared with those of one's peers. Children who exhibit these characteristics are more likely to make creative contributions as adults. In 1999 educational psychologist Jonathan Plucker of Indiana University reported results from a multidecade follow-up of students identified as creative with the Torrance Tests of Creative Thinking while they were in elementary school. Scores on this test, which largely measures divergent thinking, were three times better than IQ tests at predicting the quantity and quality of publicly recognized creative accomplishments in adulthood.

Aside from their ability and creativity, gifted individuals stand out in the commitment and sacrifice they are willing to make in pursuit of their goals. In a chapter in a 1985 book entitled *Advances in Motivation and Achievement,* psychologist Mihaly Csikszentmihalyi wrote, "The unifying similarity among geniuses and innovators is not cognitive or affective but motivational. What is common among them is the unwillingness or inability to strive for goals everyone else accepts."

Giftedness has long been associated with high levels of intrinsic motivation—that is, engaging in a task for the sake of learning. In fact, many high academic achievers are also motivated by and enjoy extrinsic factors such as trophies, scholarships and

(The Authors)

RENA F. SUBOTNIK is director of the Center for Psychology in Schools and Education and the Center for Gifted Education Policy at the American Psychological Association. PAULA OLSZEWSKI-KUBILIUS is director of the Center for Talent Development and professor in the School of Education and Social Policy at Northwestern University. FRANK C. WORRELL is a professor in the Graduate School of Education and director of the School Psychology Program at the University of California, Berkeley.

other forms of recognition. In a 2010 study school psychologist David J. Kover of the San Francisco Unified School District and one of us (Worrell) showed that a group of academically talented students had similar levels of intrinsic and extrinsic motivation. High achievers may hunger more than others not only for knowledge but also for fame, fortune or power to change the world.

THOSE YOUTHS WHO HAD BEEN INVOLVED IN MORE EDUCATIONAL ACTIVITIES AND CLASSES HAD, AT AGE 33, A HIGHER RATE OF NOTABLE ACCOMPLISHMENTS IN SCIENCE, TECHNOLOGY OR MATH.

High achievers may have exceptional task commitment, meaning they are willing to engage in study and practice that, though not necessarily enjoyable, is instrumental to improvement. In a 2008 study psychologist Timothy W. Curby, then at the University of Virginia, and his colleagues demonstrated that the kindergarten pupils most likely to be identified as gifted in third grade exhibited not only high cognitive ability but also early task orientation, which is "the ability to do and complete work even in an environment in which teachers may not be directly supervising the work or when there are distractions present." In findings published in 1990 psychologists Camilla P. Benbow and Olya Arjmand, then at Iowa State University, used a statistical method to determine variables that distinguished between high and low achievers in mathematics among 356 students identified as mathematically gifted based on their SAT scores. Their analysis revealed that the strongest predictor of high achievement in a related area—going to medical school or graduate school for math or science—was the number of optional math and science examinations the students had taken, a variable that reflects a *commitment* to the discipline.

Passion contributes to the development of great ideas and performances, although it has been rarely studied in the context of gifted education. In one exception, psychologist Jennifer A. Fredricks of Connecticut College and her colleagues examined the quality in a 2010 study of 66 high school and college students who had been identified as gifted in academics, sports or the arts in childhood. The athletes and artists readily expressed passion about their involvement, telling experimenters, for instance, "I love the game … I want to play all the time." Among academically gifted youths, however, a typical statement was: "Well, I don't get all excited or anything—I mean, it's schoolwork." The study suggested that academically gifted children do not show a lot of enthusiasm for school in general. Yet students might have displayed interest in specific subjects if the survey had been structured that way.

Opportunity

Although the goal of education in the U.S. is for all children to maximize their potential, the focus of funding has primarily been on the most vulnerable children, such as those with disabilities, who are rightly guaranteed a free appropriate public education. Educators and policy makers assume that academically gifted children will be successful no matter what their educational environment. Yet research has shown that it takes about 10,000 hours of guided study or practice to reach levels of expertise in most domains. Although substantial numbers of children with outstanding intellectual ability are singled out and receive at least some support, few of these youngsters become eminent in adulthood, suggesting that many are not receiving the guidance and instruction they need to fulfill their potential.

A key to developing this talent may lie in giving students lots of opportunities to pursue their interests. In a 2010 study Jonathan Wai of Duke University and his colleagues assessed participation in various educational opportunities such as academic competitions, research apprenticeships, academic clubs, summer programs and accelerated classes among 1,467 individuals who had been identified as talented in math at age 13. They found that those who had been involved in more of these activities and classes—what the authors called a larger "educational dose"—had, at age 33, a higher rate of notable accomplishments in science, technology or math, such as earning a Ph.D., obtaining patents or securing tenure.

Effective talent development requires different kinds of teachers at different stages.

More Science

See the *Psychological Science in the Public Interest* article "Rethinking Giftedness and Gifted Education: A Proposed Direction Forward Based on Psychological Science," on which this story for *Scientific American Mind* is based, at the Association for Psychological Science's Web site: **www.psychologicalscience.org**

Ability matters for achievement, but expertise in any domain requires a lot (about 10,000 hours) of hard work. Recent data suggest that many gifted children are not receiving the guidance and instruction they need to fulfill their potential.

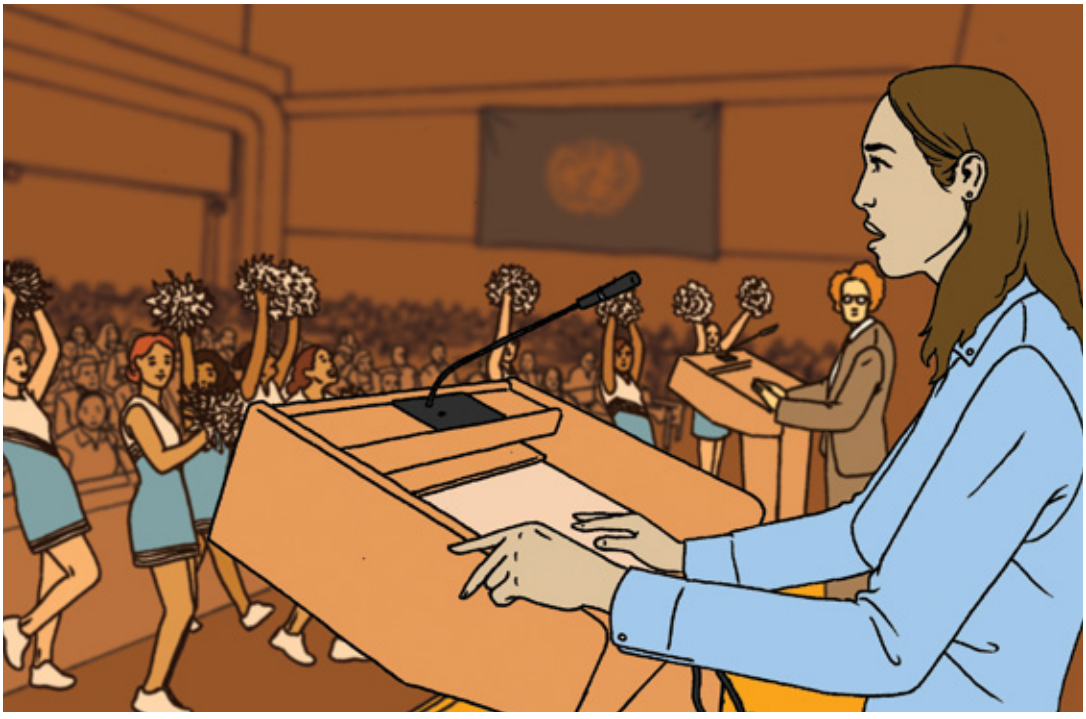
Mentorship is vital for transforming ability into renown. In a study of the origins of eminence through mentorship published in 1977, sociologist Harriet Zuckerman, then at Columbia University, interviewed 92 Americans who had won a Nobel Prize in science between 1901 and 1972. She found that more than half the interviewees had studied or collaborated with previous laureates. These mentors helped their protégés develop a feel for important problems and elegant solutions and mobilized resources, such as access to grants, fellowships, jobs and publications, on their behalf.

Developing youthful talents, especially in low-income and rural communities, by extending and supplementing the regular curriculum can expose children to new topics and ideas and enable them to engage with a subject in more depth. Summer programs, for example, may feature a range of topics that are not typically available in the regular classroom, such as human anatomy for fourth graders and robotics for middle schoolers.

Such enrichment activities are a staple of most gifted programs in schools, but expanding them could ferret out new talent. Courses that introduce subjects typically not studied until high school or college, for example, may give interested and able students a head start. In some cases, students may take these courses in specialized schools for gifted students such as the Illinois Mathematics and Science Academy and New York City's Brooklyn Technical High School and Bronx High School of Science.

The greater the diversity of offerings, the greater are our chances of unmasking potential. In 2004 the news program *60 Minutes* ran a piece on low-income adolescents of color from Harlem, four of whom were representing the U.S. at the Olympics in fencing that year. How did students from low-income backgrounds living in an inner-city neighborhood get involved in such an esoteric sport? By good fortune, a former African-American fencing champion had retired to Harlem and began giving lessons 15 years earlier. His work provided the opportunity for many youngsters who may never have held a sword to discover that they had a talent for the sport (as well as the interest, passion and commitment to pursue it).

Students who seize such opportunities and demonstrate sufficient commitment should be given access to increasingly challenging classes or competitions, regardless of their age. Academic acceleration may involve skipping a grade, entering a higher grade level in a single subject or enrolling early in Advanced Placement courses. It may also consist of speeding up instruction in a course so that two years of material are covered in one year.



Gifted kids may be intrinsically driven, but they want public recognition, too. Schools tend to celebrate academic accomplishments far less than those in, say, athletics. Finding ways to cheer on or celebrate intellectual feats could encourage high academic achievement.

Acceleration significantly boosts both achievement and motivation in gifted students. In several meta-analyses reported in 2004 by psychologist James A. Kulik, then at the University of Michigan, he found that accelerated elementary and secondary students demonstrated levels of achievement superior to mainstreamed gifted students of the same age and ability. Kulik also found that accelerated students were more likely to seek degrees beyond a bachelor's. In the same year gifted education specialist Karen B. Rogers of the University of St. Thomas in Saint Paul, Minn., reported that accelerated students placed in various types of programs advanced beyond their peers between two and seven months, with greater improvement seen in classrooms in which students covered several years of content in an academic year.

Exceptionally gifted students may benefit the most from a faster-paced learning environment. In a study published in 2006, gifted education researcher Miraca Gross of the University of New South Wales in Australia tracked for over two decades the educational, social and emotional development of 60 youths in Australia with IQ scores of 160 and above. Seventeen of these youths were radically accelerated, allowing them to graduate from high school three years early. These students were very satisfied with their lives, professionally and personally. In contrast, many of the students accelerated only one year or not at all experienced significant social difficulties, and some even dropped out of high school or college.

Schools hardly ever use acceleration strategies. Educators often cite scheduling difficulties, but in fact, a strong bias exists against them. Yet acceleration should be a key part of gifted education. Indeed, we should expect children with talent to increasingly channel their efforts into specific areas as they mature. Schools should be staffed with extremely knowledgeable teachers even at the earliest grades, and we need more affordable summer programs that compress semester-long or yearlong courses into a few weeks of intensive instruction.

Persistence

Providing opportunities is not enough, however. Talented individuals must take advantage of them. Research shows that young people may shy away from educational or extracurricular offerings for various reasons, including fear of competition and failure, poor study and organizational skills, and shyness. Capitalizing on favorable circumstances thus requires certain psychological strengths, among them an ability to cope with challenges and criticism and a willingness to take strategic risks.

Such traits, along with persistence, focus and drive, are also essential to the ability to undergo the intense practice and preparation necessary to reach the top. In a 2001 study sports psychologist Daniel Gould of Michigan State University and his colleagues investigated the development of psychological strength in U.S. Olympic champions. He found that becoming a champion required more than just athletic prowess. It also depended on an ability to focus, mental toughness, facility with setting goals, competitiveness, confidence, coachability, drive, optimism and emotional control.

BECOMING AN OLYMPIC CHAMPION REQUIRES MORE THAN JUST ATHLETIC PROWESS; IT ALSO DEPENDS ON THE ABILITY TO FOCUS, MENTAL TOUGHNESS, DRIVE, OPTIMISM AND EMOTIONAL CONTROL.

