TV SEXUALITY, VIOLENCE AND YOUR TEEN *page 56*

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

July/August 2011
www.ScientificAmerican.com/Mind

I'LL BUY THAT
Psychology of Design
page 42

BIRTH OF A BRAIN

Thinking for two makes Mom savvier, bolder—and brings out Dad's nurturing side *page 24*

PLUS:

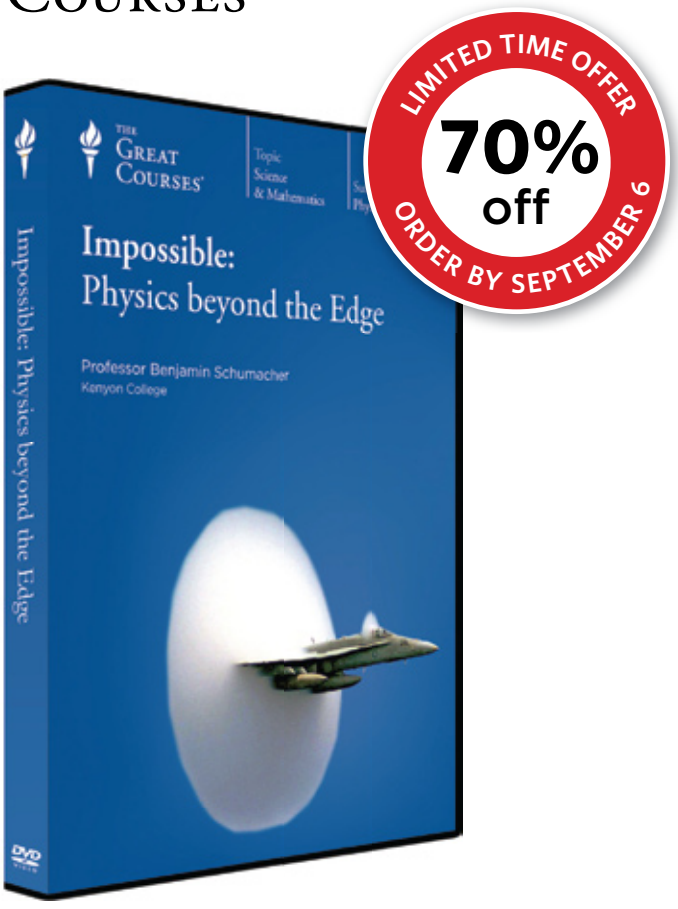
SMARTER FOR LIFE
Bilingual Benefits

TOLL FROM STRESS
Links to Parkinson's, Other Diseases

MIRROR ILLUSIONS
What They Reveal about Us

© 2011 Scientific American

THE GREAT COURSES®



Explore the Physics of the Impossible

Traveling through a wormhole. Chasing quantum particles. Reversing the flow of time. These and other astounding adventures are staples of science fiction. And yet they also provide an engaging way to grasp the fundamental laws of nature and discover profound truths about our universe.

Impossible: Physics beyond the Edge uses this ingenious approach in 24 lectures that teach you more about physics than you ever imagined. Your guide is Professor Benjamin Schumacher, a pioneer in quantum information who deals everyday with things once deemed impossible. His richly illustrated course probes the nature of the impossible from many perspectives and takes you to the frontier of current scientific knowledge—all in pursuit of an answer to the question, "Is it possible?"

Offer expires 09/06/11

1-800-832-2412

WWW.THEGREATCOURSES.COM/5MIND

U.S. Navy photo by Ensign John Gay

Impossible: Physics beyond the Edge

Taught by Professor Benjamin Schumacher
KENYON COLLEGE

LECTURE TITLES

1. From Principles to Paradoxes and Back Again
2. Almost Impossible
3. Perpetual Motion
4. On Sunshine and Invisible Particles
5. Reflections on the Motive Power of Fire
6. Maxwell's Demon
7. Absolute Zero
8. Predicting the Future
9. Visiting the Past
10. Thinking in Space-Time
11. Faster than Light
12. Black Holes and Curved Space-Time
13. A Spinning Universe, Wormholes, and Such
14. What Is Symmetry?
15. Mirror Worlds
16. Invasion of the Giant Insects
17. The Curious Quantum World
18. Impossible Exactness
19. Quantum Tunneling
20. Whatever Is Not Forbidden Is Compulsory
21. Entanglement and Quantum Cloning
22. Geometry and Conservation
23. Symmetry, Information, and Probability
24. The Future of the Impossible

Impossible: Physics beyond the Edge
Course no. 1299 | 24 lectures (30 minutes/lecture)

SAVE $185

DVD ~~$254.95~~ NOW $69.95
+$10 Shipping, Processing, and Lifetime Satisfaction Guarantee
Priority Code: 51665

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 300 courses is an intellectually engaging experience that will change how you think about the world. Since 1990, over 9 million courses have been sold.

SCIENTIFIC AMERICAN
MIND™
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

EDITOR IN CHIEF: Mariette DiChristina
MANAGING EDITOR: Sandra Upson
EDITOR: Ingrid Wickelgren

ART DIRECTOR: Patricia Nemoto
ASSISTANT PHOTO EDITOR: Ann Chin

COPY DIRECTOR: Maria-Christina Keller
SENIOR COPY EDITOR: Daniel C. Schlenoff
COPY EDITOR: Aaron Shattuck

EDITORIAL ADMINISTRATOR: Avonelle Wing
SENIOR SECRETARY: Maya Harty

CONTRIBUTING EDITORS: Gareth Cook, David Dobbs, Robert Epstein, Emily Laber-Warren, Karen Schrock, Victoria Stern

CONTRIBUTING RESEARCHERS: Smitha Alampur, Kenneth Silber, Kevin Singer

MANAGING PRODUCTION EDITOR: Richard Hunt
SENIOR PRODUCTION EDITOR: Michelle Wright

BOARD OF ADVISERS:

HAL ARKOWITZ: Associate Professor of Psychology, University of Arizona

STEPHEN J. CECI: Professor of Developmental Psychology, Cornell University

R. DOUGLAS FIELDS: Chief, Nervous System Development and Plasticity Section, National Institutes of Health, National Institute of Child Health and Human Development

S. ALEXANDER HASLAM: Professor of Social and Organizational Psychology, University of Exeter

CHRISTOF KOCH: Professor of Cognitive and Behavioral Biology, California Institute of Technology

SCOTT O. LILIENFELD: Professor of Psychology, Emory University

STEPHEN L. MACKNIK, Director, Laboratory of Behavioral Neuropsychology, Barrow Neurological Institute

SUSANA MARTINEZ-CONDE, Director, Laboratory of Visual Neuroscience, Barrow Neurological Institute

JOHN H. MORRISON: Chairman, Department of Neuroscience, and Director, Neurobiology of Aging Laboratories, Mount Sinai School of Medicine

VILAYANUR S. RAMACHANDRAN: Director, Center for the Brain and Cognition, University of California, San Diego, and Adjunct Professor, Salk Institute for Biological Studies

DIANE ROGERS-RAMACHANDRAN: Research Associate, Center for the Brain and Cognition, University of California, San Diego

STEPHEN D. REICHER: Professor of Psychology, University of St. Andrews

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

PRODUCTION MANAGER: Christina Hippeli
ADVERTISING PRODUCTION MANAGER: Carl Cherebin
PREPRESS AND QUALITY MANAGER: Silvia De Santis
CUSTOM PUBLISHING MANAGER: Madelyn Keyes-Milch
PRODUCTION COORDINATOR: Lisa Headley

COVER PHOTOILLUSTRATION BY AARON GOODMAN; SCIENTIFIC AMERICAN MIND IS A TRADEMARK OF SCIENTIFIC AMERICAN, INC., USED WITH PERMISSION

The Parent Brain

Juggling deadlines is hard enough. Raising a child, too? Might as well ask me to perform brain surgery—maybe on Mars, while tap dancing.

As *Scientific American Mind*'s managing editor, I cope with overlapping deadlines for story editing, art planning and production needs. I can only marvel at parents who hold down a job such as mine while also keeping a child safe, well nourished and happy through the vulnerable early years. Human history, of course, proves that we are capable. Whether foraging for berries thousands of years ago or combing over raw prose as I do now, countless generations of women have found a way to balance their daily duties and child care.

Just how women's brains achieve that equilibrium—and how men's do as well—is only now becoming clear. Babies bewitch their parents with new scents and sounds, speeding neural adaptation, as this issue's cover package explains. In "Maternal Mentality," psychologists Craig Howard Kinsley and Elizabeth Meyer explore a mother's morphing brain through the lens of Meyer's own pregnancy. Turn to page 24 for more.

Perhaps more surprising is the way a new father responds to a child. As Brian Mossop writes in "How Dads Develop," beginning on page 31, hormones encourage neurons to grow and fashion new brain circuits, tuning a father to the sensory stamp of his baby. With Mom and Dad rewired for child care, a newborn is in good hands.

One way a parent can make a baby's neurons bloom is to raise the child to be bilingual, which produces cognitive benefits such as a better handle on abstract thinking and enhanced short-term memory, reports Erica Westly in "The Bilingual Advantage," starting on page 38. And if overwhelmed parents sometimes lean on television when they need a break, they need not fret too much: some popular shows can actually help youngsters learn life lessons—at least when they watch with friends or family, as I learned in "Pop Star Psychology," by Sandra Czaja, on page 56. Raising a child, it turns out, is neither brain surgery nor rocket science but something that biology, shaped by evolution, equips us to do.

Sandra Upson
Managing Editor
editors@SciAmMind.com

© 2011 Scientific American

SCIENTIFIC AMERICAN MIND
Volume 22, Number 3, July/August 2011

FEATURES

SPECIAL REPORT BABY POWER
Inside the brains of parents

COVER STORY

© 2011 Scientific American

DEPARTMENTS

Scientific American Mind (ISSN 1555-2284), Volume 22, Number 3,July/August 2011, published bimonthly by Scientific American, a trading name of Nature America, Inc., 75 Varick Street, 9th Floor, New York, NY 10013-1917. Periodicals postage paid at New York, NY, and additional mailing offices. Canada Post International Publications Mail (Canadian Distribution) Sales Agreement No. 40012504. Canadian BN No. 127387652RT; QST No. Q1015332537. 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, 75 Varick Street, 9th Floor, New York, NY 10013-1917. To purchase additional quantities: U.S., $10.95 each; elsewhere, $13.95 each. Send payment to SA Mind, PO Box 4002812, Des Moines, IA 50340.
For subscription inquiries, call (888) 262-5144. To purchase back issues, call (800) 925-0788. Printed in U.S.A.

Copyright © 2011 by Scientific American, a division of Nature America, Inc. All rights reserved.

© 2011 Scientific American

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

VICE PRESIDENT AND PUBLISHER: Bruce Brandfon
DIRECTOR, GLOBAL MEDIA SOLUTIONS: Jeremy A. Abbate
MANAGER, INTEGRATED MEDIA SALES: Stan Schmidt
SALES DEVELOPMENT MANAGER: David Tirpack
PROMOTION MANAGER: Diane Schube
MARKETING RESEARCH DIRECTOR: Rick Simone
SALES REPRESENTATIVES: Jeffrey Crennan, Chantel Arroyo

MANAGING DIRECTOR, CONSUMER MARKETING: Christian Dorbandt
SENIOR MARKETING MANAGER/RETENTION: Catherine Bussey
SENIOR MARKETING MANAGER/ACQUISITION: Patricia Elliott

DIRECTOR, ANCILLARY PRODUCTS: Diane McGarvey

PRESIDENT: Steven Inchcoombe
EXECUTIVE VICE PRESIDENT: Michael Florek

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.

FOOD FOR THOUGHT

In the article on physical ailments influencing the brain, "Ruled by the Body," Erich Kasten listed a number of medical conditions that can masquerade as mental disorders. To that list, I would add celiac disease, in which an intolerance to the gluten found in wheat and other grains causes an autoimmune reaction in the gut that prevents the absorption of crucial vitamins and minerals. The resulting malnutrition can cause fatigue, muddled thinking, anxiety and depression, along with many digestive symptoms. Although this condition has become more widely known in the U.S. during the past couple of years, it is not commonly tested for—yet its effects can be mentally and physically debilitating.

Victoria Treder
Chiefland, Fla.

TRAUMA MIMICS ADHD ...

I read with interest Katherine Sharpe's brief article, "Hyper One Day, Calm the Next" [Head Lines], regarding children who "lose" the diagnosis of attention deficit hyperactivity disorder (ADHD). I am a therapist who works with children with a history of severe childhood trauma. I have learned in my seven years with this population that indeed what looks or tests like ADHD or ADD may not be at all.

Children with early histories of neglect, abuse, abandonment or poor attachment often display behaviors that seem convincingly ADHD-like: distractibility, poor focus, impulsivity, short attention span, and an inability to delay gratification, control aggression, and so on. Traumatized children may also have many ADHD-like symptoms because of delayed cognitive development, hypervigilance regarding possible threats to their safety, and emotional dysregulation (stress hormones remain on alert status). And finally, children with sensory-processing disorders will have behaviors that closely mimic ADHD in their overreaction to hearing noises or being bumped by other kids.

The mental health community is only just beginning to research the impact of these issues—for reference, look up the work of physicians Daniel Siegel, Bessel van der Kolk and Bruce Perry. If a child is being treated, symptoms and behaviors may diminish in time. So it could look like an ADHD child "loses" their diagnosis.

Grace Katzenstein
Clinical supervisor, Kinship Center
Tustin, Calif.

... AND ADHD MIMICS IMPOSTOR THINKING

In "Great Pretenders," author Birgit Spinath gives a clear overview of the imposter phenomenon. As a clinical psychologist, I think the research cited here may be complicated or confounded by the fact that some of the patients discussed may have had undiagnosed adult ADHD, which could lead to similar thoughts and behaviors.

Adults with ADHD are often intelligent, talented and creative. Because of experiential learning in school, they frequently and understandably infer that there is something wrong or lacking about them and their abilities. Sadly, this regularly results in a lack of confidence, shame and fear of shame—behaviors hard to distinguish from the imposter syndrome. Applying the practical, useful description of adult ADHD in *Married to Distraction,* by Edward M. Hallowell, Sue Hallowell and Melissa Orlov (Ballantine Books, 2011), could help therapists and

© 2011 Scientific American

patients make the distinction between the two profiles so that treatment can focus on the real problem.

Bob Dick
Raleigh, N.C.

Thank you so much for this helpful article on the impostor phenomenon. For years I have struggled with deep self-doubt in the face of what outwardly looks like success. I have earned an advanced degree, published two books and continued to feel like a failure. Frankly, I had blown off the impostor phenomenon as an explanation for my difficulties. It was not until I read one of the Clance impostor phenomenon questionnaire items in your sidebar that I began to recognize myself. After taking the entire evaluation (available on Clance's Web site: www.paulineroseclance.com), I now realize this is the source of my struggle. I am immensely grateful to you for bringing this phenomenon to light so that people like me can find ways to overcome it and enjoy their hard-earned successes with the joy, satisfaction and fulfillment that they deserve.

Tara Rodden Robinson
commenting at
www.ScientificAmerican.com/Mind

THERAPISTS IN AA

I have been an addictions counselor for several years. I have concerns that the organization of Alcoholics Anonymous (AA) is misrepresented in "Does Alcoholics Anonymous Work?" by Hal Arkowitz and Scott O. Lilienfeld. The authors suggest that AA does not support the use of mental health professionals. This is in direct contrast to the statement in "The Big Book," AA's basic text: "God has abundantly supplied this world with fine doctors, psychologists and practitioners of various kinds." In addition, on page 133 the book indicates that health care professionals, including psychiatrists, are often indispensable in the care of a newcomer. AA's philosophy is to include the assistance of health care professionals according to the literature that drives the AA program.

Mike Lovett
via e-mail

Could some people who feel like impostors actually suffer from ADHD?

ARKOWITZ AND LILIENFELD REPLY: *The writer is correct in stating that AA does in fact support the use of professional mental health services by members. Our statement that they do not was in error. As we pointed out, a combination of AA and psychotherapy is better than either one singly, and we are pleased that AA does encourage its members to seek this helpful combination.*

I found it remarkable that the article on Alcoholics Anonymous did not deal more with the religious aspects of the 12-step credo—for instance, comparing its effectiveness with that of the secular AA-style organizations you listed.