Coaches routinely teach elite athletes how to handle setbacks, adjust anxiety levels for optimal performance and imagine success. In recent years music conservatories have given more systematic attention to these skills. The Juilliard School's precollege and conservatory programs implicitly inculcate values, such as deep devotion to one's art and teachers, that are associated with successful negotiation of the conservatory years. The school has also offered courses on mental-skills training to directly address variations in outcome, from music star to underachiever.

Academically talented students can experience competitive and occasionally stressful environments. Although these youths often display extraordinary motivation and commitment, they rarely receive additional psychological coaching to deal with the rigors of acceleration and other challenges. School and college teachers receive no systematic training in this realm. Neither are they typically trained to boost creativity through exercises that invigorate metaphorical and divergent thinking or problem solving.

Schools could do more to encourage high academic achievement, too. Although teachers and administrators often publicly recognize accomplishments in athletics, leadership and the performing arts, they tend to ignore or downplay academic feats. Stereotyping kids with intellectual talents as "nerds" or "brainiacs" also betrays a lack of support for these children, many of whom work very hard to meet their goals.

Indeed, the idea that gifted children are "naturals" and do not need to study or practice can severely undercut motivation. According to research by psychologist Carol S. Dweck of Stanford, the assumption that intelligence and talent are fixed traits can lead people to focus primarily on proving themselves worthy of their gifted or "smart" label and to undervalue the role of effort in achievement. In contrast, believing that intelligence and talent are malleable motivates a person to put in the daunting amount of effort necessary to achieve goals such as becoming a respected physicist, historian or philosopher. Dweck's research suggests that this attitude can be fostered with proper instruction and parenting practices [see "The Secret to Raising Smart Kids," by Carol S. Dweck; Scientific American Mind, December 2007/January 2008].

The aim of our proposed framework is to increase the number of individuals who can develop the innovative products and services and to deliver the creative performances that can improve and enhance our lives. The world needs more of these people. We are not advocating that all services be channeled to those on the path to eminence. Yet a focus on eminence sustains a continued attention to excellence. When people are given the means to transform talent into transcendent achievement, they experience great personal satisfaction and, at the same time, deliver unimaginable benefits to society. M

(Further Reading)

- **Developing Talent in Young People.** Edited by Benjamin S. Bloom. Ballantine, 1985.
- **The Transition from Childhood Giftedness to Adult Creative Productiveness: Psychological Characteristics and Social Supports.** P. Olszewski-Kubilius in *Roeper Review,* Vol. 23, pages 65–71; 2000.
- **A Nation Deceived: How Schools Hold Back America's Brightest Students.** N. Colangelo, S. G. Assouline and M.U.M. Gross. *Templeton National Report on Acceleration,* Vols. 1–2. John Templeton Foundation, 2004.
- **Accomplishment in Science, Technology, Engineering, and Mathematics (STEM) and Its Relation to STEM Educational Dose: A 25-Year Longitudinal Study.** J. Wai, D. Lubinski, C. P. Benbow and J. H. Steiger in *Journal of Educational Psychology,* Vol. 102, No. 4, pages 860–871; 2010.
- **Should Eminence Based on Outstanding Innovation Be the Goal of Gifted Education and Talent Development? Implications for Policy and Research.** R. F. Subotnik and R. Rickoff in *Learning and Individual Differences,* Vol. 20, No. 4, pages 358–364; 2010.

SPECIAL ISSUE: GENIUS

SWITCHING ON CREATIVITY

CASES OF SAVANT SYNDROME HAVE INSPIRED AN ELECTRICAL BRAIN STIMULATION TECHNIQUE FOR BOOSTING CREATIVE INSIGHT

By Allan W. Snyder, Sophie Ellwood and Richard P. Chi

A great idea comes all of a sudden. In the depths of the mind, networks of brain cells perform a sublime symphony, and a twinkle of insight pops into consciousness. Unexpected as they are, these lightbulb moments seem impossible to orchestrate. Recent studies suggest otherwise. By freeing the mind of some of its inhibitions, we might improve creative problem solving.

The human brain constantly filters thoughts and feelings. Only a small fraction of the stimuli impressed on us by our environment ascends to the level of conscious awareness. Prior learning enforces mental shortcuts that determine which sensations are deemed worthy of our attention. Our laboratory is investigating whether we can weaken these biases and boost openness to new ideas by temporarily diminishing the neural activity in specific brain areas.

The inspiration for this approach comes from individuals with brain impairment. People with savant syndrome—those rare individuals who possess uncanny skill in specific, circumscribed domains while struggling in others—appear to show a pattern of left-hemisphere dysfunction with a tendency for right-hemisphere dominance. We theorize this arrangement renders their mental filters less powerful than those in normal, healthy adults.

Genius, rare as it is, must demand a qualitatively different view of the world than what most of us experience. Austrian physician Hans Asperger, whose name is associated with the eponymous condition on the autism spectrum, suggested that "a dash of autism" might set brilliant minds apart. We have been investigating this hypothesis by using weak electric current to modulate brain activity in healthy people in our laboratory. The effects fade in an hour, preserving normal cognition. This method of brain stimulation is safe and portable, suggesting the possibility of a device—a "creativity cap"—that anyone might use to spur creativity on demand.

Limited by Mind-sets

The brain does not passively receive information. It actively interprets what we think of as our raw experience in light of past knowledge. Two people looking at the same cloud formation, for example, may form completely different impressions of the patterns in the vapor: the ultrasound technician may see a diseased gallbladder, whereas the portrait painter may observe a dignified face.

Mind-sets are crucial. They allow us to predict likely outcomes based on incomplete information and to negotiate day-to-day activities efficiently.

PHOTOILLUSTRATION BY WILLIAM DUKE

Stephen Wiltshire, an artist with autism, can produce faithful recreations of intricate scenes after viewing them for only a short time. Such unusual skills may offer clues to inspiring creativity more broadly.

DAN KITWOOD *Getty Images*

Without them we would see the world naively, unable to distinguish between important and irrelevant details. This cognitive architecture also leaves us susceptible to errors, however, including illusions, false memories and prejudice. Mind-sets make us less receptive, perhaps even resistant, to novel interpretations. Once a mind-set is formed, we lose conscious access to the stimuli that make up a thought. For example, read this passage:

A bird in the
hand is worth
two in the
the bush

Many readers fail to spot the double "the." Neurologist Oliver Sacks read the sentence in our lab many times without detecting it. Humans are instinctively conceptual, not literal, thinkers.

We argue that creative insight requires two cognitive styles—one approach is mind-set-driven, and one grants us an unfiltered experience of the world around us. We would like to access perceptual details usually hidden from conscious awareness, potentially unlocking the genius within us all.

A Dash of Autism

A clue for achieving this goal comes from savants, most of whom fall on the autism spectrum. Savant skills sometimes appear in early childhood; other times they emerge after damage to the brain. These abilities tend to call on a less conceptual, more literal way of thinking. For example, when the teacher of a boy with infantile autism asked him to recall the ending of a particular book, he recited the last page verbatim but showed no comprehension of its gist. Although in the extreme this cognitive style is a setback in daily life, it can also confer a range of advantages, including superior drawing abilities and a reduced susceptibility to illusions and false memories.

Stephen Wiltshire, for instance, is a British artist with autism who has been able to produce spectacularly detailed drawings from a young age. He can draw with photographic realism, in minute detail, whereas most adults tend to draw according to their internal schemas, producing crude but meaningful caricatures. In our view, Wiltshire and others like him have privileged access to more raw, less processed information about the world. This literal cognitive style appears to allow a person to work bottom up, from the parts to the whole.

THE ABRUPT EMERGENCE OF TO THE POSSIBILITY THAT

A number of studies suggest that savants have some form of left-hemisphere dysfunction, together with right-hemisphere facilitation. (Typically damage to one hemisphere of the brain incites compensatory activity in the other half.) This characteristic can be observed from early childhood or after an injury, stroke or dementia damages the left hemisphere. Some of these impairments occur in a brain area of particular interest to us, the left anterior temporal lobe. This region is known to be involved in semantic memory, which includes the ability to categorize or combine concepts—in essence, filtering thoughts. Neurologist Bruce Miller of the University of California, San Francisco, for example, has documented multiple cases of dementia in which degeneration in the left anterior temporal lobe is associated with the sudden emergence of savantlike literal skills. Some of his subjects

FAST FACTS

Opening the Mind

1» People with savant syndrome, who possess great skill in specific areas, seem to have a more literal, less filtered cognitive style than most people.

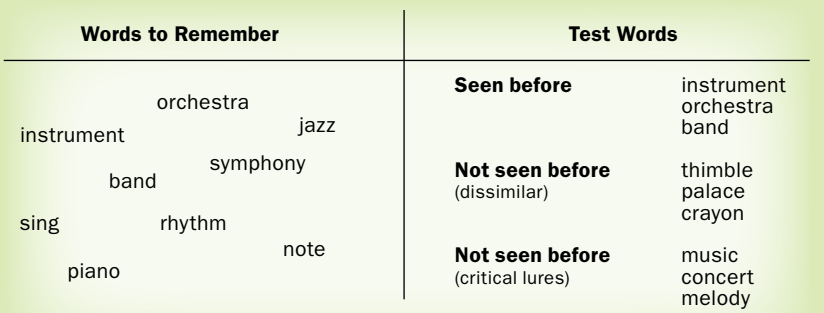
2» A savant may have dysfunction in the normally dominant left hemisphere of the brain, which the right hemisphere compensates for.

3» Using noninvasive brain stimulation, scientists are attempting to induce this pattern of brain activity, so as to produce a less filtered cognitive style and to access a different way of looking at a given problem.

began producing realistic art—meticulous copies of scenes lacking abstract or symbolic features—without training.

Acquired savant skills are not restricted to drawing. T. L. Brink, then at the Palo Alto School of Professional Psychology, described the case of Mr. Z, who as a nine-year-old child suffered a gunshot wound to the left temporal lobe. He lost the ability to read and write but suddenly gained extraordinary mechanical skills; for example, he discovered he could dismantle and reassemble multigear bicycles without instruction. Another case is Orlando Serrell, whom we have studied, who was hit on the left side of his head with a baseball when he was 10. He has exhibited savant skills in calendar calculation—the ability to swiftly discern the day of the week that a given date falls on—and in literal recall of the weather every day since his accident. The abrupt emergence of autisticlike cognitive abilities in acquired savant syndrome points to the possibility that these skills are latent in us all, but beyond conscious access.

A BOOST FROM BRAIN STIMULATION



In one experiment participants were shown a list of words. Later they were shown another list and asked which words they had seen earlier. The use of transcranial magnetic brain stimulation improved subjects' ability to distinguish between words they had already seen and closely related but absent words—the critical lures.

AUTISTICLIKE COGNITIVE ABILITIES IN ACQUIRED SAVANT SYNDROME POINTS THESE SKILLS ARE LATENT IN US ALL, BUT BEYOND CONSCIOUS ACCESS.

Finding Our Inner Savant

Intriguingly, recent evidence suggests we need not wound ourselves to access this altered cognitive state. We can quiet neuronal activity in the left hemisphere for brief periods using well-accepted forms of noninvasive brain stimulation. Many studies have shown that such stimulation can temporarily either inhibit or enhance neuronal activity in targeted areas. These techniques are now being explored for numerous applications, including the treatment of depression, eating disorders and speech impairments, among many others.

We started by investigating transcranial magnetic stimulation, a method in which a powerful magnet, positioned over a well-defined part of the brain, interferes with the normal flow of current in nearby neurons. The magnetic field disrupts the firing patterns of established networks of brain cells, whose connections were forged through a lifetime of learning. By targeting specific areas of the brain involved in synthesizing high-level concepts, we hope to reduce the influence of prior knowledge. In published studies so far, we have been able to enhance several skills in ordinary humans, including drawing, proofreading, numerosity estimation (counting the number of items, such as matchsticks, in a group) and verbal memory. The device needed to deliver this kind of stimulation is bulky and expensive, however.

A more promising approach is called transcranial direct-current stimulation (tDCS). This method is a safe, simple way to alter the likelihood that networks of neurons near the surface of the brain will fire. In our setup, a weak electric current passes between two electrodes, a cathode and an anode, placed on the scalp over the left and right anterior temporal lobes, just above the ears. At the cathode, the underlying neurons become less likely to fire, and vice versa for the anode. This dose of current alters the behavior of neurons for about an hour, a temporary window during which recipients can access a different cognitive style.

Boosting Brilliance

In one recent experiment using our apparatus, we asked 60 right-handed participants to solve a series of matchstick arithmetic "insight" problems. An erroneous arithmetic statement, spelled out in

(The Authors)

ALLAN W. SNYDER, a physicist and neurobiologist, is founding director of the Center for the Mind at the University of Sydney and is a Fellow of the Royal Society. SOPHIE ELLWOOD is a psychology graduate and a researcher at the Center for the Mind. RICHARD P. CHI earned his Ph.D. at the Center for the Mind and Sydney Medical School and was a research fellow at the Laboratory of Neuromodulation at Harvard Medical School.

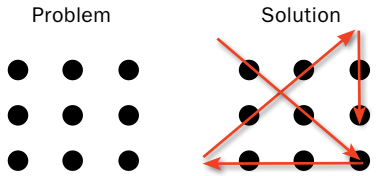
Roman numerals using matchsticks, must be corrected by moving one matchstick.

Participants were first given 27 problems that all involved one type of solution, namely changing an "X" to a "V." The goal was to prime the subjects to become fixed in one way of solving problems. Once people have learned to solve a problem, past research has shown, they often struggle to generate solutions using a different approach. As economist John Maynard Keynes put it, "The difficulty lies not in grasping the new ideas, but rather in escaping from the old ones."

The participants then received five minutes of DC stimulation. For one third of the group, we placed the cathode on the left anterior temporal lobe (to decrease the likelihood of neurons firing in that area) and the anode on the right anterior temporal lobe (to boost the chances of neuronal activity there). For another 20 participants, we switched the cathode and the anode. The final third received sham stimulation.

Next the subjects had six minutes to solve another problem. This task required a different kind of solution. As we had expected, many people were stuck. Yet 60 percent of those in the group that received stimulation according to our parameters solved the problem. Only 20 percent of those in the placebo group solved the new problem, and reversing the direction of stimulation did not have a significant effect on performance.

We did a follow-up study to ensure that our results were not a fluke. This time we used a notoriously difficult task—the classic nine-dots problem. The goal is to connect all nine dots with four straight lines, drawn without lifting pen from paper or retracing a line. A century of research has established that in the laboratory, at most 5 percent of participants manage to crack it, and very likely fewer manage to do so. Most people fail to decipher it even with hints and plenty of time. The reason is that the problem activates seemingly relevant prior knowledge that obstructs the solution. We tend to see the dots as a square, with rigid boundaries. Solving the puzzle requires the examinee to do away with false constraints and view the problem in a new light.



Solving the nine-dots problem (*shown here*) requires letting go of the idea that the dots form the border of an imaginary grid.

Subjects were given three opportunities to solve the nine-dots problem: they tackled it for three minutes before brain stimulation, three minutes during stimulation and three minutes immediately after the current was turned off. None of our participants solved the problem before stimulation or in the sham condition. Yet 14 out of 33 individuals did so as a result of receiving stimulation at the anterior temporal lobes according to our protocol. We calculated that the probability that this fraction of people could solve it by chance is less than one in a billion.

Many questions remain unanswered, of course. The precise effects of tDCS inside the brain are not completely understood, so mechanisms other than the ones we theorize might explain our results. The outcome of DC stimulation also depends on various factors, including which hemisphere is dominant and what the recipient's mental state is. Furthermore, problems are often difficult in multiple ways, and tDCS may only help with overcoming one of the many bottlenecks. In addition to ironing out these issues, we are now testing whether we can induce the ability to formulate new questions—another critical component of genius. Questioning is exemplary of receptiveness to novelty and is often obstructed by our preconceptions.

We want to emphasize that our approach aims not to enhance an existing ability but to reduce the limitations of prior knowledge. This type of cognitive enhancement is qualitatively different from what scientists normally seek to develop. Ultimately our goal is to develop a device that circumvents mental blocks to creativity. Having at our disposal two approaches, the normal way of thinking and the autistic focus on detail, could facilitate the ability to make truly novel connections—the essence of creative genius. M

DIRECT CURRENT ALTERS THE BEHAVIOR OF NEARBY NEURONS FOR ABOUT AN HOUR, DURING WHICH WE CAN ACCESS A DIFFERENT COGNITIVE STYLE.

(Further Reading)

- **Artistic Savants.** Craig Hou et al. in *Neuropsychiatry, Neuropsychology and Behavioural Neurology,* Vol. 13, No. 1, pages 29–38; January 2000.
- **Explaining and Inducing Savant Skills: Privileged Access to Lower Level, Less-Processed Information.** Allan Snyder in *Philosophical Transactions of the Royal Society B,* Vol. 364, No. 1522, pages 1399–1405; May 27, 2009.
- **Islands of Genius: The Bountiful Mind of the Autistic, Acquired, and Sudden Savant.** Darold A. Treffert. Jessica Kingsley Publishers, 2010.
- **Facilitate Insight by Non-Invasive Brain Stimulation.** Richard P. Chi and Allan W. Snyder in *PLoS One,* Vol. 6, No. 2, Article e16655; February 2, 2011.
- **Brain Stimulation Enables the Solution of an Inherently Difficult Problem.** Richard P. Chi and Allan W. Snyder in *Neuroscience Letters,* Vol. 515, No. 2, pages 121–124; May 2, 2012.

WHERE ARE ALL THE FEMALE GENIUSES?

WOMEN TEND TO CHOOSE WORK-LIFE BALANCE RATHER THAN THE PURSUIT OF EMINENCE—ALTHOUGH THE CHOICE IS NOT ENTIRELY FREELY MADE

By Sandra Upson and Lauren F. Friedman

Try this simple thought experiment. Name 10 female geniuses from any period in history. Odds are you ran out of names pretty quickly. The message is clear: something is rotten in the state of genius.

Besting most of one's species is an accident of circumstance. The sequences of DNA nucleotides, arranged *just so* to impart intelligence, curiosity and passion, are part of that fluke event. More serendipitous still are the conditions needed for a person to devote decades to an idea or calling, deaf and blind to the distractions bound up in being human.

That implausible scenario comes into sharp relief in the scarcity of female geniuses. The absence of women reveals the unequivocal role of culture and opportunity in the flourishing of brilliance.

ILLUSTRATION BY BRIAN REA

Few women dominate the chess world. A 2009 analysis offered this explanation: many more men play chess, so men are more likely to excel. Then one might ask: Why don't more women play chess?

For centuries doubts about women's abilities, combined with social customs, limited the so-called fairer sex to household concerns. In the developed world today women's access to education and resources is essentially on a par with that of men. With the barriers to opportunity crumbling, different cultural and social forces explain why women still struggle to reach the very top of their fields. "As much as we've been able to open doors, there are huge structural differences in how men and women live out their lives," says psychologist Jacquelynne Eccles of the University of Michigan.

Gifted women face a choice: they can pursue their interests wholeheartedly, or, in line with cultural imperatives, they can split their time and serve as the anchors of their families. The good news is that for those in whom the fires burn brightest, a choice exists—albeit one riddled with compromises. Attaining eminence will never be easy, but fixing the social inequity that still remains should lessen the trade-offs it demands of women today.

FAST FACTS

Under Pressure

1» For most of history women in the Western world were denied opportunities to seek higher education and develop their talents.

2» The dearth of women at the top of their fields is now often the result of compromises made for the sake of family, rather than differences in ability.

3» Women who seek eminence face difficult choices regarding when to invest in their careers versus their personal lives. More cultural and institutional support for women could dispel the lingering gender disparities.

(The Authors)

SANDRA UPSON is managing editor of *Scientific American Mind.* LAUREN F. FRIEDMAN is a staff editor at *Psychology Today* and a former intern at *Scientific American Mind.*

Beyond Biology

Francis Galton, the first person to study the hereditary basis of eminence, argued that a gifted man would achieve greatness as long as he "had no pressing calls on his attention, no domestic sorrows, anxieties and petty cares … no constant professional toil for the maintenance of a large family." For men at any time in history this condition is rare—for women, nearly nonexistent.

A woman was expected to be a well-mannered complement to her husband, able to soothe his cares and those of their children. She was not someone who holed up in an office or studio for hours on end. The few women who bucked the trend did so covertly. The Brontë sisters, for example, published their novels under masculine names. Linda Nochlin, a feminist art historian, noted that until the 1900s women artists were denied many opportunities to develop their craft that men took for granted, including the freedom to paint nude models, join art academies and network with patrons. These closed doors doomed women to obscurity.

Mental or physical frailty was also commonly invoked to discourage women from seeking higher education or public recognition for their work. Those debates are only now being put to rest. More women now graduate from college and enter medical school than men, and more female athletes qualified for U.S. Olympic teams this year than men.

Psychologist Lewis Terman, who in 1921 began an ambitious program of intelligence testing, reported that the three highest IQ scores in his first survey of gifted children belonged to girls. More recent work has established that, in aggregate, women and men perform about the same on intelligence tests.

A 2008 meta-analysis of creativity research reached a similar conclusion. Psychologists John Baer of Rider University and James C. Kauffman of California State University, San Bernardino, reviewed 78 studies of men and women at various ages and found that although some studies showed one gender scoring higher than the other on measures of creativi-

CARO BONINK *Redux Pictures*

ty, these findings were almost always counterbalanced by experiments showing the opposite effect.

Lonely at the Top

Baer and Kauffman did, however, find a large gap in the productivity of creative men and women. Explaining the differences in creative output is now the "most significant" question, they conclude. The data suggest that early in their careers, women are pulling out of the race to eminence.

Lingering gender bias, often unconscious, may account for some of the attrition. The advent of blind auditions for orchestras, beginning in the 1970s, is one famous example of discrimination and its abatement: the odds of a female musician advancing through the early rounds of a tryout increased by 50 percent after orchestras introduced screens to conceal applicants' identities. Skewed ratios still show up in countless domains, however. Recent reports have found, for instance, that women write one fifth of the editorials in traditional media outlets and about one third of the articles in top-tier magazines and literary journals. Without data on the numbers of submissions by gender, however, the causes of disparity remain occluded.

Cornell University psychologists Wendy M. Williams and Stephen J. Ceci (who is a member of *Scientific American Mind*'s board of advisers) investigated this question in a 2011 review of studies on gender discrimination in science and engineering. They concluded that the low numbers of women in these fields exist not because of unfair practices in the awarding of grants, job offers or publication in prestigious journals. When they compared only people with similar accomplishments and resources, men and women were equally likely to receive those accolades. Instead they found the gap stems from preferences relating to family and work-life balance. Women were more likely to accept less desirable posts, which offer less time for research, often to accommodate raising a child or tending to an aging parent.

A 2009 survey of more than 8,000 doctoral students in the University of California schools bolsters this observation. Half the female respondents were "very concerned" that a career in academia might not be family-friendly, compared with a third of men. Considerably more women than men described their professional activities as being too time-consuming, incompatible with children or a partner, or geographically problematic. Fears of conflicting priorities are not unfounded—the respondents who were also mothers reported logging more than 100 hours a week on academic work, caregiving and housework; fathers clocked around 90 hours.

To further pinch ambitious women in academia, the years during which women must receive their degrees, land a job and work toward tenure (received at an average age of 39) coincide perfectly with the prime years for having children. "When we put all the studies together, what we find are that marriage and childbirth are the most predictive variables in terms of the attainment of eminence," says psychologist Barbara Alane Kerr of the University of Kansas.

Divided Focus

Choices made for family reasons are intensely personal and often admirable—but they are not conducive to genius-level accomplishment. Rising above the rest demands single-minded devotion to one's craft. "Females still are less likely to aspire to that way of life," Eccles says. "It means giving up just about everything else and having a supportive network so you *can* give up everything else."

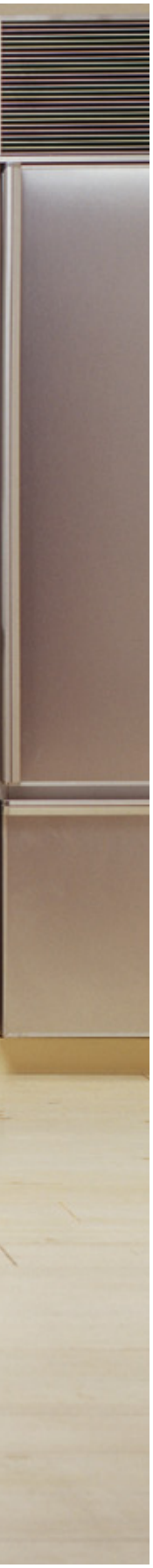
THE GOOD NEWS IS THAT FOR THOSE WOMEN IN WHOM THE FIRES BURN THE BRIGHTEST, A CHOICE EXISTS—ALBEIT ONE RIDDLED WITH COMPROMISES.