My son attended the Salvation Army version of AA here in Australia, a live-in course provided for a dozen or so men at a time. He is a very intelligent young man and found it difficult to reconcile his atheism with the requirement to submit to an authority that he did not recognize.

During his time in the course, he made a concerted effort to come to an understanding about his beliefs, as well as trying to work with the requirements of the 12-step credo. He suddenly started reading many books on philosophy, mathematics and science; I believe that he was trying to counter the submissive approach of the Salvation Army course.

The religious requirement of the course acted as an impediment to any real progress for my son. Rather than giving the authority for change to someone or something else (God), the organization should give it back to the person and reinforce it as a positive. I am sure there are AA-style credos with these features.

Barrie Collins
Blackheath, Australia

WE'RE HONORED

***Mind* magazine** is all I hoped it might be. At age 98 I have let most magazine subscriptions lapse but am keeping *Mind*, which fills in a good many gaps in my outdated medical education.

Louise Ireland-Frey
via e-mail

ERRATUM The article "What, Me Care?" by Jamil Zaki, that appeared in the January/February 2011 issue, incorrectly stated that Kenneth J. Rotenberg of Keele University in England has shown that lonely people are more likely to take advantage of others' trust to cheat them in laboratory games. In fact, Rotenberg found that lonely people display less trusting behavior toward others while engaged in laboratory games.

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

© 2011 Scientific American

MATT VINCENT

>> PERCEPTION

Towering Targets

Pay close attention, and the bull's-eye might appear larger than it really is

Successful batters often report that the baseball looked "huge" just before they hit a home run. This effect, dubbed action-specific perception, has been noted for years in all kinds of physical activities.

Yet questions remain about why the illusion happens. Some experts say it is a consequence of imagining the action before you make a move. Others suspect that knowing you nailed it might conjure a larger target in your memory. But a new study in *Acta Psychologica* suggests neither process alone is enough. Something else is needed: visual attention.

Researchers from Amsterdam and Hong Kong asked three groups of students to putt golf balls at a target about five feet away. After first checking out the target, one group had to putt the ball under a curtain obscuring the view. Another group putted between two corks en route to the target. The third group simply putted at the target without distraction. In all three cases, individuals got feedback about where their balls ended up. They then estimated the target's size by drawing it on a computer screen.

As expected, successful individuals in the straightforward putting experiment described a bigger target. Not so for the putters who could not see the target or give it their full attention.

The results challenge the theory that action-specific perception arises from imagining your motions before performing them, explains co-author John van der Kamp of the Free University Amsterdam, because such visualization was possible for all the participants. Similarly, simply knowing the putt hit the pin was not enough.

Visual attention to the target, therefore, is key. But scientists still do not know whether seeing a bigger target contributes to—or results from—success. One thing is clear: what we see is often not an accurate reflection of the world around us. Our senses are influenced by our attention and experiences. —*Andrea Anderson*

© 2011 Scientific American

>> SOCIAL COGNITION

Written All over His Face

People who feel what they see offer clues about how we read emotions and empathize

Understanding the thoughts and feelings of other individuals is essential for navigating the social world. But empathy is a complex process, based in part on fleeting facial expressions. Research suggests that we empathize by effectively putting ourselves in others' shoes: for example, when we observe someone feeling sad, we simulate their experience by activating the same regions of the brain that are involved when we feel sad ourselves.

A study in the *Journal of Neuroscience* in February bolsters this idea using rare individuals with "mirror-touch synesthesia." When watching another individual being touched, these people actually feel a touch on the same part of their own body. Neuroscientist Michael Banissy and his colleagues at University College London tested whether this heightened ability to simulate another person's experience would cause eight mirror-touch synesthetes to excel at recognizing the emotions embedded in facial expressions. They did, correctly identifying 92 percent of the facial expressions tested compared with the 81 percent identified by control subjects. Their success probably stemmed from their simulation expertise rather than a general agility with faces because further experiments showed they were no better than controls at recognizing a person's identity.

For the rest of us without mirror-touch synesthesia, the simulation process is the same but less pronounced, Banissy says. So the next time you find yourself sympathizing with someone who looks sad, thank the part of your brain that feels you frown.

—Michele Solis

DIMITRI VERVITSIOTIS Getty Images (crowd); VINCENT J. MUSI Aurora Photos (rat)

>> STROKE RESEARCH

The Healing Power of Touch

Tickling a rat's whiskers after it has a stroke prevents brain damage

Strokes cripple more people in the U.S. than any other disease. Modern drugs can unblock clogged arteries if patients get to care facilities in time. But the longer the trip to the hospital, the more nerve cells die from lack of blood. Better ways to avert brain damage could dramatically improve patients' quality of life. Recently a team of neuroscientists stumbled on a very low tech way to completely prevent stroke damage in rats: tickle their whiskers.

A team led by professor Ron Frostig of the University of California, Irvine, induced strokes in rats by blocking an artery to the brain. The researchers then stimulated their whiskers, intending to measure the rats' brain activity to learn how the stroke damage affected sensory functions. Instead they found that if they vibrated a single whisker within two hours of the stroke, neurons that ordinarily would have died continued to function normally, and the rats ended up with no paralysis or sensory deficits. The exact mechanism of the protective effect is not clear, but it seems to involve a rerouting of blood through undamaged veins in the brain.

Follow-up research published in the journal *Stroke* in February showed that the pattern of tickling does not matter (though more helps), and ongoing research in Frostig's lab has shown that the stimulation does not have to be tactile, either. Auditory beeps prevent damage equally well.

The implications for human stroke victims are exciting, but there is no guarantee that playing music or touching sensitive areas such as the hands or face will have the same effect in people. In particular, the rats' much smaller brain might have helped their recovery. Still, Frostig is cautiously optimistic: "You may be able to help people way before the ambulance arrives, way before they can get any other treatment." It wouldn't hurt to talk to them and give their hands a squeeze on the way to the hospital, he says.

—Mark Lescroart

>> CHILD DEVELOPMENT

Mental Math in Infants

Babies understand counting before they utter numbers

Most children start counting after the age of two, after observing much tallying done by parents, siblings and television characters. By watching others count, 18-month-old babies acquire a sense of numbers long before they can speak, according to a study by Michael Siegal of the University of Sheffield in England.

The babies heard a voice counting up to six as the video showed a hand either pointing to six fish in turn or moving between two of the fish. They spent more time looking at the sequence showing correct counting, indicating that they preferred it and, therefore, knew how to keep score. "Infants are much more aware of objects than we give them credit for," Siegal says.

—Janelle Weaver

CORBIS (infant)

© 2011 Scientific American

>> MENTAL GYMNASTICS

The Myth of Joyful Parenthood

The more kids cost, the more we idealize raising them

Sure, the soccer uniforms, piano lessons and college tuition add up—but there is nothing like being a parent. Or so we tell ourselves, according to a study in the February issue of *Psychological Science*. When parents are faced with the financial costs of a child, they justify their investment by playing up parenthood's emotional payoffs.

Psychologists at the University of Waterloo in Ontario gave parents in the study a government report estimating that bringing up a child to age 18 costs more than $190,000. Then half the parents read an additional report about the financial help grown children provide their parents. Those who read only about the high price tag were more likely to agree with statements idealizing the emotional benefits of parenthood, such as "There is nothing more rewarding in this life than raising a child."

Such rationalization is a common response to cognitive dissonance, the state of having two conflicting ideas in mind, according to psychological theory. In this scenario, the choice the parents made to have children conflicts with the fact that kids are such a financial burden, so the parents conclude that the emotional benefits must be so great they outweigh the material cost.

The authors of the study point out that this mind-set makes sense in light of history. Until recently, children were not so expensive—and often they were of great economic value, helping out on the farm or bringing home a paycheck. In those eras, childhood was less sentimentalized and the emotional bond between kids and parents was not as strong. As raising kids became more costly, we began to idealize parenting.

This rosy outlook may have real benefits, however, according to another result of the study. Moms and dads presented with only the costs of child-rearing said they enjoyed the time they spent with their offspring more than parents who also read about the benefits—and these idealizers planned to spend more hours with them in the future. "Parents rationalize the cost of children by convincing themselves it's such an enjoyable thing to do, which then convinces them to spend more time with their kids," says University of Waterloo psychologist Richard Eibach, co-author of the study. Having your own kids may be expensive, but every minute is worth it. —*Valerie Ross*

>> HINDSIGHT BIAS

The Power of Negative Thinking

We manipulate our memories to brace for future hardships

Can our expectations for the future change how we remember the past? According to a new study published in the *Journal of Experimental Psychology,* they can—we remember unpleasant experiences more negatively if we expect to endure them again.

Researchers at New York University and Carnegie Mellon University conducted seven experiments to determine how people's expectations shape their memories. In one test, they exposed 30 students to the noise of a vacuum cleaner for 40 seconds. Afterward, half were told they would have to hear the noise again, whereas the rest were told the study was over. Everyone was then asked to rate how irritated they were by the noise. Students who expected to hear it again consistently found it more irritating. Other tests involving stimuli that bored and annoyed subjects all yielded the same results.

Jeff Galak, a Carnegie Mellon behavioral scientist who worked on the study, suggests that we remember hardships as worse than they actually were so that when we face those experiences again, they will be less painful than we expect. Galak thinks that by understanding this "bracing" strategy individuals can learn to overcome it and stop fearing exaggerated pain. He acknowledges that doing so may backfire, however—it is possible, he says, that by bracing for the worst, we actually suffer less. —*Joe Kloc*

MICAH ALBERT *Redux Pictures (family)*; ROEL BURGLER *Redux Pictures (woman with eyes closed)*

© 2011 Scientific American

FRANK SIEMERS *Redux Pictures (woman sleeping)*; ASGER CARLSEN *Getty Images (man with bags)*

>> GENETICS

The Sleepy Gene

Scientists pinpoint a key to sleepiness in fruit flies

For many of us, waking up in the morning is the toughest part of the day. It turns out that some flies have the same problem, according to research published this past February in *Nature*. Neurobiologists at Northwestern University have found a gene in fruit flies with a strong influence on their sleep patterns. After they deleted the gene, flies slept in random intervals and remained less active overall. The gene probably controls the synthesis of a key protein in pacemaker neurons, which regulate the body's clock. If a similar version of the gene is found in humans, we may gain a new understanding of circadian rhythms—and of why some of us have such a hard time getting out of bed.

—Morgen E. Peck

>> BODY MAPS

The Third Hand Illusion

Could you use an extra hand? The brain's body plan might not be limited to two arms

The brain usually has a pretty good idea of what is part of the body and what is not—although the classic rubber hand illusion can convince people to adopt a fake hand as their own when one of their real hands is hidden from view. Researchers at the Karolinska Institute in Stockholm have added a strange new twist to this experiment, persuading volunteers to believe that they have three hands rather than two.

The psychologists accomplished this sensory legerdemain by placing a false rubber right hand next to the subject's real right hand and covering both with a cloth from the wrist up (to obscure which one was connected to the body). With the left hand also in view, an experimenter stroked each right hand in parallel with a small brush—a technique that tricks the brain into "feeling" the touch on the fake hand. The experimenter then swiftly picked up a kitchen knife and swiped it toward one of the right hands.

Participants reacted with a flash of fear regardless of whether the knife was plunging toward the real or rubber right hand, indicating that the brain had started to think of the false hand as part of the body, too.

The findings, which were published online February 23 in *PLoS ONE*, suggest that the nervous system—and a lifetime of experience—may not in fact hardwire our somatosensory cortex to expect and accommodate just two arms. The brain might be far more flexible in what it can perceive as part of the body. This discovery could one day help create operational prosthetics for paralyzed stroke patients or people who could just use an extra hand on the job.

The mind is not entirely dupable, though. Exchange the false right hand for a left hand—or a prosthetic foot—and the brain does not buy it. No amount of brushstroking or knife waving could trick subjects into sweating that a chest-level foot was about to lose a toe.

—Katherine Harmon

© 2011 Scientific American

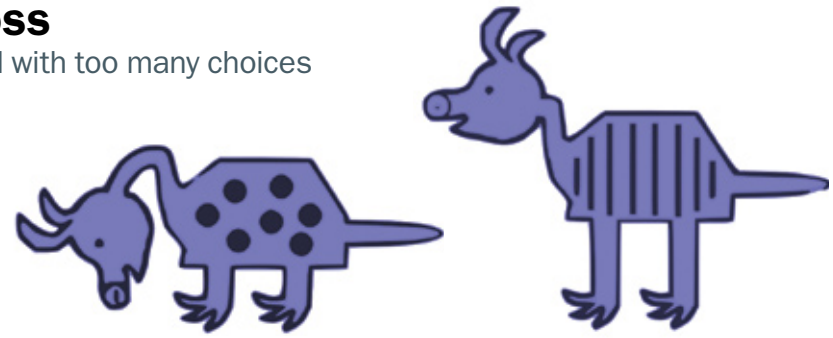
>> COMPROMISED COGNITION

Outsmarting Sleep Loss

A tired brain struggles when faced with too many choices

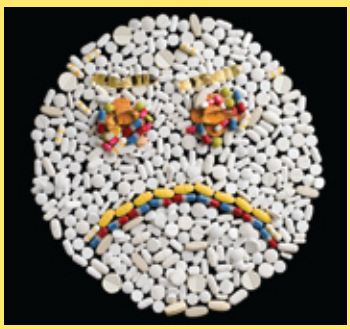
Sleep deprivation affects mental performance, as anyone who has tried to work after an all-nighter can attest. Yet some professionals, including surgeons, firefighters and military personnel, must routinely work on little or no sleep. A study by researchers at the University of Texas at Austin found the sleepy brain's Achilles' heel—open-ended problem solving—and thus may help improve worker training in these demanding fields.

The study, which was published in *Sleep* in March, consisted of two types of learning tests. In the first test, sleep-deprived students were asked to categorize drawings of fictional animals as either "A" or "not A," an open-ended task that depended on the students' ability to remember criteria for "A" and apply it consistently. In the second test, the students sorted two types of fictional animals, "A" and "B." The second test was more complex in that it required students to learn criteria for two animals instead of one, but surprisingly, sleep deprivation had the largest effect on the first test.



When sleepy subjects had to categorize imaginary animals such as these into two groups based on features such as body shape, they performed better than when they had only one group's characteristics to learn. The simpler task was open-ended and, therefore, required more attention from the subjects' compromised brain.

The researchers suspect that attention lapses—one of the main consequences of sleep loss—are to blame. Previous studies suggest that open-ended tasks, such as the first test, require more focused attention than those that offer two clear choices, as the second test did. "When we get sleep-deprived, some of our brain's learning systems operate better than others," notes Todd Maddox, the study's lead author. Fortunately, Maddox says, the more we know about the sleep-deprived brain, the better we can train people to work around its shortcomings. —*Erica Westly*



>> MEDICINE

Painful Pessimism

Positive and negative expectations influence how well drugs work

An upbeat attitude can do more than put a spring in your step; it can also improve medical outcomes. Although the power of positive thinking is clear, little is known about how negative mindsets affect the success of therapies.

Now cognitive neuroscientist Irene Tracey of the University of Oxford and her collaborators have found that both sunny and cynical beliefs determine how well drugs work. The team published its findings February 16 in *Science Translational Medicine*.

In the study, 22 healthy participants underwent a functional MRI scan while a device heated their right calf to an uncomfortable level for 10 minutes. As expected, regions in the brain associated with pain perception were active.

During the rest of the fMRI experiment, the volunteers continuously received a rapid-acting painkiller called remifentanil in their bloodstream as they sensed the same heat on their leg. But the researchers misled them about when they were getting the drug. At first, the volunteers did not know treatment had begun, so they did not think their pain would decrease. Ten minutes later they learned that the drug was being administered, so they believed their discomfort would begin to subside. After another 10 minutes, the researchers told them the infusion had stopped, so the volunteers assumed their leg would start to hurt more.

The subjects indicated that their pain was much less intense and unpleasant when they believed they were receiving the painkiller than when they thought they were not, even though the infusion had been constant. In fact, when they expected their pain to increase because they thought the infusion had been halted, that dismal outlook obliterated any benefit of the painkiller—their pain was the same as it was in the first, drug-free trial. In addition, the brain's pain network was more active when they were expecting the worst, mimicking the brain activity during the initial heat application.