For women in academia, offering child care assistance and more options for slowing down the tenure process could absorb some of the temblors knocking women off the path to greatness, as a 2004 report from the Government Accountability Office advised. More broadly, Kerr suggests that women recognize the importance of timing in their major life decisions and seek parity in their relationships within the family and with colleagues. Only when gender assumptions about household responsibilities are finally washed out of the fabric of society can women face equal odds as men.

The lack of diversity in the annals of great achievement both admonishes and enlightens us about the nature of true genius. If creative potential is a new shoot poking out of the soil, successful growth depends on whether life sends in the lawnmowers or offers protective cover. As Anne Fausto-Sterling, a biologist and gender expert at Brown University, puts it, "what's really important is how people of high ability are nurtured, sustained and given the opportunity to fulfill their abilities." Genius is still the product of lucky coincidences, but society need not load the dice. M

(Further Reading)

- **Why Have There Been No Great Women Artists?** Linda Nochlin in *ARTnews*, pages 22–39 and 67–71; January 1971. A 2007 version is available at **ARTnews.com**
- **Remarkable Women: Perspectives on Female Talent Development.** Karen D. Arnold, Kathleen Diane Noble and Rena Faye Subotnik. Hampton Press, 1995.
- **Understanding Current Causes of Women's Underrepresentation in Science.** Stephen J. Ceci and Wendy M. Williams in *Proceedings of the National Academy of Sciences USA*, Vol. 108, No. 8, pages 3157–3162; February 7, 2011.



HOWARD BERMAN *Getty Images*

THE SOCIAL GENIUS OF ANIMALS

NEW RESEARCH REVEALS THAT ANIMALS INTERACT IN SURPRISINGLY SOPHISTICATED WAYS

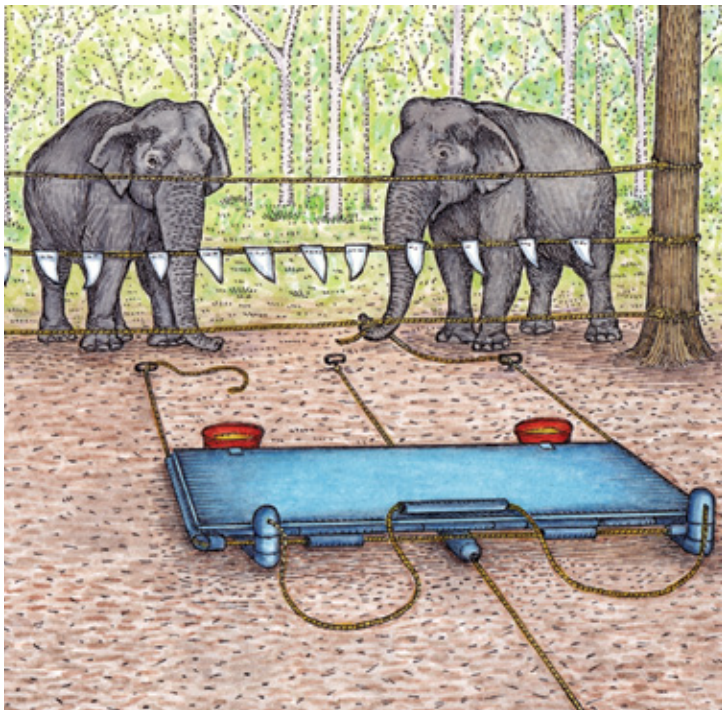
By Katherine Harmon

At the Thai Elephant Conservation Center, tucked away in the trees near Chiang Mai, a pair of Asian elephants gazes at two bowls of corn on the other side of a net. The corn is attached to a sliding platform, through which researchers have threaded a rope. The rope's ends lie on the elephants' side of the net. If only one elephant pulls an end, the rope slides out of the contraption. To bring the food within trunk's reach, the elephants have to do something only humans and other primates were thought to do: they must cooperate. Working in synchrony, each elephant grabs its end of the rope in its trunk and pulls, drawing the platform and the treats within reach.

Six pairs of these large animals succeeded in solving this double rope puzzle. A lone elephant would wait as long as 45 seconds for a partner to arrive, showing it knew it needed a buddy to get the job done. Psychologist Joshua M. Plotnik of the University of Cambridge and his colleagues, who documented these findings in 2011, also noticed that the elephant duos used different strategies for obtaining the food, suggesting that the animals had developed a deep understanding of social cooperation.

In the past century animals have repeatedly surpassed our expectations for their intellect. Koko the gorilla learned sign language; Alex the African grey parrot boasted a spoken vocabulary of more than 150 words, and even invertebrates such as the octopus have been seen using tools in the wild. Until the mid-20th century, we assumed only humans could use tools and learn meaningful pieces of a language. Sophisticated social skills such as cooperation were presumed to be way beyond animals' cognitive reach. Only re-

ILLUSTRATIONS BY PATRICIA J. WYNNE



Pairs of elephants can work together—with each animal pulling on its end of a rope—to slide a platform, and two bowls of corn, within reach of their trunks.

cently have researchers begun to realize the extent of animals' social intelligence, their ability to understand and learn from others.

The latest findings suggest that some animals are not only capable of creating social connections but that many use them for survival. As with people, some animals have social needs. They notice when another member of their species is distracted, and they are able to figure out an effective way to get its attention. Animals may teach one another important skills, such as how to use tools. Some critters can even deceive. Intuiting what others know enables them to trick one of their kind for personal gain. The animals described below have some of the most impressive social abilities in the animal kingdom. Studying how they interact is giving scientists new insight into what they know—and a glimpse at what might be the upper limits of animal intelligence.

FAST FACTS

Social Creatures

1» Only recently have researchers realized the extent of animals' social intelligence—their ability to understand and learn from others.

2» Animals may teach one another important skills, such as how to use tools.

3» Some critters can deceive. Intuiting what others know enables them to trick a species mate for personal gain.

Making Connections

In our own lives, social intelligence might seem to play second fiddle to, say, the ability to do calculus or write a book. Individuals held up as modern geniuses, however, such as Stephen Hawking or Steve Jobs, have not only exceptional analytic skills but also an extraordinary ability to relate their ideas to a broader audience. These social skills are fundamental to our complex society. Without the ability to form a cohesive group, communicate ideas or collectively solve problems, humans could not have built the great pyramids or the first supercomputers.

Social skills require, first, a basic affinity for others. "You can't evolve all of the computational systems for social intelligence until you have that tendency that you want to be close to others," says biologist Louis Lefebvre of McGill University. Not all animals have this. Octopuses, for example, seek one another out only to procreate.

In contrast, zebra finches form monogamous pairs and congregate in groups. In a 2009 study biologist James Goodson of Indiana University Bloomington and his colleagues drilled down to the chemical essence of this social instinct: mesotocin, the bird equivalent of the human hormone oxytocin, which is implicated in bonding. When the researchers blocked mesotocin in the brains of the birds, they shrugged off their fellow finches. Females spent less than one third as much time near their same-sex cage mates after the treatment than before it. Extra doses of mesotocin had the opposite effect: the birds became even more social than they typically are.

Goodson and his colleagues also examined the biology of this hormone in other species of finches with different degrees of social affinity. The team found fewer receptors for mesotocin in key spots of the brain in species that were more territorial (less social) than the zebra finch—and more receptors in species that traveled in flocks. Scientists have identified similar patterns of brain chemicals and social preferences in many mammals. In prairie voles, for example, how mates bond with one another and their children is also associated with different levels of oxytocin and vasopressin, another hormone linked to social behavior and bonding.

Know Yourself—And Others

Good social graces also require a sense of the self as distinct from others. This primitive level of

self-awareness allows animals to go beyond acting out a programmed set of behaviors for mating or defense.

Researchers test self-awareness by placing a visible mark on an animal and showing it a mirror. An animal passes the test if it appears to recognize that the dot is on its body as opposed to on the "other" animal in the mirror. It can signal this awareness, for example, by reaching toward the spot on its own body. Great apes, elephants, bottlenose dolphins, orcas and magpies have all passed, suggesting they have more social prowess than animals that simply flock or school together.

The second requirement for social networking is an understanding that others have different mental states—knowledge, desires, beliefs or intents—and that at any given moment another individual might be in a mental state that is different from the one you are in. This ability is called theory of mind. Psychologists often test its development in young children by having a child and an adult observe a researcher place an object in a specific location, say, a ball in a cup. The adult leaves the room, and the ball is moved. After the adult returns, a child with a mature theory of mind understands that the adult does not know the ball has moved, and he or she does not expect the adult to look for it in the new location. Similar theory-of-mind tests are difficult to conduct in animals because it is hard to communicate with them directly.

Nevertheless, we can glean hints from their physiology, such as the presence of so-called mirror neurons. These cells, which have been found in macaques and birds, swing into action when an animal sees another individual doing something. In humans, they are thought to exist in various brain regions, including the supplementary motor area, a small patch of tissue at the top of the head that helps to control movement. Because these cells' activity patterns mirror the behavior of others and to some extent reflect the movement's goal, they may enable animals to understand others' actions, possibly even their intentions. They might underlie the ability to learn motor actions by observation and also buttress a theory of mind.

Mirror neurons have not yet been discovered in dogs, but more than a decade ago psychologist Alexandra Horowitz of Barnard College collected behavioral data suggesting that dogs may have some version of a theory of mind. Over the course of 21 months Horowitz videotaped a random sampling of dogs at play in a San Diego dog park. When she analyzed the footage, she noticed some interesting behaviors that suggested dogs could be aware of another dog's perspective.

DOGS SEEM TO NOTICE WHETHER A DOG THEY WANT TO PLAY WITH IS READY TO RECEIVE THEIR PLAY SIGNAL. THEY SEEM TO REACT TO DISTINCT COGNITIVE STATES OF OTHER DOGS.

The dogs at the park varied how they signaled a desire to play depending on the other dog's position. If a prospective playmate was already facing it, the dog gave a visual signal—opening its mouth wide or bowing down into that familiar bottom-up play pose. But if the other dog was turned away and otherwise engaged, it might instead give its friend a little nip. "They seem to be noticing whether a dog they wanted to play with was ready to receive their play signal," Horowitz says. "They seem to be reacting to distinct cognitive states" of others. In a paper published in 2011 Horowitz now posits that dogs possess at least a rudimentary theory of mind.

Consistent with the mirror neuron findings, many monkeys and some birds demonstrate in their behavior some capacity for theory of mind. Monkeys, birds and dogs are exceptions, however. In most animal species, scientists have failed to see even a glimmer of evidence for this advanced social capacity.

Schools and Students

Among its many benefits, social intelligence confers the ability to distribute information. Scientists have long observed that herd animals can give warning signals if a predator is approaching; for example, a white-tailed deer may flash its conspicuous white tail, pointing it upward before bolting. Now, however, researchers are noticing that some animals that live in groups can teach one another rules of social engagement or how to create a tool.

(The Author)

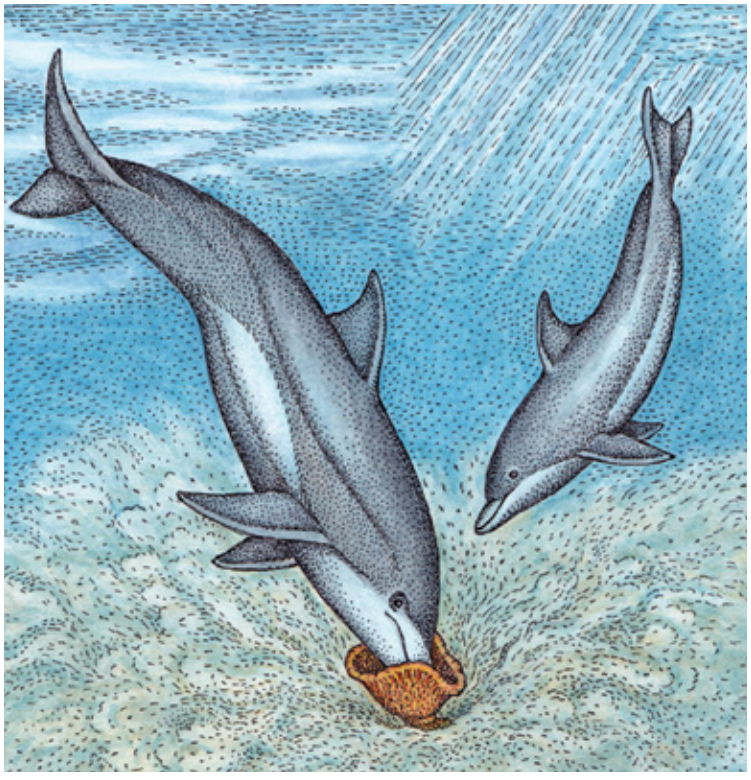
KATHERINE HARMON is an associate editor at *Scientific American*. Her book about octopuses, which examines their famed brilliance among other traits, will be published in 2013 by Current, a division of Penguin.