The effects of pessimism are probably more pronounced in patients with chronic medical conditions because they are more likely to have experienced years of frustration with ineffective medications, Tracey says. "Doctors should not underestimate the significant influence that patients' negative expectations can have," she cautions—and patients should speak up if they suspect their low expectations are getting the better of them. —*Janelle Weaver*

FROM "THE EFFECTS OF SLEEP DEPRIVATION ON DISSOCIABLE PROTOTYPE LEARNING SYSTEMS," BY W. TODD MADDOX ET AL., IN *SLEEP*, VOL. 34, NO. 3; 2011 (*animal drawings*); GETTY IMAGES (*pills*)

© 2011 Scientific American

SELF-IMAGE

Who's the Boss?

A supervisor's feedback may affect identity more in certain cultures

Most people spend a major chunk of their waking hours at work, where often the boss looms large. Just how influential the boss is on an employee's self-image might depend on culture, a study in the February 16 *PLoS ONE* reports.

Teams of researchers in California and China showed a rapid series of photographs to student volunteers, sometimes asking them to press a button when they saw themselves and other times to press it when they saw their boss. People usually recognize themselves in images much more quickly than they recognize anyone else. But the scientists found that Chinese students pressed the button in response to their boss's face more quickly than to their own face. American students showed this "boss effect" only when they perceived their boss as socially influential and able to help or hinder their climb up the career ladder.

Lead author Sook-Lei Liew, a psychology doctoral student at the University of Southern California, believes that strong cultural differences between China and America may help explain these findings. In East Asian cultures, Liew says, individuals think of themselves as interdependent with their families and colleagues. They "are more prone to take their boss's feedback as a part of themselves," she says. Americans tend to view themselves as more autonomous, making a supervisor's feedback less important to self-image.

As more and more corporations cross international lines, understanding how diverse cultures affect cultural differences in the roles and influences of management will be crucial to success, Liew says.

—Carrie Arnold

GENETICS

Why Autism Strikes More Boys Than Girls

A gene that interacts with sex hormones may explain the gender gap

Too much testosterone might explain some autistic behaviors, such as fixating on certain objects.

TIMOTHY ARCHIBALD *Redux Pictures*

Autism, a developmental disorder that causes deficits in social behavior and communication, affects four times as many boys as girls. Because of this extreme gender imbalance, some scientists posit that sex hormones may contribute to the disease. Now researchers have identified for the first time a gene that may help explain the gender discrepancy and underlie some common autism symptoms.

In 2010 biologist Valerie Hu of the George Washington University Medical Center and her colleagues found that brains of people with autism have low levels of a protein produced by a gene called retinoic acid–related orphan receptor-alpha (RORA). Now they report in a study published in *PLoS ONE* on February 16 that this gene interacts with certain types of estrogen and testosterone found in the brain.

Hu and her team examined neural cells in their lab. They found that RORA controls the production of an enzyme called aromatase, which converts testosterone to estrogen. But in their tests, the presence of testosterone made RORA less active, leading to a decline in aromatase and a buildup of even more testosterone. Estrogen had the opposite effect. In a typical brain the balance of sex hormones regulates RORA activity and keeps hormone levels steady, but any imbalance can be exacerbated by this loop.

Next, the researchers confirmed that brain tissue from donors who had autism indeed contains low amounts of the RORA protein and aromatase. The authors suggest that a deficiency in these molecules causes the chemical loop to spiral out of control, resulting in an accumulation of testosterone that may cause autism. In most females, higher levels of estrogen could be protecting them from the disorder.

In addition to the gender bias, RORA might be implicated in the abnormal routines that characterize autism. For instance, mice that lack this gene fixate on objects and show limited exploratory behavior, similar to individuals with autism. "I don't think any single gene is going to explain all of the pathology associated with autism, but RORA does explain quite a few of them," Hu says. *—Janelle Weaver*

© 2011 Scientific American

CATHERINE LEDNER *Getty Images*

>> REASONING

Can I Help You?

Solving a problem is easier when it belongs to someone else

Need to solve a tough problem? A study published online February 11 in *Personality and Social Psychology Bulletin* suggests you are more likely to succeed if you solve it on another person's behalf. Psychologists asked 137 students to picture either themselves or a stranger stuck in a tower and to think of a way to escape using only a rope that did not reach the ground. Of the students who imagined a stranger in the tower, 66 percent found the solution—divide the rope lengthwise and tie the pieces together—compared with 48 percent of those who pictured themselves in the tower. Co-author Evan Polman of New York University says one implication is that if we imagine that our problems belong to someone else, we might find better solutions. *—Nathan Collins*

>> MEMORY

Lingering Lies

The brain holds on to false facts, even after they have been retracted

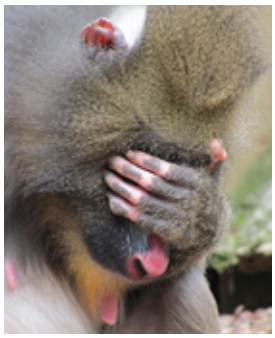
After people realize the facts have been fudged, they do their best to set the record straight: judges tell juries to forget misleading testimony; newspapers publish errata. But even explicit warnings to ignore misinformation cannot erase the damage done, according to a new study from the University of Western Australia.

Psychologists asked college students to read an account of an accident involving a busload of elderly passengers. The students were then told that, actually, those on the bus were not elderly. For some students, the information ended there. Others were told the bus had in fact been transporting a college hockey team. And still others were warned about what psychologists call the continued influence of misinformation—that people tend to have a hard time ignoring what they first heard, even if they know it is wrong—and that they should be extra vigilant about getting the story straight.

Students who had been warned about misinformation or given the alternative story were less likely than control subjects to make inferences using the old information later—but they still erred sometimes, agreeing with statements such as "the passengers found it difficult to exit the bus because they were frail."

This result shows that "even if you understand, remember and believe the retractions, this misinformation will still affect your inferences," says Western Australia psychologist Ullrich Ecker, an author of the study. Our memory is constantly connecting new facts to old and tying different aspects of a situation together, so that we may still unconsciously draw on facts we know to be wrong to make decisions later. "Memory has evolved to be both stable and flexible," Ecker says, "but that also has a downside." [For more on how memory relies on connections and makes inferences, see "Making Connections," by Anthony J. Greene; SCIENTIFIC AMERICAN MIND, July/August 2010.] *—Valerie Ross*

© 2011 Scientific American



Milly uses the eye-covering gesture she introduced.

>> ANIMAL BEHAVIOR

A Signal for Solitude

Monkeys may be able to devise gestures to communicate specific ideas

The Colchester Zoo in England is home to a community of mandrills, the largest of the monkeys. One of these mandrills, a female named Milly, began covering her eyes with her hand when she was three. A dozen years later Milly and her zoo mates continue to perform this gesture, which appears to mean "do not disturb." The signal is the first gesture with cultural roots reported in monkeys.

Culture accounts for behavioral differences that are geographic, rather than genetic or environmental. Gestures—nonvocal, communicative actions—are often cultural in humans and sometimes in apes, notes Mark E. Laidre, an evolutionary biologist now at the University of California, Berkeley. Laidre observed the Colchester mandrills for a total of 100 hours during the summers of 2007 and 2008. As reported in *PLoS ONE* in February, he found that mandrills performing the eye-covering gesture were approached and touched by other mandrills significantly less than when they were not using the gesture. "Animals who didn't want to be bothered used it," Laidre says.

Laidre and other researchers studying mandrills have not seen the eye-covering gesture in other populations, indicating it is a local phenomenon. Laidre also ruled out alternative explanations for the gesture's appearance. Milly does not have any medical issues with her eyes that might have prompted her to cover them, nor is the gesture more common on sunny days. It is also unlikely that human activity influenced the mandrills because monkeys—in contrast to apes, dolphins and dogs—do not mimic human behavior, Laidre says. All this evidence suggests that the eye-covering gesture arose naturally and that it conveys information within the mandrill community.

Having brought attention to the Colchester mandrills' gestural abilities, Laidre expects researchers will now find other monkeys using cultural gestures. If gesturing is performed more broadly among primates than previously thought, Laidre says, "the capacity to communicate with the hands in a meaningful way may have existed a long time before humans came on the scene." —*Aimee Cunningham*

>> LONG-TERM HEALTH

Where There's a Will ...

Kids' self-control is crucial for their future success

Self-control—the ability to regulate our attention, emotions and behaviors—emerges in childhood and grows throughout life, but the skill varies widely among individuals. Past studies have reported that self-control is partially inherited and partially learned and that those with less self-control are more likely to be unemployed, engage in unhealthy behaviors such as overeating, and live a shorter life. A recent study in the *Proceedings of the National Academy of Sciences USA* tying childhood self-control to health and well-being in adulthood suggests that everyone, not just those most lacking the skill, would benefit from a self-control boost.

Psychologist Terrie E. Moffitt of Duke University and her team focused on the self-control of a group of 1,037 children born in 1972 and 1973 in Dunedin, New Zealand. The investigators observed the children and took reports from parents and teachers every two years from the ages of three to 11. They evaluated the kids' attention, persistence and impulsiveness in a variety of settings to determine each child's level of self-control. Finally, when these New Zealanders reached the age of 32, the researchers assessed their health, financial stability and court records.

The study found that children with lower self-control were more likely as adults to have poor health, be single parents, depend on drugs or alcohol, have difficulties with money and possess a criminal record.

In addition to surveying and ruling out intelligence and socioeconomic status as possible explanations, the team explored whether differences in upbringing could play a role. To test this idea, the Duke researchers turned to 509 pairs of British twins born in 1994 and 1995. The team appraised the twins' self-control at age five. The sibling who had less self-control was more likely to begin smoking, behave badly and struggle in school at age 12.

Moffitt notes that within the Dunedin group, the more self-control a child had, the better off he or she was as an adult. "Even children who are above average on self-control could have improved life outcomes if they increase their self-control skills," Moffitt says. Programs that teach self-control—in school settings, for example—are effective. Thus, the Duke team posits, intervening during childhood could give all kids a better future. [For a related story on the link between intelligence and health risks, see "Outsmarting Mortality," on page 48.] —*Aimee Cunningham*

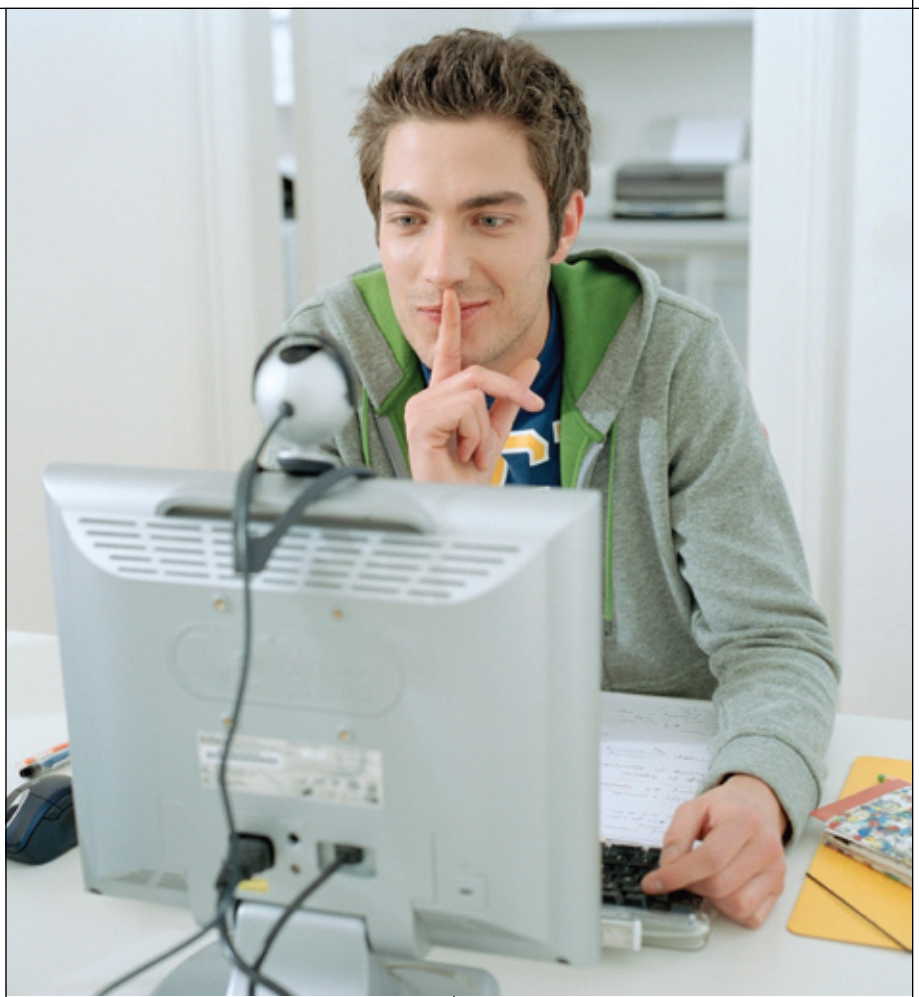
COURTESY OF MARK E. LAIDRE *University of California, Berkeley (mandrill)*; NICOLE HILL *Getty Images (children)*

© 2011 Scientific American

The Sunny Side of Smut

For most people, pornography use has no negative effects—and it may even deter sexual violence

BY MELINDA WENNER MOYER



IT USED TO BE TOUGH to get porn. Renting an X-rated movie required sneaking into a roped-off room in the back of a video store, and eyeing a centerfold meant facing down a store clerk to buy a pornographic magazine. Now pornography is just one Google search away, and much of it is free. Age restrictions have become meaningless, too, with the advent of social media—one teenager in five has sent or posted naked pictures of themselves online, according to the National Campaign to Prevent Teen and Unplanned Pregnancy.

With access to pornography easier than ever before, politicians and scientists alike have renewed their interest in deciphering its psychological effects. Certainly pornography addiction or overconsumption seems to cause relationship problems [see "Sex in Bits and Bytes," by Hal Arkowitz and Scott O. Lilienfeld; Scientific American Mind, July/August 2010]. But what about the more casual exposure typical of most porn users? Contrary to what many people believe, recent research shows that moderate pornography consumption does not make users more aggressive, promote sexism or harm relationships. If anything, some researchers suggest, exposure to pornography might make some people *less* likely to commit sexual crimes.

Does Porn Harm Women?

The most common concern about pornography is that it indirectly hurts women by encouraging sexism, raising sexual expectations and thereby harming relationships. Some people worry that it might even incite violence against women. The data, however, do not support these claims. "There's absolutely no evidence that pornography does anything negative," says Milton Diamond, director of the Pacific Center for Sex and Society at the University of Hawaii at Manoa. "It's a moral issue, not a factual issue."

In 2007 researchers at the University of Zagreb in Croatia surveyed 650 young men about their pornography use and sex lives. As they reported in the *Archives of Sexual Behavior*, the scientists found that users of mainstream, nonviolent pornography were neither more nor less sexually satisfied than nonusers. Both groups felt the same degree of intimacy in their current or recent relationships and shared the same range of sexual experiences. But when it came to violent or fetishist porn, the groups diverged. Consumers of these types of pornography appeared to masturbate more frequently, have more sexual partners over the course of their life, and experience slightly less relationship intimacy than their nonviolent porn–viewing counterparts.

Regular pornography use does not seem to encourage sexism, either. In 2007 Alan McKee, a cultural studies expert at the Queensland University of Technology in Australia, designed a questionnaire to assess sexist tendencies. He enclosed his survey in shipments of pornographic material distributed by a mail-order company and also posted it online. Responses from 1,023 pornography users indicated that the amount of pornography the sub-

CORBIS

© 2011 Scientific American

Sex offenders say that pornography helps them keep their **abnormal sexuality** within the confines of their imagination.

jects consumed did not predict whether they would hold negative attitudes toward women. The survey respondents who were most sexist were generally older men who voted for a right-wing political party, lived in a rural area and had a lower level of formal education.