Zebrafish, for example, seem to transmit subtle social cues to other members of their school. These small creatures can make an easy meal for larger fish in the wild, so they tend to be cautious of new objects. If they are reared in captivity, however, they show little fear of a moving object, swimming within close proximity of it.

A team of researchers led by biologist Sarah Zala of the Konrad Lorenz Institute for Ethology in Vienna wanted to know if these fish would change their behavior if surrounded by others that acted differently. The group introduced some shy, wild zebrafish to more brazen domestic ones. The wild ones learned from their new acquaintances to be bolder when a moving object was introduced near the tank. Instead of swimming away from it, they joined their fearless new companions and ventured toward it. When the emboldened wild fish were separated from their new friends, they still bravely swam near novel things. The results, published in June of this year, indicate these fish had not just mindlessly followed the other fish but had learned a new behavior.

Dolphins can convey more intricate behaviors to others. One group of bottlenose dolphins in Australia uses a technique called sponging to find food. Biologist Janet Mann of Georgetown University and her colleagues saw the females sporting sea sponges on their snouts, a technique that seemed to allow the dolphins to push along the seafloor to look for fish and other food without hurting their noses. The scientists sampled DNA from these sponging mammals and compared it with DNA from area dolphins that did not use this tactic. They discovered that the sponging dolphins, but not the others, had a common maternal line. In a 2008 report of the findings, the researchers suggested that mothers in this particular group managed to teach this complex act to their daughters.

ROSIE DID NOT EAT AS MUCH, SLEEP AS SOUNDLY OR SHOW AS MUCH ENERGY AS USUAL FOR THE WEEKS AFTER HER MOTHER DIED, HINTING THAT THE CHIMPANZEE WAS IN MOURNING.



One study suggests that certain dolphin mothers teach their daughters to don a sea sponge on their snout to guard against injuries while they scour the seafloor for food.

Mother chimpanzees also use social learning to hand down wisdom to daughters. Young female chimps at the Gombe National Park in Tanzania are much handier at making tools to retrieve termites than are males. Adult females there use long twigs or stems to fish out termites, whereas males are more likely to kill larger game for their meals. In a study published in 2004 Elizabeth Lonsdorf, then a field director at the Lincoln Park Zoo in Chicago, and her colleagues found that the younger females spent more time with their mothers learning this skill than did the males, who were more likely to be playing—perfecting their social skills for later battles for dominance, mates and food.

Deception

Social learning can be a big advantage for a group or species, which can transmit the most successful strategies to others. Some animals, however, use their social awareness for personal gain by hiding information from potential competitors. A group led by psychologist Federica Amici of Liverpool John Moores University in England trained low-ranking capuchin monkeys, long-tailed macaques and spider monkeys to unlock a box to obtain a food reward. When alone, these monkeys unlocked the box and indulged. But when a dominant monkey was around, the trained animals—especial-

ly the macaques—chose to forgo the hidden treat, ignoring the box so as not to reveal how to open it.

Some species of birds engage in a similar type of deceit, bolstering the argument that these animals might also possess some theory of mind. Whether in a laboratory or the wild, Western scrub jays are more likely to move their food stashes when other birds are around. In fact, lab experiments have shown that scrub jays will either move or pretend to move a newly caught worm if they think another bird might have seen them bury it. This behavior suggests some awareness of what the other individual knows and how they can protect their own interests. "Nonprimate species are thinking about these things in some very clever ways," says psychologist Laurie Santos of Yale University.

At least one of the cooperating Asian elephants in Plotnik's experiments also learned how to game the social system. The elephant, named Neua Un, figured out that instead of pulling on her side of the rope, she could stand on her end so it would not slip. Then she let the other elephant do all of the hard work. She also moved her trunk every now and then, as if to convince her partner that she, too, was pulling.

Emotional Aptitude

Of course, social IQ involves more than knowing how to get another person's attention or teaching the young new information and skills. A deeper social intelligence, one that allows for empathy and grief, is arguably the intangible, almost indescribable fiber that weaves us together. It is tied to our emotional well-being, and as new studies about longevity are showing, these rich social connections are important to our physical health as well. Although we might not be able to ask animals directly how they think and feel about others, we can watch them for clues.

In a 2010 paper psychologist James Anderson of the University of Stirling in Scotland and his colleagues described video footage of an adult female chimp named Rosie and her companions, who lived at the nearby Blair Drummond Safari and Adventure Park, reacting to the death of her elderly mother. Rosie did not eat as much, sleep as soundly or show as much energy as usual for weeks after her mother died, suggesting that the animal may have been in mourning. Other apes, including gorillas in the Democratic Republic of Congo's Virunga National Park, displayed similar patterns after the death of a parent or a peer.

Grief is not the only complex emotion observed in animals. Psychologist Frans B. M. de Waal of Emory University and his colleagues have shown that chimps prefer actions that will help peers to those that just benefit themselves, indicating that they are inclined toward altruism—a highly social quality once thought to be the exclusive domain of humans.

When a scrub jay spots another bird eyeing its food stash, it will move or pretend to move its edibles, indicating that these birds are cognizant of what their fellow jays know.

Social intelligence, as distinctive and intricate as it is, may not be easily separable from other forms of smarts such as problem-solving ability or knowledge of the world. For example, a scrub jay that moves its food stores to keep them secret has performed both social and nonsocial mental gymnastics, including, Lefebvre says, "sophisticated memory mechanisms and time travel [that project] future needs for food." Yet although brilliance very likely spans multiple axes, social cunning is one important—and often underappreciated—element. Indeed, the smarter we humans become about assessing the social intelligence of animals, the more closely related to us they may seem. M

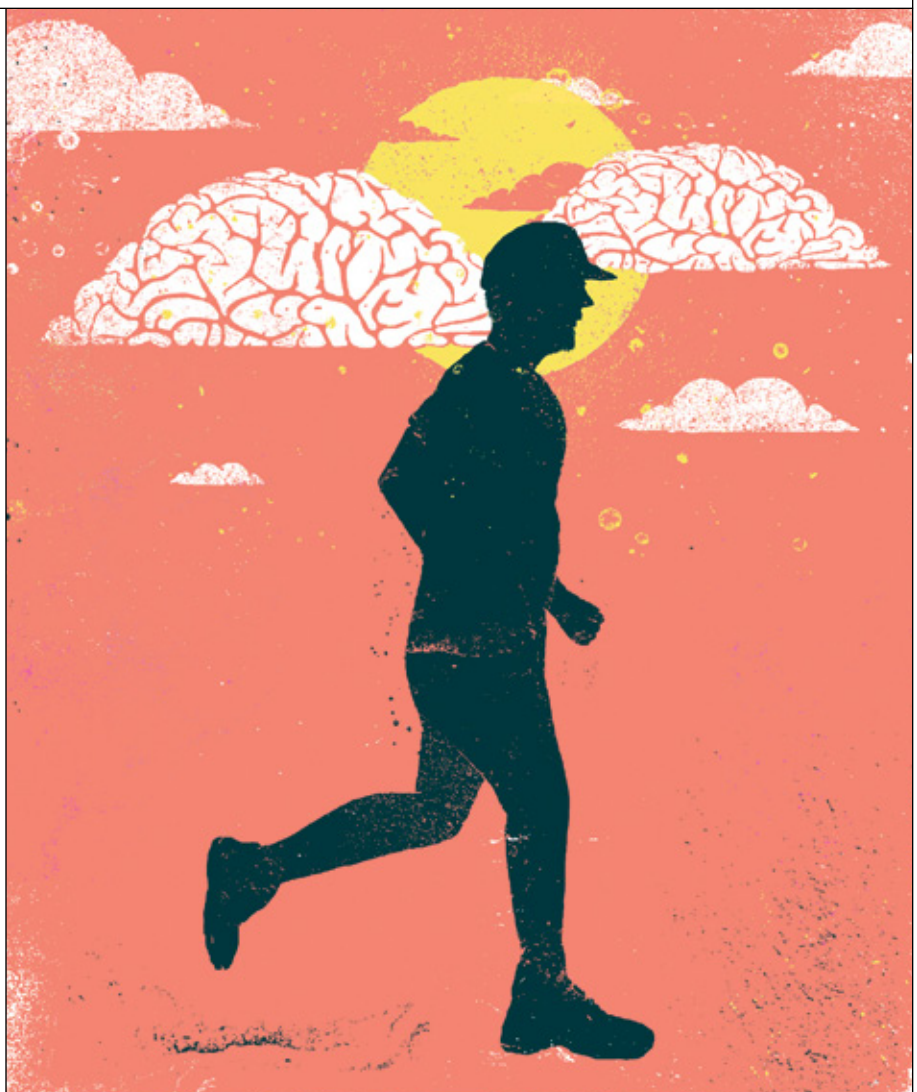
(Further Reading)

- ***Pan* Thanatology.** James R. Anderson, Alasdair Gillies and Louise C. Lock in *Current Biology,* Vol. 20, No. 8, pages R349–R351; April 27, 2010.
- **Elephants Know When They Need a Helping Trunk in a Cooperative Task.** Joshua M. Plotnik et al. in *Proceedings of the National Academy of Sciences USA,* Vol. 108, No. 12, pages 5116–5121; March 22, 2011.
- **Monkeys Represent Others' Knowledge but Not Their Beliefs.** Drew C. W. Marticorena et al. in *Developmental Science,* Vol. 14, No. 6, pages 1406–1416; November 2011.
- **Theory of Mind in Dogs?** Examining Method and Concept. Alexandra Horowitz in *Learning and Behavior,* Vol. 39, No. 4, pages 314–317; December 2011.

Memory in Old Age: Not a Lost Cause

Researchers have found ways to lessen age-related forgetfulness

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD



WHEN Mick Jagger first sang "What a drag it is getting old," he was 23 years old. Now at 69, he is still a veritable Jumpin' Jack Flash on stage. Jagger seems to have found the secret to staying physically fit in his advancing years, but getting old can be a drag on the psyche. Many older adults fear memory loss and worry they are headed down the road to dementia, such as Alzheimer's disease. Every time they forget their keys, leave a door unlocked or fail to remember a name, they are reminded of this nagging concern. In most cases, however, such annoying incidents are part of normal age-related memory loss, not a sign of impending dementia.

Although lots of older adults think such a decline is inevitable, there is good news for many of them. Researchers have developed an array of helpful methods and activities that exercise our minds and bodies that can help keep the older mind in relatively good condition. In this column, we examine the most promising ways to shore up memory in the normal aging brain.

Memory Divided

Memory is not a single entity. The term encompasses several types of remembering, not all of which decline with age. For instance, older people still retain their vocabulary, along with general knowledge about the world (semantic memory). They can also perform certain routine tasks, such as making an omelet or typing on a computer (procedural memory), about as well as they could when they were younger. People do become worse, however, at recalling recent events in their lives (episodic memory) or where they first learned a piece of information (source memory), managing the temporary storage of short-term information (working memory), and remembering to do things in the future (prospective memory).

Prospective memory, in particular, is an important target for memory strategies because forgetting upcoming tasks or appointments can cause considerable frustration or embarrassment. In 2002 psychologist Narinder Kapur of Southampton General Hospital in England and his colleagues reviewed studies on the effectiveness of various common techniques to bolster prospective memory. They found that external aids such as making lists or programming reminders into a cellphone could be helpful in reducing memory problems such as failing to pay bills or attend meetings.