But the questionnaire may have missed a key nuance. In a study published in 2004 in the *Journal of Psychology & Human Sexuality,* researchers at Texas Tech University administered a different survey to male and female college students and found that although consumers of pornography did not display more negative attitudes toward women, they were more likely than other respondents to believe that women should be protected from harm—what the investigators call "benevolent sexism."

Self-Medicating with Fantasy

Perhaps the most serious accusation against pornography is that it incites sexual aggression. But not only do rape statistics suggest otherwise, some experts believe the consumption of pornography may actually reduce the desire to rape by offering a safe, private outlet for deviant sexual desires.

"Rates of rapes and sexual assault in the U.S. are at their lowest levels since the 1960s," says Christopher J. Ferguson, a professor of psychology and criminal justice at Texas A&M International University. The same goes for other countries: as access to pornography grew in once restrictive Japan, China and Denmark in the past 40 years, rape statistics plummeted. Within the U.S., the states with the least Internet access between 1980 and 2000—and therefore the least access to Internet pornography—experienced a 53 percent increase in rape incidence, whereas the states with the most access experienced a 27 percent drop in the number of reported rapes, according to a paper published in 2006 by Anthony D'Amato, a law professor at Northwestern University.

People who feel pornography is a problem in their lives are often those who try to suppress their sexual thoughts and desires.

It is important to note that these associations are just that—associations. They do not prove that pornography is the cause of the observed crime reductions. Nevertheless, the trends "just don't fit with the theory that rape and sexual assault are in part influenced by pornography," Ferguson explains. "At this point I think we can say the evidence just isn't there, and it is time to retire this belief."

What if it turns out that pornography use actually reduces the desire to rape? It is a controversial idea, but some studies support it. Work in the 1960s and 1970s reported that sexual criminals tend to be exposed to pornographic materials at a later age than noncriminals. In 1992 Richard Green, a psychiatrist at Imperial College London, disclosed in his book *Sexual Science and the Law* that patients requesting treatment in clinics for sex offenders commonly say that pornography helps them keep their abnormal sexuality within the confines of their imagination. "Pornography seems to be protective," Diamond says, perhaps because exposure correlates with lower levels of sexual repression, a potential rape risk factor.

A Personal Concern

Repression seems to figure prominently into the puzzle of pornography. In 2009 Michael P. Twohig, a psychologist at Utah State University, asked 299 undergraduate students whether they considered their pornography consumption problematic; for example, causing intrusive sexual thoughts or difficulty finding like-minded sex partners. Then he assessed the students with an eye to understanding the root causes of their issues.

It turns out that among porn viewers, the amount of porn each subject consumed had nothing to do with his or her mental state. What mattered most, Twohig found, was whether the subjects tried to control their sexual thoughts and desires. The more they tried to clamp down on their urge for sex or porn, the more likely they were to consider their own pornography use a problem. The findings suggest that suppressing the desire to view pornography, for example, for moral or religious reasons, might actually strengthen the urge for it and exacerbate sexual problems. It's all about "personal views and personal values," Twohig says. In other words, the effects of pornography—positive or negative—have little to do with the medium itself and everything to do with the person viewing it. M

MELINDA WENNER MOYER is a freelance science writer and frequent contributor to *Scientific American Mind.*

(Further Reading)

- **Pornography, Public Acceptance and Sex Related Crime: A Review.** Milton Diamond in *International Journal of Law and Psychiatry,* Vol. 32, No. 5, pages 304–314; September/October 2009.
- **Viewing Internet Pornography: For Whom Is It Problematic, How, and Why?** Michael P. Twohig, Jesse M. Crosby and Jared M. Cox in *Sexual Addiction & Compulsivity,* Vol. 16, No. 4, pages 253–266; October 2009.

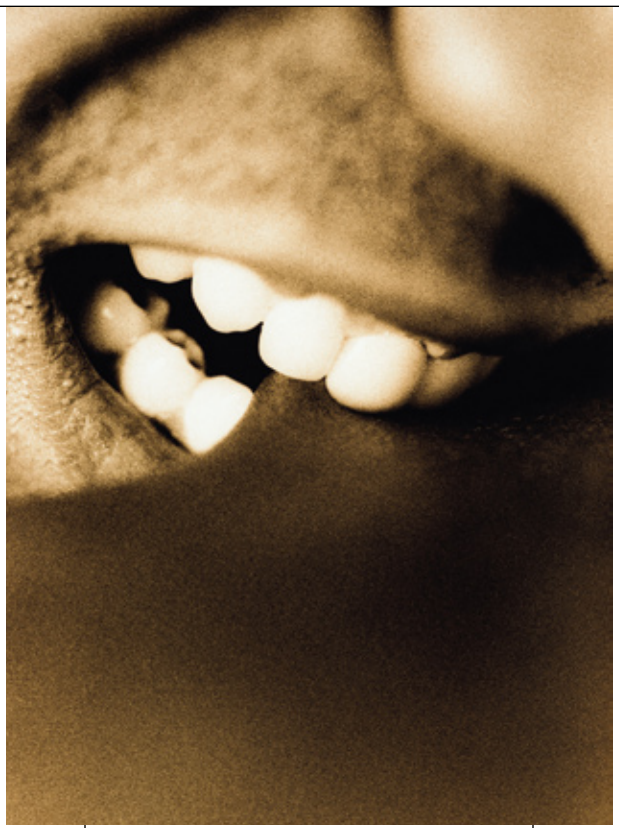
RYAN McVAY Getty Images

© 2011 Scientific American

Sex and Violence

Using optical and genetic techniques, neuroscientists have identified an "on/off" switch for aggression in the brain

BY CHRISTOF KOCH



CHRISTOF KOCH (*Koch*); BARNABY HALL *Getty Images* (*biting*)

RECENTLY DEVELOPED powerful, yet also delicate and refined, genetic tools can invasively probe nervous systems of animals, far surpassing the safer but much cruder techniques that psychologists and cognitive neuroscientists use to observe the human brain. Now in a remarkable series of experiments, researchers have located a trigger for aggression in mice—providing us with fresh insights into the workings of our human consciousness.

You might object that mice and men are not the same and that studying the murine mind is different from studying the human mind. This fact is obviously true. Yet both *Mus musculus* and *Homo sapiens* are nature's children, sharing much perceptual, cognitive and affective processing. The same process of relentless evolutionary selection has shaped both species—our last common ancestor was a mere 75 million years ago. The structure of their brains, and of their genomes, reflects this similarity. Indeed, only a neuroanatomist can tell a rice grain–size piece of mouse cortex from the same chunk of human cortex. If you think of a mouse as a mere automaton, Google "world's smartest mouse." The top hit will be a YouTube video of Brain Storm, a cute brown mouse running a complicated obstacle course—crossing an abyss on a rope; jumping through hoops; going up and down a seesaw, over a pencil, up a steep incline and down a ladder; and navigating around obstacles. It hesitates on occasion, sniffs the air but, once started, speedily completes the circuit.

The amazing finesse and utility of contemporary molecular biology techniques are illustrated in recent experiments dealing with sex and power—the twin themes around which much of popular culture, psychoanalysis and art is centered.

Aggression Center

Our story starts in the hypothalamus, an ancient region of the brain, conserved throughout mammalian evolution. In humans, it is about the size of an almond, housing a motley collection of neurons. These cells regulate distinct bodily functions such as temperature, circadian rhythms, sleep, hunger, thirst, sex, anger, aggression and response to stress. Earlier work showed that electrical stimulation of some of these sites provokes cats and rats to sudden bouts of rage and that the ventromedial hypothalamus (VMH) has some involvement in sexual behaviors. Yet the precise location of attack-promoting neurons, their mode of action, and the interplay between aggression and mating—normally two opposing forms of social interactions—had remained deeply mysterious.

Enter a team from the California Institute of Technology, under the leadership of neurobiologist David J. Anderson. In four steps, the seven scientists, spearheaded by postdoctoral fellow Dayu Lin (now at New York University), nailed down the critical role of aggression neurons in the VMH. The setting was the home cage of an individually housed, sexually experienced male mouse. When another mouse, either a male or a sexually receptive female, entered the cage, the resident male mouse usually attacked the former but mated with the latter. The scientists video recorded the behavior so that the detailed time course of interaction of every pair of animals—the cautious sniffing and retreating, the pushing, shoving and biting, the mounting and consummatory activities—in hundreds of encounters could be statistically analyzed and time-aligned using software developed by machine vision engineers Piotr Dollar and Pietro Perona.

The first experiment is a molecular biology version of brain imaging. By detecting the presence of c-fos, a protein that is rapidly synthesized following neuronal activity, researchers can identify nerve cells that are involved in some behavior. Unlike functional MRI, which visualizes "voxels" of active gray matter containing upward of one million neurons, this method homes in on individual cells. A subset of neurons within the VMH, termed the ventrolateral region of the VMH (VMH-vl), became active following male-male encounters that ended up in fights. Simi-

© 2011 Scientific American

The male mouse **indiscriminately attacked** other mice, sometimes even a blown-up latex glove.

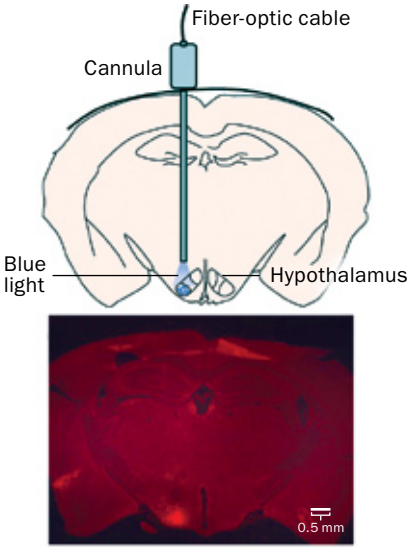
lar results occurred in males mating with females. But were these neurons the same or different cells? With help from collaborators at the Allen Institute for Brain Science in Seattle, the team applied a variant of the c-fos method that distinguishes the neurons activated in two different, successive behavioral encounters. These results indicated that, surprisingly, many brain regions surveyed contained separate but intermingled populations of neurons activated during fighting versus mating, with only a small degree (about 20 percent) of overlap.

Now that the biologists had identified one site—out of many—housing neurons that activated selectively for social encounters, they listened in on the goings-on by placing very fine electrodes in proximity. Silent when the mouse is solitary, these cells' activity level progressively increased as a male intruder entered the cage and the resident mouse attacked. More puzzling was the observation that some neurons were also active, albeit only transiently, in the initial exploratory phases of mating with a female. Conversely, many of the cells signaling during fighting were actively suppressed during mating, indicating an inherent opposition between aggression and sex. To paraphrase the 1960s slogan: you either make love or war, but not both.

So far these experiments have revealed interesting correlations between neuronal activity and behavior (fighting). But what role does VMHvl play in aggression? Are its neurons the cause of fighting?

Marrying Light and Genes

Anderson and his team are masters at exploiting a remarkable technique known as optogenetics [see "Playing the Body Electric," Consciousness Redux; March/April 2010] to stimulate hundreds to perhaps thousands of cells in the VMHvl, out of the 40 million cells of the mouse brain. Scientists injected into the VMHvl on one side of the animal stunted viruses



Aggression trigger: neurons in the hypothalamus at the bottom of the brain (*bright red*) are targeted by blue light. The photons trigger excitation in neurons that causes the animal to attack other mice.

carrying a modified piece of DNA engineered to encode a photosensitive ion channel selective to blue light. Because it is dark in the catacombs of the brain, enlightenment comes from a tiny optical fiber snaking its way through the tissue. Expressed in the membrane separating the cell from the outside, the neuron responded to blue light with excitation. Every pulse of light reliably triggered one or more electrical pulses in the infected neuron. Once the animals recovered, little difference was apparent in their behavior alone or when interacting with another.

Stimulating the VMHvl when the mouse was by itself did not do anything. Yet in the presence of another animal, the mouse initiated a concerted attack, often by biting the back of the intruder. Unusually for this species, the illuminated male indiscriminately attacked female, castrated male or anesthetized mice—and sometimes even a blown-up latex glove. Aggression ceased once the light stopped. The infection and light delivery had to be targeted to the VMHvl nucleus; stimulating nearby regions did not produce such an effect. It is a striking and immediate demonstration of the link between neurons and behavior. Exciting VMHvl neurons causes aggression.

Finally, Anderson and his team turned to the question of whether the VMHvl cells are necessary for aggression to occur. Using a different technique, they genetically "silenced" VMHvl cells, turning them effectively off for days at a time. This silencing significantly reduced the chances of an aggressive encounter and lengthened the time it took to initiate an attack.

Of course, we do not know what the infected rodent experiences in its murine mind when light beams illuminate its hypothalamic attack center. But its behavior is fully compatible with the idea that its sudden violence is accompanied by a bout of petulant anger directed at anything nearby, including helpless victims that pose no threat. Some readers may not be strangers to such "irrational" impulsive feelings welling up. But fortunately, most of us can control our anger, not lashing out at our screaming boss, possibly by inhibiting our hypothalamus via descending fibers from the prefrontal cortex. It is not unreasonable to hope that researchers can investigate the neuronal basis of such anger management in the mouse in the near future. **M**

CHRISTOF KOCH is chief scientific officer at the Allen Institute for Brain Science in Seattle and Lois and Victor Troendle Professor of Cognitive and Behavioral Biology at the California Institute of Technology. He serves on *Scientific American Mind*'s board of advisers.

(Further Reading)

◆ **Functional Identification of an Aggression Locus in the Mouse Hypothalamus.** Dayu Lin, Maureen P. Boyle, Piotr Dollar, Hyosang Lee, E. S. Lein, Pietro Perona and David J. Anderson in *Nature,* Vol. 470, pages 221–226; February 10, 2011.

FROM "FUNCTIONAL IDENTIFICATION OF AN AGGRESSION LOCUS IN THE MOUSE HYPOTHALAMUS," BY DAYU LIN ET AL., IN *NATURE*, VOL. 470; FEBRUARY 10, 2011. REPRINTED WITH PERMISSION FROM MACMILLAN PUBLISHERS LTD

© 2011 Scientific American

Reflections on the Mind

Experiments with a simple mirror setup can reveal much about the workings of the brain

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

KLAUS MELLENTHIN *Getty Images*

YOU PROBABLY LOOK in a mirror every day without thinking about it. But mirrors can reveal a great deal about the brain, with implications for psychology, clinical neurology and even philosophy. They can help us explore the way the brain puts together information from different sensory channels such as vision and somatic sensations (touch, muscle and joint sense). In doing so, they can reveal a lot about our sense of self. Would a person who has never looked at his reflection—even in a pool—ever develop a sophisticated self-representation?

Using two bricks, or some duct tape, prop up an 18-inch-square mirror vertically on a table. Sit so that the edge faces you (*a*). Now put your left hand on the table at the left side of the mirror (either palm up or down) and match your right-hand position on the right side. If you now look into the right side of the mirror, you will see the right hand's reflection optically superimposed in the same place where you feel your left hand to be. (You may need to adjust the position of the left hand to achieve this sensation.) It will now look like you are viewing your own left hand, but of course you are not. Now try the following experiments.

While continuing to look in the mirror on the right side and keeping your left hand perfectly still, move your right hand, wiggle its fingers or make a fist. The "left hand" in the mirror will appear to move in perfect synchrony with the right but, paradoxically, feel completely still. The conflict creates a slight jolt; it feels spooky, sometimes mildly uncomfortable. The brain abhors discrepancies.