Another successful strategy involves associating information to be recalled with an image, sentence, phrase or word. The more personally relevant the

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); SÉBASTIEN THIBAULT (*illustration*)

association is, the more likely it is to be remembered, an approach known as self-referential processing. For example, if we need to return a book to the library, we might imagine ourselves doing just that. Made-up acronyms also can be a big help. In this strategy, a person forms a new word from the initial letters of what he or she wants to remember. To remember to buy a birthday gift for his wife, for example, a man might construct the acronym "BIG" for "Buy Gift."

In 2008 psychologists Betty L. Glisky of the University of Arizona and Martha L. Glisky of the Evergreen Hospital Medical Center described other useful methods for improving memory that involve visual or semantic elaboration. In one of these, a person conjures up images related to something he or she wants to retain. To remember the name "Peggy," you might imagine a pirate with a wooden (peg) leg. Such a tactic could be helpful as long as you do not end up calling her "Pegleggy."

A semantic approach entails tacking on words to what you wish to recall. For example, in a music appreciation class that one of us (Arkowitz) took in elementary school, the teacher asked the class to associate the main musical theme of the classical piece, the *Peer Gynt Suite*, with the following rather silly sentence: "Morning is dawning and Peer Gynt is yawning and music is written by Grieg." The tie-in with the phrase was designed to help the kids remember the name of the composer.

Although Glisky and Glisky found support for these visual and semantic techniques, among others, they cautioned that memory improvements in the laboratory do not necessarily translate to enhancements in daily life, because these benefits depend on people practicing and using the tactics regularly. This gap in efficacy may be widest for strategies that take considerable time and effort to learn. Also, improvements in one area of memory often do not generalize to others.

Studies have found some support for the validity of the saying "Use it or lose it." The more we use our memory—for example, reading, doing crossword puzzles and playing board games—the better it may be, probably because such activities involve considerable use of memory. Of course, those with better memories may also be more likely to exercise their minds in the first place, accounting for some (but probably not all) of the association between good memory and amount of cognitive stimulation.

> To remember to buy a birthday gift for his wife, a man might construct the acronym **"BIG" for "Buy Gift."**

Fit Body, Fit Mind

If Jagger is as physically fit as he looks, his mind may be following suit. Some studies have found that higher levels of aerobic exercise are associated with better memory in older adults. Although many of these studies do not prove that aerobic exercise causes the memory improvements, some do suggest a causal connection. When psychologist Stanley Colcombe of the University of Illinois at Urbana-Champaign and his colleagues reviewed 18 controlled studies addressing this association in 2003, they found evidence that aerobic exercise did indeed lead to enhancements in memory.

Sustained aerobic activity may not be the only way to keep your mind agile and your memory sharp. In a study published in 2011 neurologist Ruth Ruscheweyh of the University of Münster in Germany and her colleagues assessed total physical activity in 62 older adults over six months. Their questionnaire included both formal exercise and daily routines such as walking to work, climbing stairs and gardening. The researchers linked reported increases in overall activity, no matter its type, with improvements in episodic memory at the end of six months. The greater the rise in activity levels, the bigger the memory boost. Thus, keeping physically active through regular workouts along with everyday errands and tasks may be the best recipe for reinvigorating your powers of recollection. [For more on the connection between physical and mental fitness in old age, see "Fit Body, Fit Mind?" by Christopher Hertzog, Arthur F. Kramer, Robert S. Wilson and Ulman Lindenberger; Scientific American Mind, July/August 2009.]

The research suggests that many memory techniques as well as a physically and mentally energetic lifestyle can improve memory in older adults. We still have a long way to go before we have highly effective methods, but given the vigor of this field, we can expect great progress in the near future. M

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

Send suggestions for column topics to editors@SciAmMind.com

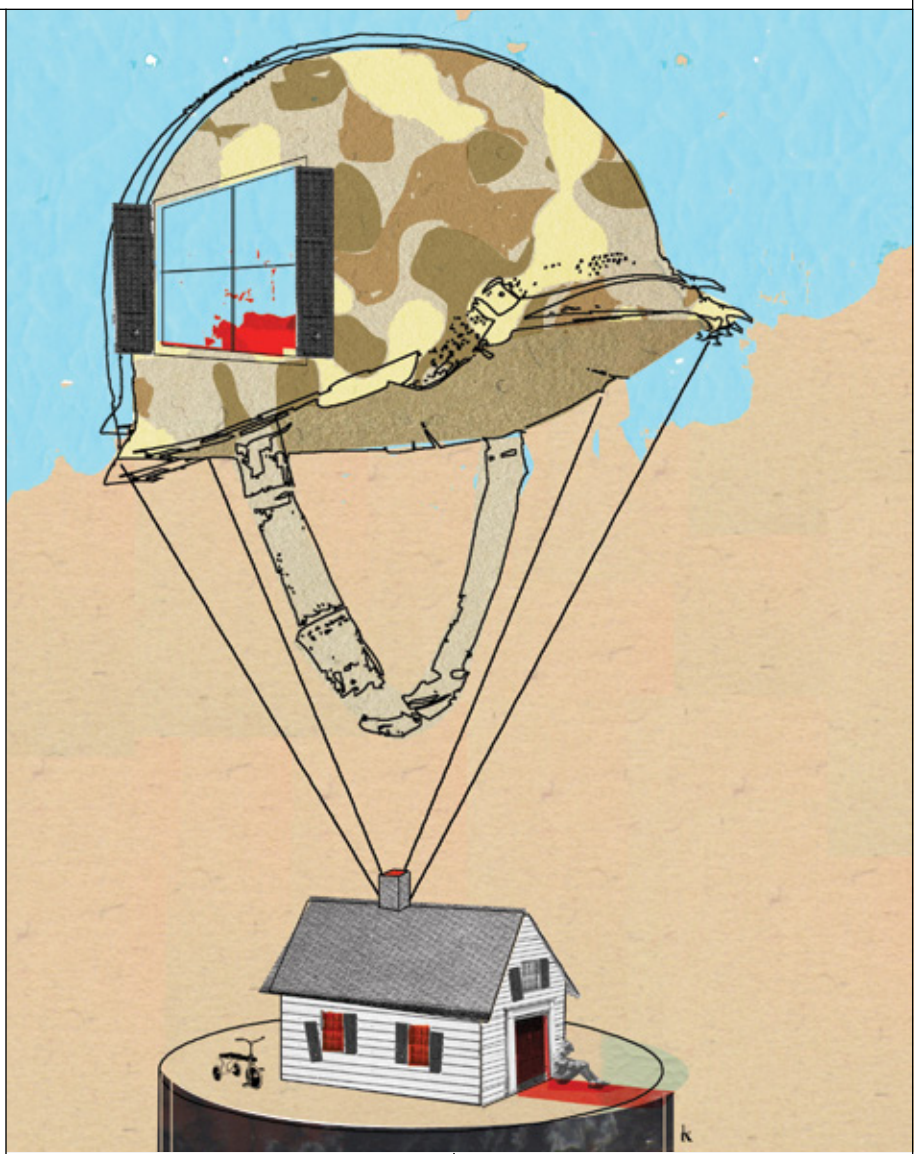
(Further Reading)

- **Memory Rehabilitation in Older Adults.** Elizabeth L. Glisky and Martha L. Glisky in *Cognitive Neurorehabilitation: Evidence and Applications.* Second edition. Edited by Donald Tuss, Gordon Winocur and Ian Robertson. Cambridge University Press, 2008.
- **Train Your Brain: How to Maximize Memory Ability in Older Adults.** Robert Winningham. Baywood Publishing Company, 2009.

Embattled Childhood: The Real Trauma in PTSD

Many soldiers' cases of post-traumatic stress disorder may in fact stem from troubled civilian life

BY WRAY HERBERT



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

IN 2009 a regiment of Danish soldiers, the Guard Hussars, was deployed for a six-month tour in Afghanistan's arid Helmand province, a Taliban stronghold. They were stationed along with British soldiers—270 in all—at a forward operating base called Armadillo. Although none of the Guard Hussars were killed during the tour of duty, they nonetheless experienced many horrors of battle. A commander was seriously injured by a roadside bomb, and a night patrol ended in a firefight that killed and dismembered several Taliban combatants.

The Guard Hussars' war experience is graphically depicted in the award-winning documentary film *Armadillo,* which debuted in 2010. It follows the soldiers from their emotional farewells in Denmark through their months in combat and, finally, back to joyous homecomings and family reunions. The film is a study of the inner lives of young men as they experience the excitement and camaraderie, the tedium and—mostly—the terror and trauma of war.

Coincidentally, these same soldiers were also the subject of another, very different kind of study. At the same time that the film was being shot, the men were part of a larger group of Danish soldiers who were being scientifically observed and tested for emerging symptoms of post-traumatic stress disorder, or PTSD. A large team of Danish and American psychological scientists, led by Dorthe Berntsen of Aarhus University, wanted to do what had never been done before in this field of research: instead of studying soldiers who were already suffering from PTSD, they decided to assess young recruits before they were sent off to war, when they were still relatively unscathed, then to record them during the war experience, and finally to follow them back home and through several months of readjustment. In this way, the scientists hoped to see why some soldiers develop PTSD and others do not and how the symptoms of the disorder progress.

As in the film, the scientists first encountered the soldiers at home in Denmark, where they were readying for deployment to Afghanistan. Psychologists met with their 746 subjects five or six weeks before they were scheduled to be deployed and administered a battery of psychological tests. These included a PTSD inventory, a test for depression,

and a questionnaire about traumatic life events, including childhood experiences of family violence, physical punishment and spousal abuse. Additional tests were administered during the soldiers' service, related to the direct experience of war: perceptions of war zone stress, actual life-threatening war experiences, battlefield wounds and the experience of killing an enemy combatant. The scientists continued to assess the soldiers when they were sent home, at a couple of weeks, at three months, and finally at least seven months after their return.

> The onset of PTSD was not predicted by traumatic war experiences but by **childhood experiences** of violence.

Cumulative Cause

The study revealed some surprising findings. The current and widely held view of PTSD is that its main cause is exposure to combat and other war atrocities—and that more trauma boosts the likelihood of experiencing the disorder. Moreover, experts believe that for those who develop PTSD, the typical pattern is for symptoms to emerge soon after a particularly traumatic experience and to persist over time. For unknown reasons, some soldiers appear resilient in the face of war trauma, never developing symptoms or else rapidly recovering.

These expectations did not match up with what the scientists found. Indeed, the consensus view of the disorder may be fundamentally wrong in at least two ways. As reported in a forthcoming issue of the journal *Psychological Science,* PTSD does not appear to be triggered by a traumatic battle experience, nor does there appear to be any typical trajectory for PTSD symptoms.

What Berntsen and her colleagues found instead is wide variation in both the causes and development of PTSD. The vast majority of Danish soldiers were resilient—recovering quickly from mild symptoms—or altogether impervious to psychological harm. The rest fell into distinct and unexpected patterns. The first group showed no symptoms before deployment or even during their tour of duty, but symptoms spiked after they returned home. For these soldiers, symptoms did not appear to follow any specific traumatic event, but by seven months after the men had returned, their stress symptoms had worsened to the point where they were diagnosed with PTSD. [For more on the potential cumulative causes of PTSD, see "Does Post-Traumatic Stress Disorder Require Trauma?" by Hal Arkowitz and Scott O. Lilienfeld; Scientific American Mind, May/June 2012.]

Problems at Home

Even more interesting were the remaining soldiers, about 13 percent of the subjects in the study, whose stress seemed to ease during deployment. That is, they had significant stress symptoms, such as major anxiety and frequent nightmares, after signing up for service but before deploying—symptoms that eased in the first months of war, only to spike again later, when they were safely at home. This pattern has never been observed before, and it seems puzzling: Why would shipping off to a dangerous and unfamiliar war zone ameliorate stress symptoms?

The scientists have a theory, and it has to do with the root causes of PTSD, previously undocumented. As compared with the resilient Danish soldiers, all those who developed PTSD were much more likely to have suffered emotional problems and traumatic events prior to deployment. In fact, the onset of PTSD was not predicted by traumatic war experiences but rather by childhood experiences of violence, especially punishment severe enough to cause bruises, cuts, burns and broken bones. PTSD sufferers were also more likely to have witnessed family violence and to have experienced physical attacks, stalking or death threats by a spouse. They also more often had past experiences that they could not, or would not, talk about.