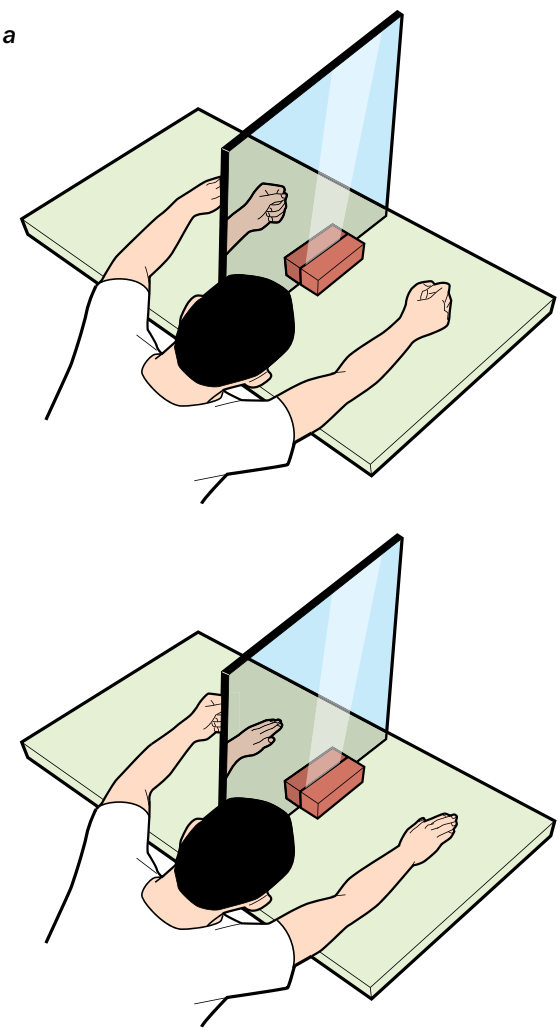
Now do the opposite; keep the right hand still and move the left hand. The left hand appears still but feels like it is moving. You will feel the same kind of jarring sensation, but it will be less powerful than

If you are lucky, you will feel tingling touch sensations in the left hand even though **nothing is being done to it**.

in the preceding case. The reason for the asymmetry is not clear.

Why the jolt? The answer resides in the right superior and inferior parietal lobules (located above your right ear), where signals from your various senses—visual, somatic—converge to create your internal sense of a body image. Stand up now and close your eyes. Either raise your arms or let them dangle by your side. Obviously you have a vivid sense of being "anchored" in your body except under special circumstances (such as ketamine anesthesia). Now open your eyes, and you have visual confirmation of what your other senses are telling you: you see your hand where you felt it to be. In short, your senses normally blend different sensory inputs to create a vivid dynamic image of your body moving in space and time.

The mirror experiment you did earlier disrupts this consistency of signals in the right superior parietal lobule. The discrepancy is picked up in part by the right insular cortex (buried in the temporal lobe), and that information is then relayed to the right frontal lobe, where it can be picked up through brain imaging (as shown by Richard Frackowiak, Ray Dolan and Chris Frith, all at University College London, and Peter Halligan of Cardiff University in Wales).



By placing your hands on either side of a mirror so that the reflection of your right hand is optically superposed on the left, you can experiment with illusions that reveal how the brain creates our sense of self. The text describes some sensory disparity effects that you can try.

Is That My Hand?

You do not need fancy brain-imaging gizmos to try out some additional experiments that can give you insights into brain function.

Return your hands to either side of the mirror. Now have a friend touch, stroke, pinch, tap or rub your right hand while you look at its reflection. Obviously it will look like your own left hand is being stroked, pinched, tapped or rubbed. But because it is not actually being touched, you will experience one or all of the following (the response varies from person to person).

First, the hand may feel numb, anesthetized or asleep, and it will still feel as if it belongs to you. (Your brain is in effect saying, "I see my hand being rubbed but don't feel it, so it must be asleep.") This perception is unaffected by your higher-level intellectual knowledge of the optics of the situation. Your perceptual systems integrating vision and touch are on autopilot, as it were, applying their own statistical rules.

Second, you may see the hand as not belonging to you. Your brain is then ignoring its proprioceptive (muscle and joint feedback) congruence with the visual image of your hand. It is as if the brain is concluding that "because I see the touch but don't feel it, that hand must be someone else's." Sometimes you will "see" the hand as a cadaver's hand or a realistic plastic dummy. Interestingly, the brain does not settle on "halfway" ambiguities—at any given time you clearly experience one of the percepts.

Last, if you are lucky, you will actually feel some tingling touch sensations in the left hand—even though nothing is being done to it. This effect is a striking example of the brain "filling in" the missing information. Two sources of information (proprioception and vision) are internally consistent in telling you that it is your hand. But the third piece of information—that the hand *looks* like it is being stroked—is inconsistent with lack of touch sensations. So the brain "flags" the discrepancy as tingling—as if to say, "I'm feeling something odd." Very infrequently, you may actually feel the touch—as though the brain fills in the blanks to create an internally consistent package to higher centers. We call this phenomenon intermanual touch referral.

Clues to Managing Pain

Try the following experiments. Before the stroking begins, look into the

JASON LEE

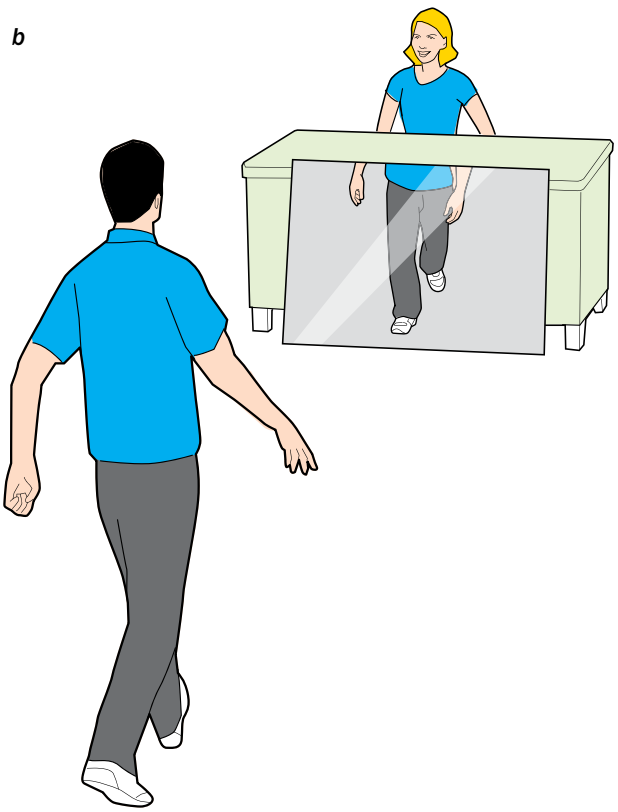
When you start wiggling the fingers synchronously, the brain gets information that the hand is **really yours**.

mirror and wiggle the fingers of your two hands in perfect synchrony. Nothing odd so far. Now have a friend deliver strokes, taps or pinches as before, but this time to the visible hand only. All of a sudden you start feeling intermanual referral (that is, feeling the actual touch in the hidden hand) much more vividly and less fleetingly than when your hands were stationary. Why?

In constructing a picture of the world, the brain assigns various weights to different sensory inputs based on a lifetime's experience of their statistical reliability, as well as ongoing patterns of activation. In short, the brain does not average the signals—it looks for improbable internal consistencies.

When you start wiggling the fingers synchronously, the brain suddenly gets extra information that the hand is really yours. These data force your brain to accept the hand as your own, so you lean toward experiencing intermanual referral with or without tingling. The flood of proprioceptive signals coming in from the hidden hand vetoes any attempt by your brain to engage in disownership. So your brain adopts the next available strategy: accept the hand and feel intermanual referral.

The same effect occurs if you wiggle right- and left-hand fingers nonsynchronously. This time the tendency to think of the reflection as your own left hand is slightly mitigated by the incongruity between vision and proprioception. (The sight of wriggling is somewhat desynchronized from the felt position of the fingers.) Consequently, the intermanual referral is halfway between our previous two experiments.



The person sitting at the desk in front of you has her legs covered by a mirror. As you walk toward her, it feels like you are "out there" but walking toward yourself. The effects vary from person to person. It may help if the other person is of the opposite sex.

One last experiment you—the reader—can do. Drop some itching powder on the (hidden) left hand so that it begins to itch. Next have the right hand vigorously stroked and scratched while wiggling both hands synchronously (that is, generate intermanual referral). Question: Does the illusory stroking and scratching felt in the left hand relieve the real itch? It worked better on one of us (Ramachandran) than the other (Rogers-Ramachandran), but you should try it on yourself. If it can be replicated on a large number of subjects, it would be the first example of a purely visual input (which creates an illusory touch) relieving a real itch in a normal hand. Write to us (vramacha@ucsd.edu or diarama@ucsd.edu).

These effects are more than amusing curiosities; they may be clinically useful for treating pain and paralysis in existing limbs as well as phantom ones, as we discovered in the early 1990s.

Consider the curious but tragic pain disorder called complex regional pain syndrome (CRPS). If you suffer a fracture after your finger is jammed in a doorway, pain ensues. Chronic pain results in a reflex immobilization of the hand to prevent further injury and promote healing. In a few days or weeks the tissue swelling and inflammation subside, along with the pain. But in a small percentage of cases, the immobilization turns into permanent paralysis, and the hand becomes progressively more swollen, painful, inflamed and dysfunctional. The pain and paralysis spread upward to involve the entire arm. There is no known treatment.

In a lecture we gave in 1996 at the University of California, San Diego, Decade of the Brain Symposium, we referred to this phenomenon as learned pain. Every time the motor command centers sent a command to move the hand, excruciating pain accompanying the command blocked further movement. In a few unlucky individuals, an unconscious association—or memory link—is established between the initial command itself and pain, so the brain just gives up: learned pain. Speaking metaphorically, the hand becomes immobilized by fear; it is paralyzed. Admittedly, a hand-wave argument, but nonetheless it is about as compelling an example of mind-body interactions that you can find in all of clinical medicine.

More than 20 treatments, many of them involving drugs or surgery, have

JASON LEE

© 2011 Scientific American

been tried for CRPS. What they all have in common is they do not work. (One technique, sympathetic ganglion block, works to some extent but involves an invasive procedure.)

Can the pain be "unlearned"? Prompted by our successful pain-relief treatment using mirrors for patients with phantom limbs, Candy McCabe, now at the University of the West of England, Bristol, and her colleagues tried mirror therapy. The patient looks at the reflection and moves both hands symmetrically so that it appears to the brain that the affected arm—the left, for example—is moving but not painful after all. Similarly, stroking or hitting the right hand creates the optical illusion that the dystrophic hand is being stroked and hit with impunity. Perhaps these two bits of evidence remove the "block" on the affected arm leading to a positive cycle of pain reduction, accompanied by a reduction of swelling and redness.

Chimps can identify themselves in a mirror reflection. The ape will rub its own forehead—not the mirror image—to study an ink splotch (surreptitiously) placed there.

Taken collectively, these were the first demonstrations that "real" chronic pain can be reduced by visual input; indeed, even intense visual imagery may turn out to be partially effective, but this is hard to do. We first tried mirror therapy on patients with phantom pain from amputated limbs. Sometimes the missing hand feels "locked" in a painfully awkward cramp that can be excruciating, and the patient cannot volitionally move the phantom. When he looks at the reflection, a series of things may happen. First, he "sees" his phantom and recognizes that it is not being poked or held in a vice after all; there is no reason for it to be painful. Second, merely seeing the phantom may be beneficial because the brain can attribute the pain to the arm and, paradoxically, a pain whose source is known may be less troubling than "disembodied," inexplicable pain (caused by discordant visual and proprioceptive signals). Third, seeing the cramped, paralyzed hand move seems to animate it in such a way as to relieve the cramp, an example of successful clinical application of visual capture. Repeated use may lead to an unlearning of learned paralysis. In placebo-controlled clinical trials on returning war veterans, mirror visualization feedback has since been found to be strikingly successful in some patients and moderately so in others. (Jack Tsao and his colleagues at Walter Reed Army Medical Center conducted the trials.)

Remarkably, in controlled clinical trials, we and others have found mirror therapy to relieve paralysis from cerebrovascular stroke. This relief may be partly because the paralysis could be learned and partly because many paralyzed limbs also have a form of CRPS associated with them. Both these effects contribute to the limb paralysis, which would explain the relief provided by the mirrors.

Litmus Test for Self-Awareness

Let us return to normal perception again and describe an observation we made in collaboration with Eric Altschuler of UMDNJ–New Jersey Medical School.

Have a friend sit behind an ordinary writing desk. In front of the desk, place a mirror so that it covers it completely and you can see only your friend's torso behind the desk. Now stand at a distance of 20 feet from the desk, look at her and carefully align her torso with the reflection of your lower trunk and feet. Now walk toward the desk, and you will see your friend "walking toward you" with her feet moving in perfect synchrony with your own (*b*). If you are among the lucky 75 percent of subjects, you will have a spooky sensation of an out-of-body experience with "you" out there inhabiting your friend's body, presumably because this is the only way your brain can interpret the perfect synchrony of her legs and yours. Try having her move her face a bit. Does that enhance or diminish the effect?

You may ask why this effect does not occur when you simply walk toward the mirror looking at your own reflection. The answer is twofold. First, can you really be sure it does not? When you shave or put on makeup do you not, at least to a limited extent, "project" yourself into the mirror? Perception is a multilayered phenomenon—hence, it is prone to endless paradoxes in contrived situations. Second, given your lifelong experience with mirrors, you have become habitu-

Merely **seeing the phantom** may be beneficial because the brain can attribute pain to a source.

JAMES BALOG Getty Images

© 2011 Scientific American

Perception is a multilayered phenomenon—hence, it is prone to **endless paradoxes** in contrived situations.

JOSHUA SHELDON Getty Images

ated; just as horses are not normally scared of their own shadows. A feral child (or man) seeing himself in a mirror the very first time might indeed experience himself inhabiting the stranger in the mirror.

Finally, Gordon Gallup, Jr., now at the University at Albany, has suggested that mirrors can provide a litmus test for self-awareness, a topic that has been much discussed by philosophers for two millennia. When a chimp is asleep, dab a splotch of paint on its forehead. If you show it a mirror when it wakes up, it will spontaneously reach for its forehead to remove the splotch; it does not reach into the mirror. This response may or may not tell us that the chimp is self-conscious, but it does show that the chimp knows that it is looking at itself in the mirror and that it is looking at a reflection—a capacity that eludes monkeys. They fail the test.

We saw a 70-year-old neurological patient recently who, despite her progressive Alzheimer's-type dementia, remained fairly intelligent and articulate. Her main presenting symptom, disturbing to her family members, was that she was terrified of seeing her own reflection: mirror phobia. She kept referring to it as a malevolent phantom twin who was following her. So all reflecting surfaces in her house had to be covered. Yet when we did the Gallup mirror splotch test on her, she passed, reflexively removing the splotch. This experience shows that merely passing the test does not indicate that you (whether you are a person or a chimp) are aware at a conscious level ("believe") that what is in the mirror is really "you."

Thus, mirrors have vast implications, whether for demonstrating the role of visual feedback in treating pain and paralysis or for the psychological and philosophical issues surrounding construction of body image and sense of self by your brain. There's plenty to reflect on. **M**

VILAYANUR S. RAMACHANDRAN and DIANE ROGERS-RAMACHANDRAN are at the Center for Brain and Cognition at the University of California, San Diego. They are on the board of advisers for *Scientific American Mind*.

(Further Reading)

- **Vision and Touch.** Irvin Rock and Charles S. Harris in *Scientific American,* Vol. 216, No. 5, pages 96–104; May 1967.
- **The Perception of Phantom Limbs: The D. O. Hebb Lecture.** Vilayanur S. Ramachandran and W. Hirstein in *Brain,* Vol. 121, pages 1603–1630; 1988.
- **Synaesthesia in Phantom Limbs Induced with Mirror.** Vilayanur S. Ramachandran and Diane Rogers-Ramachandran in *Proceedings of the Royal Society of London B,* Vol. 263, pages 377–386; 1996.
- **A Simple Method to Stand Outside Oneself.** Eric Lewin Altschuler and Vilayanur S. Ramachandran in *Perception,* Vol. 36, No. 4, pages 632–634; 2007.