These previously overlooked PTSD sufferers whose stress actually diminished in the war zone were also much less educated than the resilient soldiers. This disadvantage, combined with their pronounced mental health problems before going to war, suggests that they may in reality have been escaping a different war zone: the family. In other words, they showed improvement as soldiers only because they were in such poor psychological condition in civilian life. Army life—even combat—offered them more in the way of social support and life satisfaction than they had ever had at home. These soldiers were probably benefiting emotionally from being valued as individuals for the first time ever and from their first authentic camaraderie—mental health benefits that diminished after they once again returned to civilian life. M

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

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

(Further Reading)

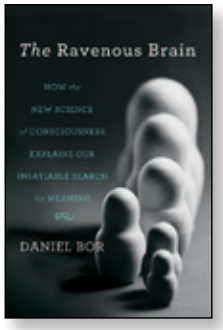
◆ **Peace and War: Trajectories of Posttraumatic Stress Disorder Symptoms before, during and after Military Deployment in Afghanistan.** Dorthe Berntsen, Kim B. Johannessen, Yvonne Thomsen, Mette Bertelsen, Rick Hoyle and David Rubin in *Psychological Science* (in press).

books

HUNGER WITHIN

The Ravenous Brain: How the New Science of Consciousness Explains Our Insatiable Search for Meaning

by Daniel Bor. Basic Books, 2012 ($27.99)



Memorize this string of letters: CSB ICR AAI CTA. Now try this one: ABC CIA IRS TSA. Both contain the same 12 letters, but most people find the second far easier to remember because the letters form known acronyms. This process—known as chunking—lies at the root of conscious thought and enables us to "build pyramids of knowledge" in our minds, says neuroscientist Bor.

In his new book, *The Ravenous Brain,* Bor takes on the biggest mystery of modern neuroscience: consciousness. Drawing on research published in the past 20 years, including some of his own, he presents a fresh view of consciousness in which chunking is its essential function. He contends that human consciousness evolved to help us learn by extracting relevant information from our surroundings and organizing it into meaningful patterns. According to several studies, we can be aware of no more than four items at any time; chunking is key because it allows us to compress data so we can maximize the information we gather. Multiple objects, sights, sounds, smells and feelings can be grouped together to give rise to a scene or memory. For instance, when chunked, the aroma of buttered popcorn, high-pitched laughter and wood-paneled floors may bring you back to sleepovers at a childhood friend's house.

As we incorporate more knowledge over time, we learn to execute new tasks and make associations with little or no conscious effort. Ultimately this ability helps us navigate the world better, maximize our chances of survival, and drive human innovation in art, literature and science.

Bor manages to pack a great deal of information—perhaps too much—into a small book. He presents a sweeping overview of how the brain evolved, from the primordial soup to present day, and argues that consciousness could actually be generated in nonbiological substrates such as computers.

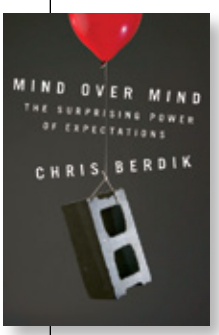
Although Bor touts his theory of consciousness as "controversial," much of what he discusses is common sense. The idea that the function of consciousness is to draw our attention to, and make sense of, salient stimuli seems intuitive. True, his theory cannot be put to the test, but it does add an intriguing perspective to our growing understanding of how the human mind works.

—Moheb Costandi

HEAD GAMES

Mind over Mind: The Surprising Power of Expectations

by Chris Berdik. Current/Penguin, 2012 ($26.95)



Wearing all black can make you a more aggressive competitor, and striking a pose can make you act authoritative. According to journalist Berdik, fulfilling expectations—such as perceiving a commanding, "I am the law" persona—is what our brain does best. In *Mind over Mind,* Berdik explains how anticipation can inform, even dictate, our future experiences.

Building on theories from medicine, neuroscience and psychology, Berdik reveals how our "forward-thinking brain" shapes our actions, personality and health. He describes hoodwinked wine tasters (who may reject and later reward an identical vintage based entirely on price tag) and subjects of virtual-reality studies (whose behavior after unplugging may echo their earlier ogre or beauty queen avatar).

Our expectations need not dictate our future experiences, however. For example, when primed to think of ourselves as part of a certain group, we may act according to a stereotype, but studies have found that just discussing this tendency can actually prevent us from falling victim to it. Berdik also uncovers the perils of expecting too much, such as when star athletes crumble at a crucial moment. In a study in which participants watched an uplifting movie, subjects who had earlier read about the benefits of joy came away less happy after watching the film than those who had not.

Berdik's ideas about our future-focused brain coalesce most convincingly on the topic of placebos. The mechanism behind the placebo effect remains unclear (Berdik discusses how it may involve the brain's anticipation circuitry), but just believing that a treatment will work can cause a patient's body to mimic the effects of medication or even surgery. Pharmaceutical companies have found that a placebo effect even increases with time as our confidence in the treatment grows. Although the use of placebos remains problematic for ethical reasons, he asserts that medical professionals should further explore its potential to hijack our brain's natural self-healing mechanisms.

Berdik successfully packs his book with rich examples detailing the science of expectation, but he does not offer his readers a unifying explanation about why and how our brain behaves this way. Instead he suggests that we can harness the brain's tendencies to our advantage and that mindfulness and self-reflection may push us to change our lives for the better.

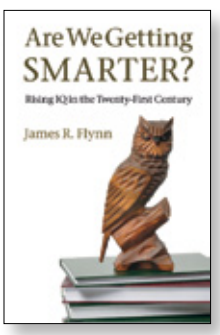
—Daisy Yuhas

BRIGHTEST BULB

Are We Getting Smarter? Rising IQ in the Twenty-First Century

by James R. Flynn. Cambridge University Press, 2012 ($22)

The average person today scores 30 points higher on IQ tests than his or her grandparents did. This observation is the starting point of the new book *Are We Getting Smarter?* by Flynn, an emeritus professor at the University of Otago in New Zealand.



Best known for documenting the eponymous Flynn effect—the tendency for standardized intelligence testing scores to increase over many decades across the world—Flynn is the right man for the job. Based on analyses of current IQ data, he speculates that we are not born with more mental potential than our ancestors; however, because our modern brain is expected to handle higher-level cognitive tasks from a very young age, our mental capabilities have changed. In particular, we have become more adept at learning theoretical concepts in science and technology.

The gains in IQ are not evenly distrib-

uted across populations. Flynn makes predictions about which countries' scores will rise the most and shares recent data showing that women now outshine men.

Yet there is a catch to this IQ trend, one that Flynn calls a "bright tax." The more intelligent the person, the steeper the decrease in IQ score as a person ages, sometimes by more than 20 points. The cause of this decline, however, remains a puzzle. Flynn reasons that our modern brains require more maintenance to stay sharp, so as we age and use our analytical skills less, our IQ may drop quite steeply.

In fact, interpreting IQ scores can mean life or death. Flynn argues that the U.S. Supreme Court needs to reconsider how it uses IQ scores when determining a person's fate. Convicts who have scores below a certain number cannot be put to death, but with this IQ inflation over time more convicts will face the death penalty unless IQ scores are standardized across different tests and time frames.

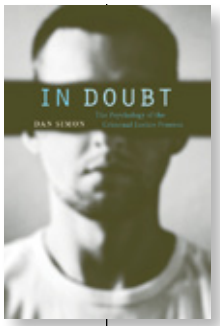
Though fascinating, *Are We Getting Smarter?* often reads like a transcript of a lecture. Flynn tends to explain his ideas with charts and statistics rather than examples. Despite this flaw, the book remains valuable for grasping our changing capacity for learning over time—and our room for growth.

—Samantha Murphy

IVO VAN IJZENDOORN *iStockphoto*

FAULTY MINDS

In Doubt: The Psychology of the Criminal Justice Process



by Dan Simon. Harvard University Press, 2012 ($45)

Ten years into serving a life sentence for the rape of Jennifer Thompson, Ronald Cotton stepped out of prison a free man. It took that long for DNA evidence to exonerate Cotton, refuting a weak case built mostly on eyewitness accounts.

According to Simon's new book *In Doubt,* despite advances in DNA forensic technologies, eyewitness testimony remains the most common way to nab criminals in the Anglo-American justice system. The problem, however, is that our mind often subconsciously twists the evidence to coincide with our biases, and we end up incarcerating innocent people. Simon, a professor of law and psychology at the University of Southern California, says that the false conviction rate, based on exoneration data from capital murder cases, is estimated to be near 5 percent, although that figure represents only a fraction of those wrongly imprisoned.

Eyewitness testimony boils down to how well the witness remembers the event. Studies have shown that a victim of a crime may remember a specific piece of information from the horrid event, such as the attacker's jacket or a strange smell, but fail to recall other details. Investigators are left with a weak profile of the perpetrator. In Cotton's case, the victim initially chose two men from the lineup, and only after repeated questioning from investigators could Thompson say Cotton was her assailant.

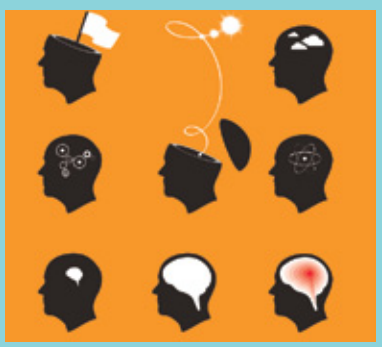
The human mind is also bad at encoding the details of a face, which means that an eyewitness may struggle to identify a suspect, even immediately after an event. Researchers have confirmed this observation, revealing that pedestrians do not realize they are talking to a different stranger mid-conversation after a diversion allows one stranger to swap in unnoticed for another.

As the investigation wears on, witnesses and victims relive the emotional events of the attack. This memory loop, in which recollections are retrieved and then reencoded, offers opportunities for bias to seep into the victim's personal account. Surprisingly, no matter how many opportunities there are for memories to morph throughout a trial, witnesses still consider their memories unshaken. In one study, 90 percent of subjects reported they were confident in their memory recall, when in fact only 60 percent of them were accurate. To remedy these problems, Simon calls for investigators to record all interviews to standardize the way they interact with victims, witnesses and suspects. He recommends that juries be instructed about bias in the courtroom. Such efforts are more likely to guide those involved to the underlying truth.

In *In Doubt,* Simon offers a compelling, though dense, overview of our flawed justice system and our imperfect brain. He backs up every claim with research, which makes the solutions he presents seem viable. Overall, Simon's book can help us avoid our mental pitfalls and see the truth more clearly.

—Brian Mossop

ROUNDUP



Better Brains

Three books suggest ways we—and our gadgets—can become smarter.

Despite housing some of the most elite educational institutions in the world, the U.S. is still falling far behind other nations in science, math and reading. In **The Learning Brain: Memory and Brain Development in Children** (Oxford University Press, 2012), neuroscientist Torkel Klingberg proposes that enhancing children's working memory, which regulates concentration and stores relevant information, may be key to improving academic abilities. Helping children to relieve stress and exercise more can, for instance, improve working memory.

We intuitively know that plagiarizing is wrong. In **Good Thinking: Seven Powerful Ideas That Influence the Way We Think** (Cambridge University Press, 2012), psychologist and philosopher Denise Cummins reveals how we know this. She discusses how economists, philosophers and other experts have helped to define what makes a decision rational or a judgment moral. She lays out the seven basic tenets that guide our critical thinking and explores tactics to correct faulty logic.

With smartphones getting smarter by the day, what can we expect from devices of the future? Ray Kurzweil, author of the best seller *The Singularity Is Near,* says the next step lies in unraveling what makes our brain tick. In **How to Create a Mind: The Secret of Human Thought Revealed** (Viking Adult, 2012), he argues that "reverse-engineering" the human brain will allow us to understand its intricacies and use that knowledge to advance technology.

—Victoria Stern

ask the Brains

Why is it impossible to stop thinking, to render the mind a complete blank?

—**John Hendrickson,** *via email*

Barry Gordon, *professor of neurology and cognitive science at the Johns Hopkins University School of Medicine, replies:*

FORGIVE YOUR MIND this minor annoyance because it has worked to save your life—or more accurately, the lives of your ancestors. Most likely you have not needed to worry whether the rustling in the underbrush is a rabbit or a leopard, or had to identify the best escape route on a walk by the lake, or to wonder whether the funny pattern in the grass is a snake or dead branch. Yet these were life-or-death decisions to our ancestors. Optimal moment-to-moment readiness requires a brain that is working constantly, an effort that takes a great deal of energy. (To put this in context, the modern human brain is only 2 percent of our body weight, but it uses 20 percent of our resting energy.) Such an energy-hungry brain, one that is constantly seeking clues, connections and mechanisms, is only possible with a mammalian metabolism tuned to a constant high rate.