© 2011 Scientific American

(calendar)

July

6–10 What is creativity? How does it arise? Philosophers and neuroscientists alike are searching for answers to these intriguing questions. Neuroscientists are using functional MRI to discover whether we have brain circuits specifically associated with creative thinking. And philosophers may seek to understand both what motivates aha! moments in everyday life and how these instances determine who we are. During the five days of the **37th Annual Meeting of the Society for Philosophy and Psychology**, neuroscientists, psychologists and philosophers will come together to discuss themes of common interest, including the nature of honesty and the neuroethics of using brain scans for lie detection.
Montreal
www.socphilpsych.org

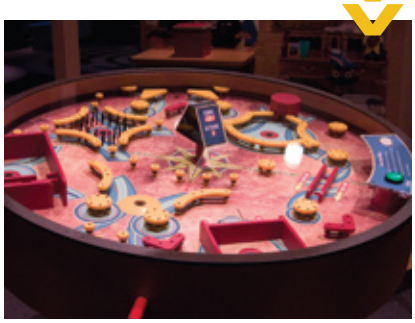
15 Although mind reading is not possible for mere mortals, it still represents an intriguing possibility in the science-fiction and fantasy realms. In ***Harry Potter and the Deathly Hallows: Part 2***, the final film installment of the popular book series written by J. K. Rowling, Harry finds he shares a strong mental connection with his arch nemesis, Voldemort. Harry and Voldemort possess an ability called legilimency, a magical skill where they can extract feelings and memories from each other's mind. The ability also allows them to convey visions or memories or even to plant false visions.
http://harrypotter.warnerbros.com/harrypotterandthedeathlyhallows

August

4–7 Oxytocin, sometimes referred to as the love hormone, enhances feelings of lust and trust between people. A recent report, however, suggests that the effects of this brain-altering chemical are not all so rosy; oxytocin may amplify negative as well as positive feelings. In other words, an influx of oxytocin may make a suspicious person even more hostile. At the four-day **119th American Psychological Association Convention**, scientists will discuss how different hormones alter brain function and how neurodegenerative diseases, such as Alzheimer's, stress the brain.
Washington, D.C.
www.apa.org/convention

Until September 4

Some research suggests that solving puzzles can boost general brain function. Enter the **Mindbender Mansion**, a traveling exhibit filled with brainteasers and interactive challenges designed to enhance children's problem-solving skills. The show, which makes an appearance at the Boonshoft Museum of Discovery this summer, invites visitors to uncover hidden clues and secret passwords as they solve up to 40 brainteasers. The aim is to help children think creatively as they arrange puzzle pieces to form new shapes and solve Sudoku-like problems.
Dayton, Ohio
www.omsi.edu/mindbender-mansion-exhibit



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

Roundup

Podcasting about the Brain

Ongoing

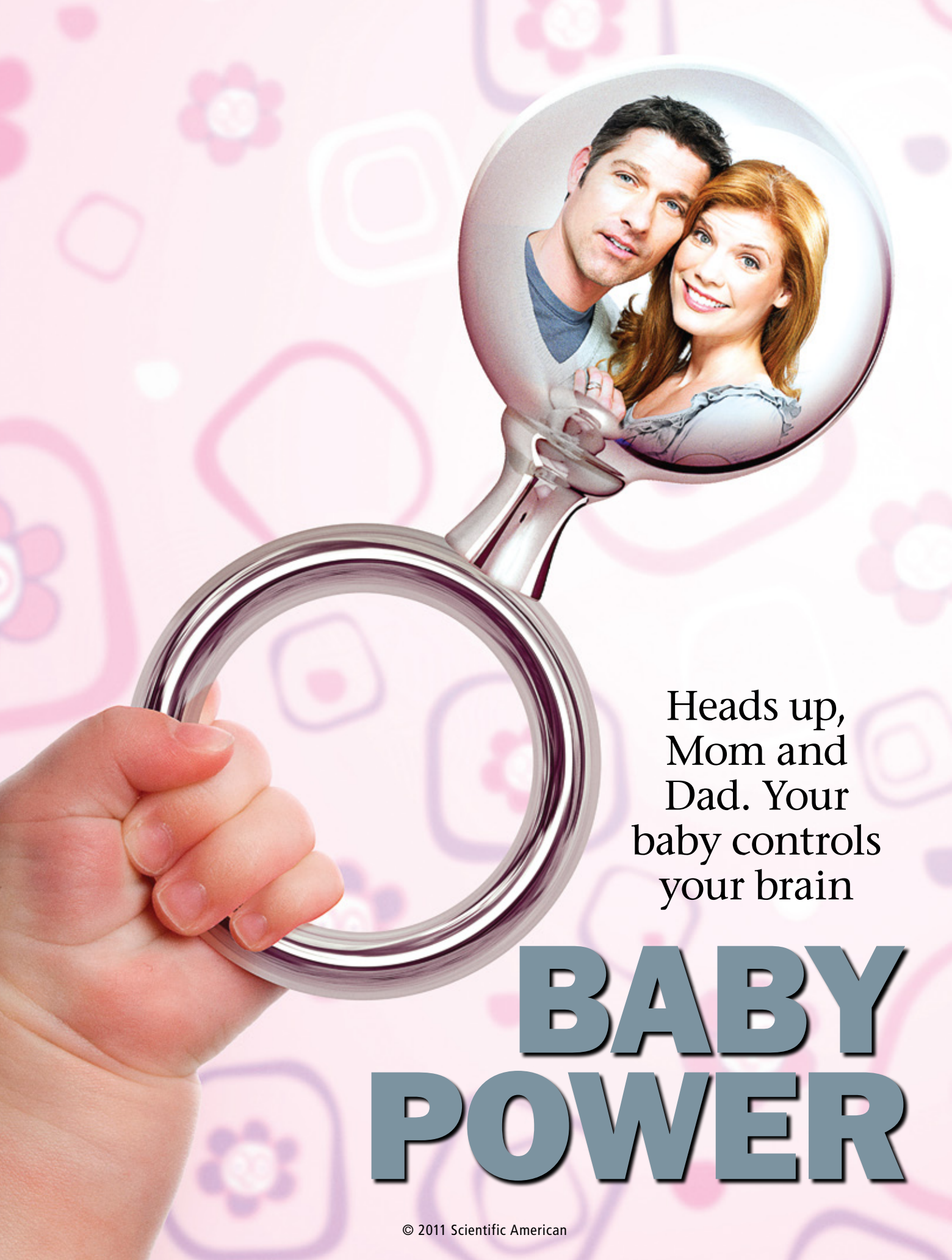
Wish you could chat sometime with a neuroscientist? **The Brain Science Podcast** might be the next best thing. Host Ginger Campbell interviews leading brain scientists, physicians and psychologists about their work, delving into subjects such as intelligence and memory. In one episode, Campbell asks Emory University psychologist and *Scientific American Mind* contributor Scott O. Lilienfeld to dissect how psychological issues are portrayed in movies and television. Campbell also explores controversial topics, such as whether hypnosis is an effective treatment for insomnia and other disorders.
www.brainsciencepodcast.com

The study of consciousness has only recently entered the sight lines of neuroscientists. For the podcast **All in the Mind**, Nobel laureate Gerald Edelman joins host Natasha Mitchell to discuss how brain science can probe the essence of consciousness. In another episode, Mitchell investigates the effectiveness of psychological debriefing, a technique aimed at helping people process traumatic events. She also interviews prominent neuroscientist Fred Gage about the brain's ability to make new cells into adulthood and how this discovery might one day serve to treat brain disease or damage.
www.abc.net.au/rn/allinthemind/default.htm

Why do we find music so pleasurable? According to new research, listening to your favorite tunes causes dopamine to flood the brain, reaching a peak at just the moment when you experience maximum emotional arousal. Join Kerri Smith as she explains these findings and more. Every month Smith hosts **NeuroPod**, a neuroscience podcast from the journal *Nature* that delves into the latest research on the brain. In recent episodes, Smith has recounted how certain molecules may boost memory and how scientists uncovered the neural pathways linked with Parkinson's disease and schizophrenia.
www.nature.com/neurosci/neuropod/index.html

WARNER BROTHERS/EVERETT COLLECTION (Harry Potter); COURTESY OF OREGON MUSEUM OF SCIENCE AND INDUSTRY (*table*); ISTOCKPHOTO (*headphones*)

© 2011 Scientific American



Heads up, Mom and Dad. Your baby controls your brain

BABY POWER

© 2011 Scientific American

Having a child changes the way you think. With a baby's birth, parents become flooded with new responsibilities and emotions. In this special report, we explore how those experiences forge a bond between parent and child.

The connection does not depend on shared genes, as many adoptive moms and dads can attest. Nor does pregnancy explain it all. The challenges of child care rewire both parents' brains so that being a mother or father becomes easier.

That moms and dads have a strong influence on their kids is clear. Now we also know that on both sides of the bond, brains respond.

➥For a video of a new mother and her changing brain, visit **ScientificAmerican.com/Mind/jul2011/mommy-brain**

PHOTOILLUSTRATION BY AARON GOODMAN (*baby with parents in rattle*); GETTY IMAGES (*woman cradling baby*)

Maternal Mentality

Pregnancy and childbirth shape a woman's mental makeover

By Craig Howard Kinsley and Elizabeth Meyer

With her second child growing larger by the day, Liz is experiencing the tyranny of her pregnancy. Her belly seems impossibly huge to her. Easy sleep is a distant memory now that she must contend with tens of pounds of extra girth. With belching and heartburn following every meal, she feels as if she is subsisting on a diet of small volcanoes.

But Liz is not just any late-term mother-to-be. She is also a neuroscientist studying the changes that occur in a mother's brain—in fact, she co-authored this article. Although it will not relieve her indigestion, she derives some comfort from a new and growing body of research that is revealing the marked and generally positive alterations that accrue to a mother's brain.

© 2011 Scientific American

Because the maternal brain emerges gradually, the construction site it becomes in the interim can cause some problems for its owner. Some mothers complain of fuzzy-headedness, and certain data even show minor brain shrinkage during pregnancy. But the compensations are great. Research suggests that motherhood enhances certain types of cognition, improves resistance to stress and sharpens some kinds of memory. On the face of it, the fact that the nervous system manages to transform a new mother from a self-centered organism into an other-focused caregiver is actually quite impressive. All it takes is for new neurons to sprout, certain brain structures to blossom in size and waves of powerful hormones to batter the pregnant woman's physiology. The result is a different and in some ways better brain—or at least one capable of juggling the challenges of everyday life while maintaining a laserlike focus on the baby.

FAST FACTS

Tuning a Mother's Mind

1» **Although human mothers tend to complain of lost mental sharpness, recent animal studies suggest that motherhood actually improves the brain in many ways.**

2» **Changes in a mother's brain make women more attuned to threats as well as bolder in the pursuit of food and in the face of danger.**

3» **Scientists can detect changes that are linked with motherhood in the structure of the brain. Among them is increased gray matter in areas involved in infant care.**

A Sensory Trigger

A baby does what he can to attract and hold his mother's attention. A young son's distinctive cry, his unique scent and the way he curls his fingers around his mother's are just a handful of the sensations that shower down on her highly sensitized nervous system. The infant creates a rich environment that stimulates the mother, pushing her brain into a higher gear.

Of all the senses, smell—olfaction—plays the largest role in reproduction. Females rely on their sense of smell from the very beginning to help them select their mates all the way through to the weaning of their young, during which scents act as a form of communication between mother and child. An extreme example of the power of smell is known as the Bruce effect, a phenomenon in which certain scents induce abortions in pregnant rodents. If a female's mate disappears after conception and an interloper starts hanging around, the new male's smell will inhibit the production of key hormones, causing the female's pregnancy to abort. Otherwise, chances are high that the interloper would end up killing and eating the pups, thereby obtaining a high-protein meal and removing a rival's genes in the bargain. In a kind of "Sophie's choice" for rodents, the female is basically making a cold calculation—better to lose the young as embryos than as pups.

Because of our limited ability to peer into human brains, rodents help us approximate the changes that are taking place inside mothers such as Liz. What we have seen so far is that the mammalian brain possesses a dramatic ability to shape-shift when life demands it. During a rat's pregnancy, for example, we know that the olfactory system starts churning out new neurons. The theory is that the extra neurons allow moms to become more adept at processing the cues hidden in infant odors. Indeed, mothers distinguish themselves quite obviously in how they react to smells. Whereas virgin female rats find the odors of infants noisome, once they become pregnant, those smells attract them. Human mothers also demonstrate these effects, as psychologist Alison Fleming of the University of Toronto Mississauga and her colleagues reported. They found that mothers are much more likely to rate their infants' odors as pleasant, as compared with nonmothers.

To transform women's perceptions of smells, the olfactory system may rely on a region known as the medial amygdala, suggests neurobiologist Michael Numan of Boston College and his colleagues. This brain area could be acting as a hub for the olfactory system, with information arriving here to be processed for emotional content. The olfactory tweaks may aid in solidifying the mother-child bond by making babies' odors alluring. Before she had her first child, Liz had avoided the smells of children, even those to whom she was related. But with the birth of her son, she discovered she had no problem stuffing her nose into his diaper to determine if he needed a change.

TERRY VINE *Getty Images*

© 2011 Scientific American

Upon entering the world, a baby encounters a flood of new sensations. So does a mother—the infant creates a rich environment that stimulates a mom's highly sensitized nervous system.

GETTY IMAGES

Caution and Courage

If Liz devoted all her attention to her infant, however, both mother and child would perish. A mother rat that stays safely in the nest with its offspring also dooms them to death from hunger and thirst. Mothers of both species must find ways to resolve the competing demands on their time. In other words, women are not the only members of the animal kingdom who find themselves juggling the duties of a working mom.

To allow a rat mother to toggle between caring for its young and heading out to find food, an area of the midbrain called the periaqueductal gray (PAG) acts as a circuit breaker. Researchers at the University of São Paulo proposed in 2010 that the PAG weighs the balance between eating and acting maternally by evaluating input from the brain's limbic system, a set of structures that governs survival-type behaviors. No exact parallel to the PAG's toggle function in rats has been identified in humans yet, but much has been made of a mother's superhuman ability to multitask, perhaps reflecting a similar adaptation.

When a mother ventures into the world, she puts her vulnerable baby at risk. But she may be more attuned to potential threats, perhaps even exaggerating them, suggests research at the Health Sciences Federal University of Porto Alegre in Brazil. Researchers there have shown significant alterations in the architecture of dendrites in the medial nucleus of the amygdala, which in addition to its important role in the olfactory system also controls defensiveness and avoidance behavior. Indeed, when Liz shops she scans the stores for risks to her baby, avoiding the creepy guy by the magazines or the sketchy teens by the vending machines.

Pregnancy transforms a woman from a self-centered organism into an other-focused caregiver. Her brain ends up different and in some ways better.

© 2011 Scientific American

The hormones of pregnancy may form a neural shield, protecting a mother from threats that could compromise her ability to care for a child.

Although overall Liz is more cautious, she is also probably much bolder in the face of a threat than she was before becoming a mother. Psychologist Jennifer Wartella in our lab at the University of Richmond has found that, compared with virgins, mother rats exposed to a stressful open-field maze were less likely to freeze in place, explored more readily and appeared to experience less fear (that is, Wartella saw fewer switched-on neurons in the amygdala). With its fear response in check, a rat mom may be able to forage more efficiently and return to its nest and vulnerable offspring more quickly.

Helping a mother navigate the world is her improved ability to decipher the clues in the environment. Recently undergraduate student Kelly Rafferty and her colleagues at our lab have been investigating a mother's ability to plan ahead. They allowed mother and virgin rats to forage in an unfamiliar maze that contained water. The rats were then returned to their home cages, some of which contained a water bottle and some of which did not. Subsequently they were moved back to the maze containing water. The mother rats assigned to the waterless home cage spent more time near the maze's water sources and drank more water, as compared with both mothers with full access to water and virgin females. After accounting for potential differences in the rats' thirst, the neuroscientists concluded that the mothers appear to anticipate a future environment and plan for it.

As the previous experiments demonstrated, mother rats seem to excel at tasks that require enhanced attention. Behavioral neuroscientist Kelly Lambert of Randolph-Macon College and her colleagues have collected other evidence of sharp-witted mothers. In 2009 they showed that when it comes to identifying which cue among several signals food, mother rats perform best. And recent work by Amy Au and Tommy Bilinski in our lab has begun to identify the rats' strengthened ability to deduce the meanings of symbols. The researchers designed experiments where a rat in an environment learns to associate, say, a triangle or a set of wavy lines with a food reward. After being moved to a new environment, lactating females transferred their knowledge from the old setting to the new one better than virgin females did, again suggesting a heightened attention to detail.

A human mother's brain undergoes a striking structural metamorphosis, too. Last year using magnetic resonance imag-

REGINE MAHAUX *Getty Images*

A mother's seemingly superhuman ability to multitask might be controlled by the periaqueductal gray, a brain region that helps rat mothers switch between venturing out into the world to search for food and staying in the nest to act maternally.