Constant thinking is what propelled us from being a favorite food on the savanna—and a species that nearly went extinct—to becoming the most accomplished life-form on this planet. Even in the modern world, our mind always churns to find hazards and opportunities in the data we derive from our surroundings, somewhat like a search engine server. Our brain goes one step further, however, by also thinking proactively, a task that takes even more mental processing.

So even though most of us no longer worry about leopards in the grass, we do encounter new dangers and opportunities: employment, interest rates, "70 percent off" sales and swindlers offering $20 million for just a small investment on our part. Our primate heritage brought us another benefit: the ability to navigate a social system. As social animals, we must keep track of who's on top and who's not and who might help us and who might hurt us. To learn and understand this information, our mind is constantly calculating "what if?" scenarios. What do I have to do to advance in the workplace or social or financial hierarchy? What is the danger here? The opportunity?

For these reasons, we benefit from having a brain that works around the clock, even if it means dealing with intrusive thoughts from time to time.

Optimal moment-to-moment readiness requires a brain that is working constantly.

As I get older, why does my memory for names seem to deteriorate?

—**Tony Karger,** *U.K.*

Paul Reber, *a psychology professor at Northwestern University, answers:*

FORGETTING SOMEONE'S NAME is a common misstep. The structure of memory explains why you can often recognize the person's face and even come up with other details, such as where and how you met, but the name remains elusive.

We are often only able to piece together elements from a past event. When remembering what you had for dinner one week ago, for example, you can probably picture yourself sitting at a table with a plate of food in front of you. You can likely recall whether you were alone or with others or whether it was a casual night in or a fancy affair. Your brain, however, offers only crude brushstrokes. It does not create as complete a picture as a video recording would.

Vivid, accurate memory is actually a hard trick to pull off for the human brain. Our brain is not wired like a camera; it is composed of billions of neurons that perform many jobs besides remembering. During memory retrieval your brain cheats, filling in the gaps to concoct the most likely scenario. Let us say you remember sitting around the dining room table with friends. You conclude that you were eating roast chicken and mashed potatoes—your go-to menu when hosting guests. Your brain doesn't store a full picture of the evening, but recalling one aspect of the night can cue other elements, ultimately generating a full picture. This process of association is useful for filling in the blanks; however, it can also be unreliable, which explains why eyewitness accounts are surprisingly error-prone.

With names, the problem is that they are usually arbitrary. The fact that you met Tom on the sideline of a soccer field means he probably has a child the same age as yours, likely lives nearby and might have a job common to people in your area. All those elements create a reasonable picture of Tom, except none of these clues offers hints about his name. It could just as easily be Dick or Harry.

As we age and our memory starts to function less well, names are most likely among the first things to escape us. You can use tricks to help remember, such as rhyming the name with an object. What is easiest, however, is to keep in mind that everyone has difficulty with names, so you can be less embarrassed when one eludes you and less critical of others when yours escapes them. M

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

JAMIE CARROLL /iStockphoto

Head Games

Match wits with the Mensa puzzlers

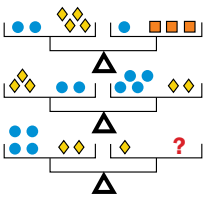
1 SNAKED SENTENCE

This box contains a colloquial expression that describes a person who is not quite up to par intellectually. Start at the correct letter and move one letter at a time in any direction to find the saying. (Hint: start with an "I.")

R E T R F I
C A H I D M
A N E D U B
E B D S A W

2 EQUIVALENCIES

The first two scales below balance as shown. How many squares should replace the question mark in the bottom scale to make it balance?



3 ALL DOWNHILL FROM HERE

Fill in the blanks surrounding SKI, according to the clues.

a. S K I _____: Captain
b. ___S K I ___: More annoying
c. S K__ I__: A measure of wool
d. S K I _____: Adept
e. __S K I ___: Priced at
f. S ___K I ___: Getting deeper
g. S _____K I ___: Type of violet
h. S K _____ I ___: Scrooge, for one

4 SMALL-CIRCULATION TITLES

For each clue, start with the name of a real magazine and change one letter to find the answer to the riddle.

a. A magazine for feeble athletes.
b. A publication for Don Juan types.
c. A monthly for log cabin dwellers.
d. A journal for antique fork collectors.

5 PRETENTIOUS POP

Decipher these famous song titles that have been put into overly fancy language.

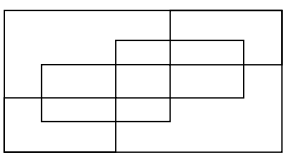
"The terra firma beneath my feet is in fact possessed by thou."

"It is truly my only and most earnest desire to receive a particular number of jaw fixtures as a present for the Yule season."

"Protective coverings for the lower extremities made of napped *Ovis aries* hide and emitting light of a wavelength between 450 and 495 nanometers."

6 CAREFUL COUNTING

How many rectangles of all sizes are formed by the lines in this diagram? (Wherever two lines meet in this diagram, they meet at right angles.)



7 MYSTERY LETTER

The following groups of letters are words that have had the same letter removed at least three times each. The remaining letters are scrambled. Replace the missing letter (which is the same for each word) and unscramble them.

SUIE TONEU EAIOR

8 DAILY BUDGET

Billy went shopping for some new clothes. At the first store, he spent one quarter of what he had plus $5. At the next stop, he spent half of what he had plus $5. At the last store, he spent one third of what he had plus $10, leaving him with $10 for lunch. How much did Billy start with?

9 MAGIC SQUARE

In the square below, each horizontal, each vertical and the two main diagonals should add up to 1,000. Fill in the blank boxes with the following assortment of numbers to make the addition correct:

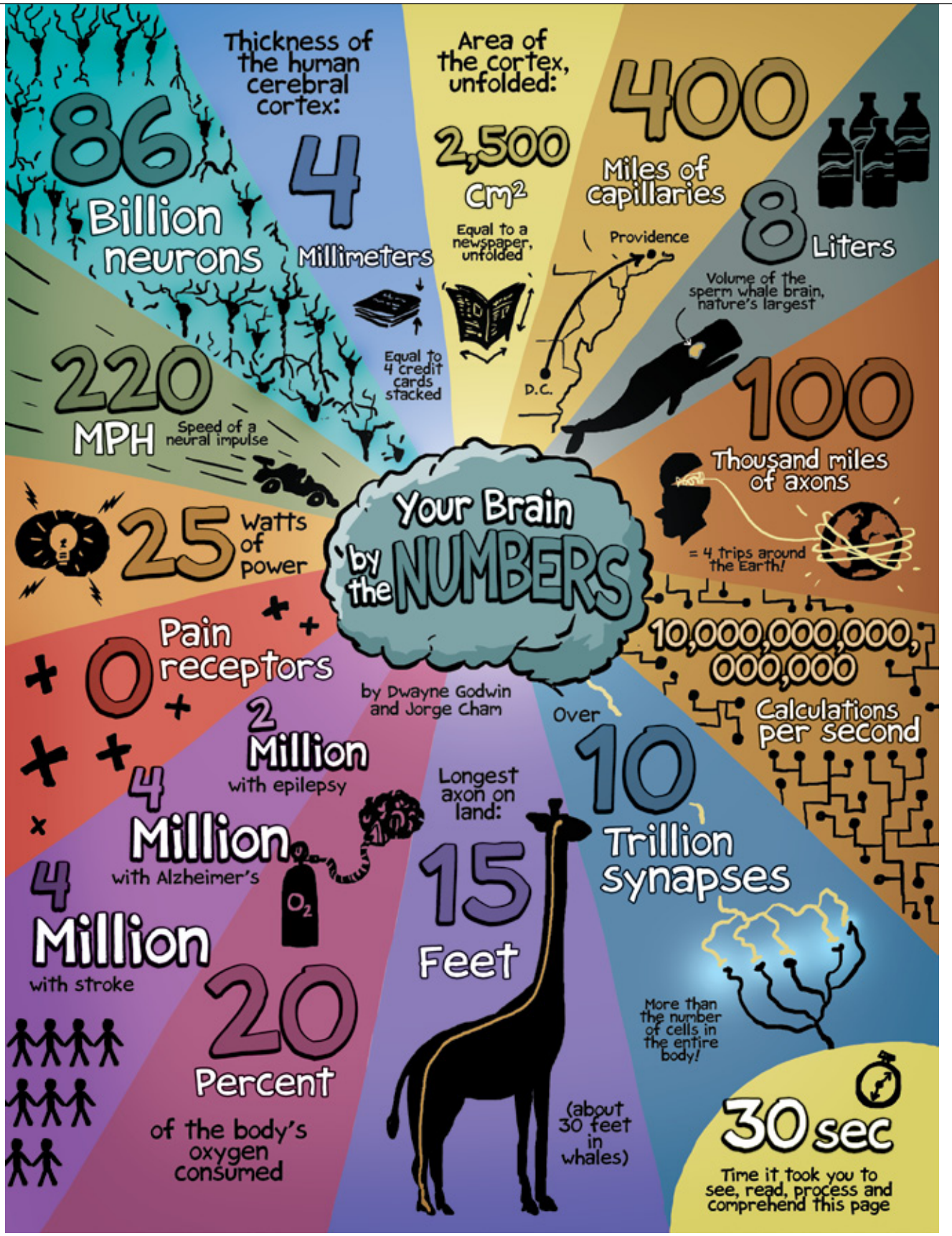
203	385	205	3	203
16				370
203				197
351				33
197	9	194	403	197

204 (twice), 206 (twice), 194 (twice), 196 (twice), 200 (once)

Answers

1. If dumb was dirt, he'd be an acre.
2. 2 squares (2 circles = 1 diamond; 3 circles = 1 square).
3. a. SKIPPER e. ASKING
b. PESKIER f. SINKING
c. SKEIN g. SHRINKING
d. SKILLFUL h. SKINFLINT
4. *a. Sports Weakly.* b. *Rogue.* c. *Wood Housekeeping.* d. *Tine.*
5. "This Land Is Your Land"; "All I Want for Christmas Are My Two Front Teeth"; "Blue Suede Shoes."
6. 24.
7. "M": Mummies, momentum, memoriam.
8. $100.
9.

203	385	205	3	203
16	204	206	204	370
203	206	200	194	197
351	196	194	196	33
197	9	194	403	197



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.*

Liquid Assets.

15 Rich Holiday Reds—worth $229.99—JUST $69.99

($19.99 shipping plus applicable tax)

Your 2010 Bordeaux has a gold medal and all the richness of this exceptional vintage. You'll also enjoy another sought-after 2010, a Côtes-du-Rhône with two gold medals, a top trophy and layers of black fruit flavor. And wait until you taste gold-medal Saracosa — a Super Tuscan in every sense.

A festive offer direct from the cellar.

Our winemakers are so determined to put their wines on your holiday table, they've given us a limited number of cases at very attractive prices. For this fantastic 15-bottle introduction to The WSJwine Discovery Club, we're able to offer you their exceptional reds (worth over $15 a bottle) for a remarkable $4.67 each.

We think you'll be impressed. And, we'll reserve for you an equally exciting dozen every three months — with no obligation. You can change wines, delay delivery or cancel at any time. At $149.99, you'll save at least 20%. Each case arrives with tasting notes and a money-back guarantee.

No risks, rich rewards — give it a try today.

WSJwine from THE WALL STREET JOURNAL.

Order now at **wsjwine.com/mind**

or call **1-877-975-9463** quote code **4168012**

Lines open Mon-Fri 8am-11pm, weekends 8am-8pm ET. WSJwine is operated independently of The Wall Street Journal's news department. Offer available to first-time WSJwine Discovery Club customers only and limited to one case per household. You must be at least 21 years old to order. All wine orders will be processed and fulfilled by a licensed retailer in the industry and applicable taxes are paid. Delivery is available to AZ, CA, CO, CT, FL, IA, ID, IL, IN, LA, MA, MI, MN, MO, NC, ND, NE, NH, NJ, NM, NV, NY, OH, OR, SC, TN, TX, VA, WA, WI, WV, WY and DC. Please go online for full terms and conditions. Void where prohibited by law.