© 2011 Scientific American

ing studies, neuroscientist Pilyoung Kim, now at the National Institute of Mental Health, and her colleagues found significant increases in gray matter in mothers' brains in the weeks and months after they give birth. Gray matter, which got its name from the color of cell bodies, is a layer of tissue packed with neurons. The growth the scientists saw was particularly visible in the midbrain, parietal lobes and prefrontal cortex—all areas involved in infant care. The mothers with the biggest increase in gray matter volume also reported the more positive perception of their babies.

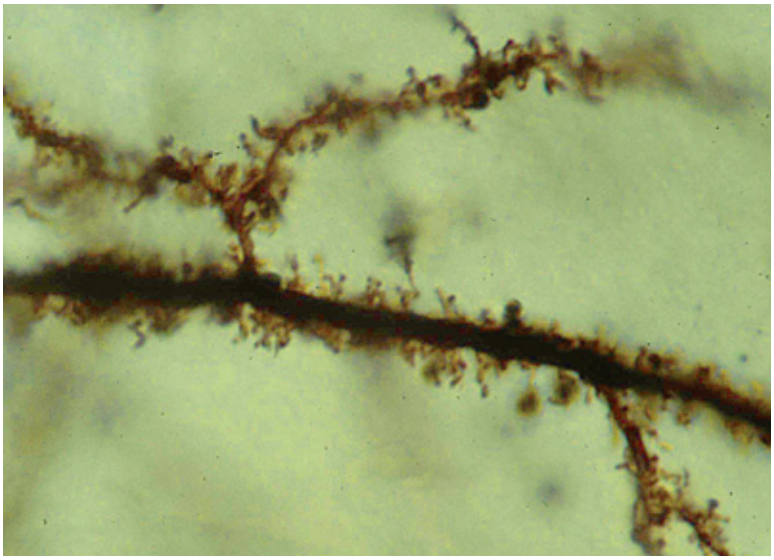
Maternal Morphine

As the time of delivery nears, powerful hormones swing into action. Although the most obvious players are oxytocin, which stimulates uterine contractions and milk letdown, and prolactin, which instigates milk production, other hormones trigger changes inside the brain, too. Neuroanatomists at the Victor Segalen Bordeaux 2 University in France have observed a dramatic structural remodeling of the hypothalamus, a brain region that acts as a major regulator of the hormones associated with basic emotional behaviors such as fighting and sex. Neurons in a part of the hypothalamus known as the medial preoptic area, or mPOA, grow bigger and become more active. Indeed, lesions of the mPOA can eliminate maternal behavior.

Meanwhile the hypothalamus ramps up the feelings of pleasure a mother receives. Robert S. Bridges of the Tufts Cummings School of Veterinary Medicine and his colleagues found different concentrations of opioid receptors in female rats depending on whether the rodent was a virgin, pregnant or lactating. But the phenomenon fades with experience. Females that go through several pregnancies show a decline in sensitivity to their own opioids, much like addicts who require ever greater doses of a drug to get high.

The drug analogy, by the way, is not spurious. Animals may in fact be engaging in maternal behavior simply because it feels good. Many human mothers report a very pleasurable feeling as they breastfeed their infants. After pups attach to a female rat's nipple, the mom receives a "hit" of reinforcing opiate. But the rat's body imposes a natural limit. As the pups continue to suckle, the mother's core body temperature rises. Soon enough the mother begins to feel uncomfortable and moves away. Later, desiring another burst of opiates, the rat comes back to the nest, the pups reattach and the cycle begins again.

As an added benefit, maternal hormones may well make the brain more resilient. Last year neurobiologist Teresa Morales Guzmán of the National Autonomous University of Mexico showed that the brain of a lactating female is more resistant to the effects of a neurotoxin. The hormones of pregnancy appear to construct a neural shield that protects a mother from damage that otherwise might compromise a rat's ability to care for its young.



Dendritic spines are small, nubby protrusions on neurons that grow denser in a pregnant woman's brain. Spines speed up the transfer of signals between brain cells. Abnormal spine growth is seen in patients with several psychiatric disorders.

COURTESY OF CRAIG HOWARD KINSLEY AND ELIZABETH MEYER

Better Connections

The continuous ebb and flow of steroid hormones prompts brain cells to grow many tiny protrusions. Somewhat similar in appearance to thorns on the stem of a rose, these nubs are called dendritic spines. They add surface area to an existing neuron, allowing for more synaptic contact and therefore better information processing. Such spines can grow on a neuron after hormonal stimulation as well as after repeated bouts of stimulation from nearby connecting neurons.

Our lab recently built on previous findings from the Rockefeller University showing that dendritic spine densities in the hippocampus increased in concert with the hormonal changes of a female rat's estrus cycle, which is similar to the human menstrual cycle. Best known for its role in memory, the hippocampus also supports maternal behavior. Even after just a few hours of elevated estrogen, the growth was dramatic.

But we learned that the spines are not caused simply by the presence of estrogen. We tested three groups—late-pregnancy females, females treated with a drug that mimics late-pregnancy hormones and females that had recently begun lactating—and saw that all three showed significant increases in dendritic spine concentrations. Unlike the other two groups, lactating females have very low levels of estrogen. We believe that al-

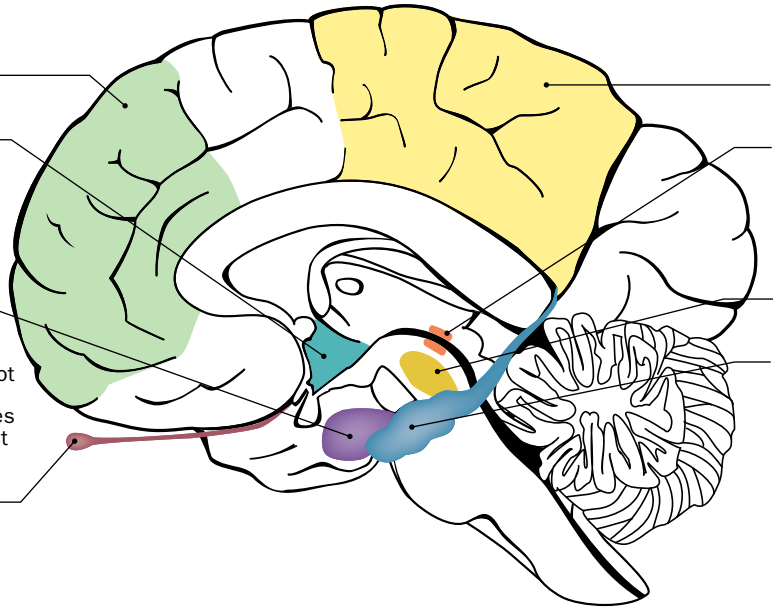
(The Authors)

CRAIG HOWARD KINSLEY is MacEldin Trawick Professor of Psychology at the University of Richmond, where ELIZABETH MEYER is a postdoctoral fellow in the department of psychology and at the Center for Neuroscience. While they were writing this article, Meyer became a mother for the second time, with the birth of her daughter, Amory.

© 2011 Scientific American

Brain under Construction

Women undergo the most dramatic brain changes during pregnancy and after birth. But men experience an important cognitive transformation, too. Below are just a few of the regions that likely become involved when parents begin raising a child. Although many of the findings are preliminary and drawn from studies on rodents, the evidence suggests that the brains of moms and dads adapt flexibly to cope with the challenges of raising a child.



though a mother's hormones initiate spine growth, the process is maintained by the many stimuli a child generates.

With such a thorough remodeling in progress, it is no wonder that many women complain of "pregnancy brain." The collateral damage of these changes might include an occasionally faulty memory. Human moms experience postpartum memory deficits, too, as work by clinical psychologist J. Galen Buckwalter of the University of Southern California and his colleagues suggests. They found that on cognitive tests of memory for words and numbers, pregnant women and new mothers fared worse than nonpregnant women of about the same age. Their performance on tasks unrelated to child care seemed to suffer.

For the most part, though, the finished product will more than make up for the hiccups a mother may experience as her brain restructures itself. Producing an offspring requires a mother to jeopardize her own health, safety and survival, so her behavioral system kicks in to protect and defend that investment. With the landscape of her brain buffeted by the hormones of pregnancy and pressures of motherhood, she emerges more efficient and geared for survival.

For Liz, the compensation for the downsides of motherhood comes not just from science but also from the heart. By the time we finished writing this article, she had given birth to a healthy baby girl. All the neurobiology in the world pales in comparison to that blissful, ineffable bond that exists between a mother and her baby. Science may explain the maternal brain, but the real marvel—especially when you are gently tucking the blanket around your baby's chin as she sleeps in your arms—might simply be the beauty of a new child's existence. M

(Further Reading)

- **The Mommy Brain.** Katherine Ellison. Basic Books, 2006.
- **Motherhood Induces and Maintains Behavioral and Neural Plasticity across the Lifespan in the Rat.** Craig H. Kinsley et al. in *Archives of Sexual Behavior,* Vol. 37, No. 1, pages 43–56; February 2008.
- **The Construction of the Maternal Brain: Theoretical Comment on Kim et al.** Craig H. Kinsley and Elizabeth A. Meyer in *Behavioral Neuroscience,* Vol. 124, No. 5, pages 710–714; October 2010.
- **The Plasticity of Human Maternal Brain: Longitudinal Changes in Brain Anatomy during the Early Postpartum Period.** Pilyoung Kim et al. in *Behavioral Neuroscience,* Vol. 124, No. 5, pages 695–700; October 2010.
- **The Lab Rat Chronicles: A Neuroscientist Reveals Life Lessons from the Planet's Most Successful Mammals.** Kelly Lambert. Penguin Press, 2011.
- **Positive Adjustments of Senescence via Reproductive Experience in the Rat.** Craig H. Kinsley et al. in *Behavioral Neurobiology of Aging.* Edited by M. C. Pardon and M. Bondi. Springer (in press).

MELISSA THOMAS

© 2011 Scientific American

How Dads Develop

When men morph into fathers, they experience a neural revival that benefits their children

By Brian Mossop

Each week in Mind Matters, www.ScientificAmerican.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. Mind Matters is edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, where he edits the Sunday Ideas section.

© 2011 Scientific American

Last year I met my four-month-old nephew, Landon, for the first time. During the weekend I spent visiting him in San Diego, my inner science nerd often got the best of me. I would find myself probing my nephew's foot reflexes and offering unsolicited explanations for why his toes curled this way or that, only to be met by my wife's disapproving looks and the new parents' blank stares. Soon enough I dropped the shoptalk in favor of baby talk.

Having spent my postdoctoral career in neuroscience, I have seen how important early experiences are for a baby animal's health. In the first few days after birth, babies' brains are like sponges soaking up their sensory environment. What to me seemed like inconsequential sights or smells had markedly different impacts on the impressionable newborns, shaping their brains as they tried to make sense of the unfamiliar world around them. But as astonishing as a baby's brain is, on this family visit what struck me was the redevelopment of my 26-year-old brother-in-law.

In my eyes, Jack has always been my wife's kid brother. When I first met him, Jack was a tall, lanky, wet-behind-the-ears 19-year-old kid who enlisted in the U.S. Navy right after graduating high school. As a two-tour Iraq War veteran, he saw more of the world in six years than most of us ever will, and he frequently regaled us with his large repertoire of crazy sailor stories. But in just a few months' time, Jack had managed to permanently ground his sea legs and become a hands-on first-time father.

Even having served in Iraq, Jack will no doubt find raising Landon the biggest challenge he has ever faced. Whether he knows it or not—and whether he likes it or not—things are about to change drastically for him. Not only will Jack be financially and legally responsible for Landon for the next couple of decades, he will form and sustain an unbreakable emotional bond with his son. In the early days after birth, changes occur in the brains of both the dad and the baby. We can now see the mark left on a baby's brain when a father is not around. When he sticks around, a father gains a cognitive edge by virtue of tending to his children. Although many of the findings are still preliminary, scientists are beginning to sketch a neural portrait of the father-child bond.

On the surface, the intangible link of fatherhood appears nothing like a mother's connection to her child.

By the end of the weekend trip, I saw glimpses that Jack was beginning to accept his new identity. After struggling for several weeks to secure Landon's car seat in the back of his souped-up Mazda RX-8, Jack finally broke down and traded it in for a sensible sedan that will let him transport the little guy more easily. In the cellular networks inside his head, a transformation was well under way.

Figuring Out Fatherhood

To unearth the roots of fatherly feelings, scientists had first to figure out where to look. On the surface, the intangible link of fatherhood appears nothing like a mother's connection to her child. During the nine months of a pregnancy, oxytocin and other hormones course through a woman's body, forging a biochemical bond between her and her baby. Even their heartbeats can synchronize while the child is in the womb.

FAST FACTS

Symbiotic Brains

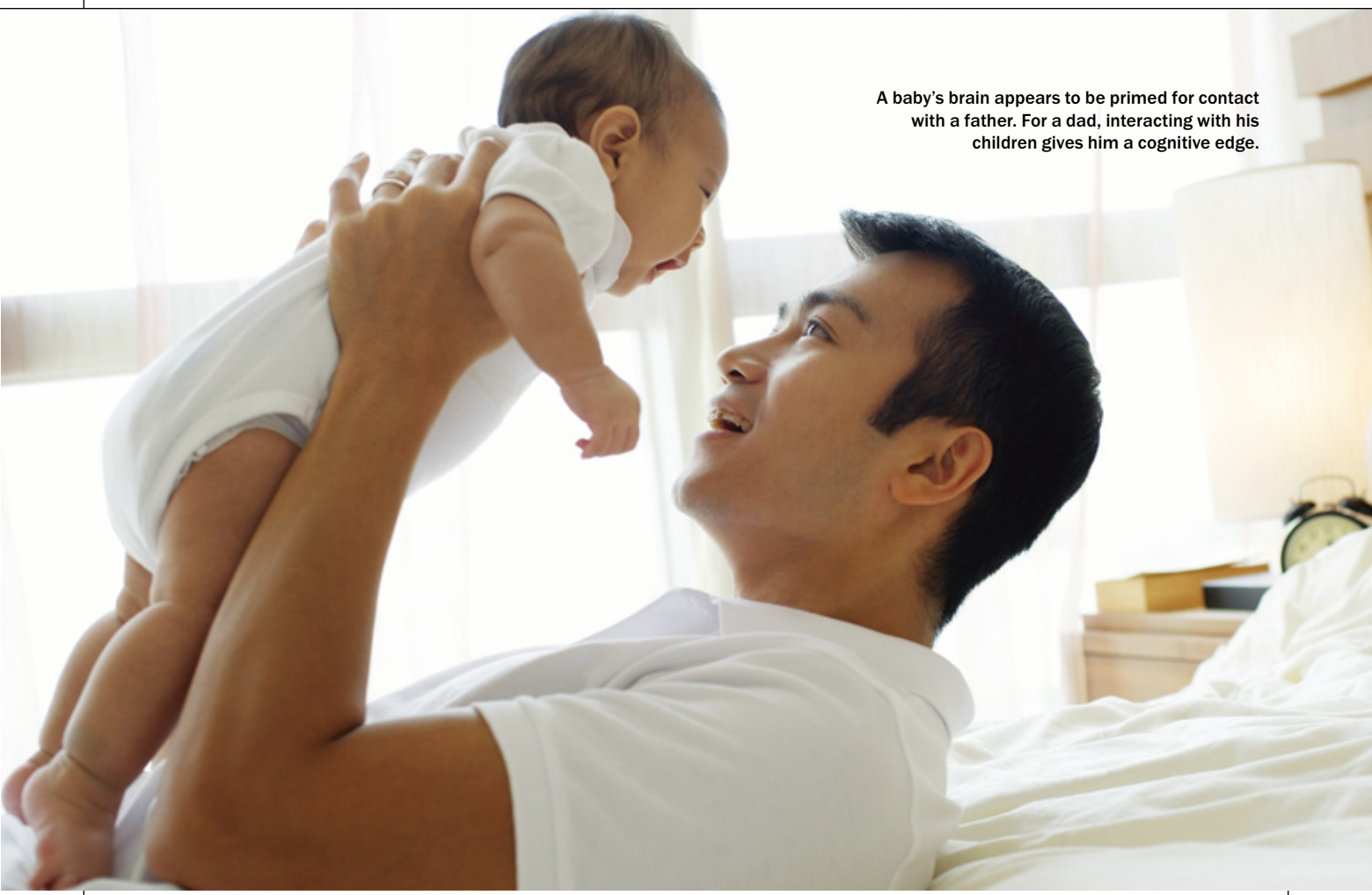
1» The brains of babies and fathers alike benefit from one another's influence.

2» A father sprouts supplemental neurons in his brain and experiences hormonal changes after the birth of a child.

3» For a baby, the presence of a father figure early on may be important for developing healthy behaviors later.

PRECEDING PAGE: PHOTOILLUSTRATION BY AARON GOODMAN

© 2011 Scientific American



A baby's brain appears to be primed for contact with a father. For a dad, interacting with his children gives him a cognitive edge.

JADE LEE *Corbis (holding baby)*; ALAN THORNTON *Getty Images (car)*

Following birth, a mother's lactation serves as a natural food source for the newborn.

What a dad offers is less obvious. Sure, men help out during conception, but afterward we are not exactly crucial to a child's survival. Nevertheless, research shows that the father-child bond makes a major contribution. If a father leaves his children to be raised solely by their mother, they are more likely to suffer a whole host of problems later in life, including emotional troubles, aggression and addiction.

The numbers are actually quite staggering. In 2008 about one in four children lived with only their mothers, whereas only 4 percent lived with just their fathers. A third of the approximately 12 million single-parent families in the U.S. live below the poverty level. Perhaps as a product of struggling to make ends meet, single parents are at a higher risk of raising children with lower academic achievement and self-esteem, as well as difficulties forming social relationships. Until recently, large population surveys were the most effective tool for investigating a father's contribution to the upbringing of a child. But new clues are emerging from deep inside the brain. Neuroscientists are now revealing one critical part of the puzzle—the biological mechanisms that connect a father and his child.

Take the sound of a baby's cry. In 2003 psychiatrist Erich Seifritz of the University of Basel in Switzerland and a team used functional MRI to show that just as in mothers, certain areas in the brains of dads became activated with a signature pattern unlike that of nonparents who heard the same sounds. Al-

For a guy to set aside the sports car and man up to a minivan, his brain must surely have revised its circuitry. Indeed, neural modifications nudge him toward nurturing behaviors.

© 2011 Scientific American

A dad's ability to grow new neurons is at the mercy of prolactin—the hormone that controls milk production in mothers.

though the team could not pinpoint exactly what had changed, the brains of both parents appeared to have adapted to recognize the sounds critical to a baby's comfort and survival.

Brains, after all, are not static. Neurons constantly rewire themselves in response to new experiences and changes in our surroundings. Additional neurons can also materialize, a process called neurogenesis. The mechanisms of neurogenesis are not fully understood, but scientists have connected extra brain-cell growth with learning new things.

Brainpower Boost

Building off these observations, Gloria K. Mak and Samuel Weiss, two neuroscientists at the University of Calgary in Alberta, designed a series of experiments to figure out how offspring might reshape a father's brain. In results published in 2010 Mak and Weiss showed that the brains of mouse dads do not simply rewire, they also sprout additional neurons. The cells form brand-new connection pathways, or circuits, in the days following the birth of the pups. In the olfactory bulb, new neurons developed that responded specifically to the smells of his pups. Another set of neurons grew in the father's hippocampus, a crucial memory center in the brain, which presumably helped to consolidate the smell of his pups into long-term memory.

The mouse father only gained the extra brain cells if he stayed in the nest, though. If he was removed on the day of his pups' birth, his brain remained the same. As Weiss sees it, this study demonstrates that the experience "is not just changing what exists [in the brain] but developing something brand-new to serve the relationship."

In mammals, neurons located in the nose use special odor receptors to detect scents and shuttle the information to the olfactory bulb, which is the integration center for our sense of smell. Simply sniffing his pups, though, was not enough to cause new neurons to spring into existence. When Mak and Weiss placed a mesh screen across a cage to separate a dad from his pups, they saw no additional brain cells appear. This test and other similar ones indicate that neither the birth of the new off-

When children are raised without a father, they are at a greater risk of developing emotional troubles, experiencing aggression and suffering from addiction.

GK HART AND VIKKI HART Getty Images (mice); PAUL CARTER Redux Pictures (woman swinging children)

© 2011 Scientific American

Evolution of Fatherhood

By Nina Bai

Changes in the brain turn a man into a father, but how those patterns emerged over time remains largely a mystery. In only about 10 percent of mammalian species do fathers invest in their offspring's survival.

Part of the answer may lie in the energy cost of humans' long childhoods, suggests graduate student Lee Gettler of Northwestern University's Laboratory for Human Biology Research, in a 2010 paper in *American Anthropologist*. Because early hunter-gatherer societies routinely walked several miles a day, men might have carried young children, thus lessening the burden on mothers and other weaker caregivers, such as grandmothers. A supportive father would have gained an evolutionary edge by enabling the mother to regain her strength and produce more children.

Hands-on child-rearing makes evolutionary sense for men in other ways, too. According to one theory, males provide child care to show off their abilities as partners. Such displays could help them keep their current mates or even attract new ones, says anthropologist Shane J. Macfarlan of Washington State University Vancouver. Some studies suggest that men are more likely to tend to their children's needs in public places, such as playgrounds and grocery stores, than at home.

Most biological and psychological studies offer glimpses of fatherhood in urban-industrial societies—mere snapshots given the hundreds of thousands of years during which humans lived as hunter-gatherers in close-knit groups. A survey of fatherhood in contemporary small-scale societies by Macfarlan and Barry S. Hewlett, also at Washington State, shows great variation across cultures. For example, the Kipsigis people of East Africa believe that the strength of a father's gaze can harm an infant, so fathers remain completely hands-off in the first four or five years of the child's life. In contrast, fathers in the Aka group of hunter-gatherers in Central Africa regularly stay within an arm's reach of their infants. The message is clear: "No universal standard for fatherhood exists," Macfarlan says.

Nina Bai is a science writer living in Brooklyn, N.Y.

spring nor their smells alone change a dad's brain, Weiss says. Rather the hands-on experience of being a father brings about the extra dose of brain cells. Physical contact with the pups, coupled with the experience of their smells, is what makes the neurons grow, the researchers suggest.

But are pups different from pals? A few weeks' separation is usually enough for adult mice to forget all about their former cage mates. Mak and Weiss demonstrated that the parent-child bond indeed stands out. These new neurons formed their own brain circuits, thus helping to form long-term memories and therefore a lasting bond. With distinct memory pathways forged, the mouse fathers easily recognized their offspring by smell even after they had been separated for three weeks. "We still struggle to understand why new neurons are born in the brains of all mammals, including humans," Weiss says. "It certainly appears as though one of the main functions may be to adapt to change, form new circuits, and, in this case, [create] what we call a 'social memory' between the father and his offspring."

Like Mother, Like Father

To solidify social memories, the brain relies on hormones to control the connection of those newly forged neurons. Mak and Weiss found that the father's ability to form new brain cells is at the mercy of a hormone called prolactin—the same hormone responsible for milk production in new mothers. When they disrupted the brain's ability to produce prolactin, they discovered that fathers did not form any offspring-specific brain cells.

Also parallel to how babies and mothers bond, many studies have shown that human fathers with higher levels of oxytocin (the "love hormone") exhibit stronger paternal instincts and motivation in the first months of their child's life. In findings published last December, Atsuko Saito of the University of Tokyo and Katsuki Nakamura of Kyoto University pushed that observation further by studying the food-sharing habits of marmoset father monkeys. Marmoset dads readily feed their youngsters during their first four months. But after six months, the fathers begin to ignore their now adolescent offspring and keep their food for themselves. To test what drives the change in behavior, the team infused oxytocin into the brains of marmoset fathers. Regardless of the dose Saito and Nakamura administered—and with no change in the fathers' appetites—the male marmosets were more likely to indulge their offspring's clamoring for food.

Because prolactin and oxytocin are both heavily tied to social interaction, their involvement in the father-child bond may not be surprising. Nevertheless, new data are providing a broader prospective. As psychologist Elizabeth Gould of Princeton University and her colleagues pointed out in an October 2010 review article, hormones relating to sex and stress have now also been linked to paternal behaviors.

Gould has published numerous papers detailing the connection between the human stress hormone cortisol (corticosterone

(The Author)

BRIAN MOSSOP holds a Ph.D. in biomedical engineering and has had postdoctoral training in neuroscience. He writes for *Wired*, *Scientific American*, *Slate* and *The Scientist* and is the community manager at the Public Library of Science (PLoS).

© 2011 Scientific American

in rodents) and structural changes in the brain. Although stress usually has a negative connotation, Gould and her colleagues have used experiments with rodents to show that it can be both good and bad for the brain, depending largely on context. For example, bad stressors, such as when animals are briefly submersed in cold water or exposed to a natural predator, have negative effects on the brain, reducing the brain's ability to generate new neurons and rewire itself. But as Gould and her colleagues published last July, stressors such as exercise and sex, which also boost corticosterone levels, actually stimulate new brain cells to grow. The challenges of fatherhood may well fall into the category of good stress.

Although male sex hormones seem to be deeply intertwined with the birth of offspring, other species show that the hormones have inconsistent effects. In certain rodents and fish, fathers produce excess testosterone. They take good care of their young and simultaneously maintain aggressive tendencies that help them to, say, defend the nest against predators. In tropical birds and primates, however, elevated testosterone levels get in the way of good parenting. Human fathers with excess amounts of testosterone may exhibit less sympathy for and desire to respond to a crying baby.

These studies make a strong case for hormones as the brokers of certain paternal behaviors. As Weiss points out, this line of research is "adding a new dimension to the impact that hormones can have on adult brain-cell production."

A Critical Link

Whereas an arsenal of hormones cultivates a father's brain in the presence of a baby, a child may actually be born ready to bond. To test this idea, a research team led by neurobiologist Katharina Braun of Otto von Guericke University of Magdeburg in Germany turned to a rodent with a remarkably familiar nest structure. Degu rat mothers and fathers split the parenting duties. Similar to human fathers, degu dads spend the early days of their pups' lives helping with basic care, huddling over them to keep them warm and bathing them with gentle licks when needed. As the pups get older, the fathers begin to play with their toddler offspring by chasing them, romping and roughhousing around the cage.

The challenges of child care are likely to be good sources of stress. The hormones induced by good stress can stimulate the growth of new brain cells.

ARIEL SKELLEY *Getty Images*

Braun and her team reasoned that degu nests lacking fathers would create a social and emotional void for the offspring, just as a missing dad would affect the dynamics of a human family. Indeed, they found that if a rodent father remained in the nest with his pups, his babies' brains developed normally. But if the father was removed from the nest shortly after the birth of his pups, they observed in two regions of the brain that the newborns developed fewer synapses, the short chemical junctions that allow brain cells to communicate with one another.

At a stage of development when most of the brain should be burgeoning with new connections, the pups raised without a father had deficits in the orbitofrontal cortex and the somatosensory cortex. The orbitofrontal cortex is part of the prefrontal cortex, which regulates decision making, reward and emotion. And although it is difficult to extrapolate from rodent studies to effects in humans, it is worth noting that faulty synapses and processing problems in this locale might well explain why we see some kids who grow up without a dad wrestle with occasionally serious behavioral problems.

Taken together, these rat studies suggest a model for why fathers matter. A newborn emerges into the world having spent weeks afloat in amniotic fluid, its senses somewhat deprived and its somatosensory cortex ripe for change. But instead of flourishing in the early postnatal days, the synapses of the somatosensory cortex wither away when degus are raised without a father. As a result, the newborns may not process touch as well as they should, which could lead to a number of other developmental problems, such as metabolism issues and irregular hormone production.

A father's brain, it seems, is significantly and beautifully intertwined with his offspring's. "Having two parents is one thing," Weiss points out, "but having effective relationships between parents and offspring is yet something else. It's ac-

Faulty brain connections may explain why children who grow up without a dad often wrestle with behavior problems later.

© 2011 Scientific American

For a dad, the scent of a child, along with physical contact, appears to be pivotal to making new neurons grow. Those neurons form the foundation of a lasting bond between father and child.

ERIK ISAKSON *Corbis*

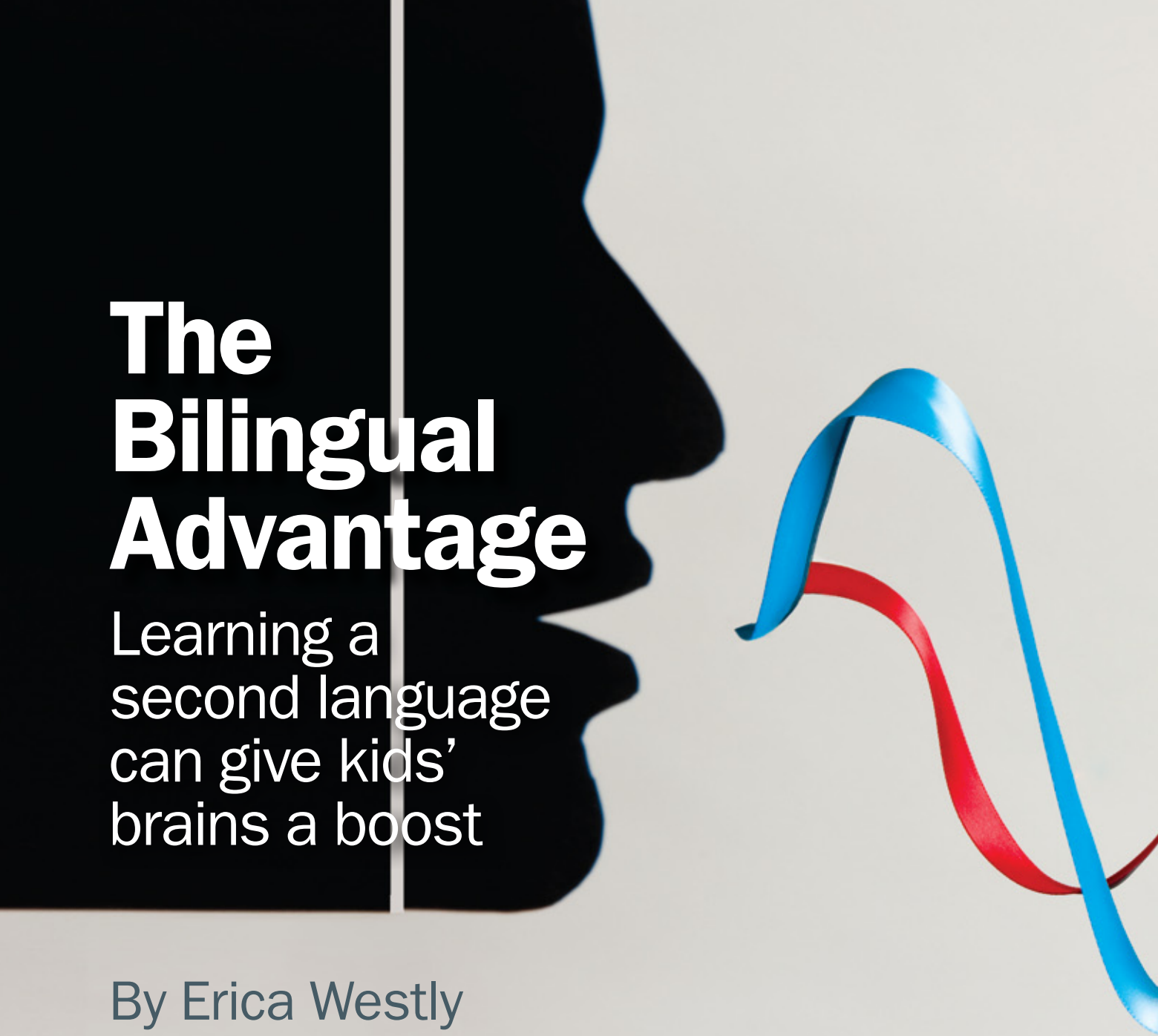
tually the effectiveness of the relationships [that matters]."

Perhaps my nephew, bolstered by a healthy set of brain connections that formed in response to the simple fact of Jack's touch, has already collected the tools he will need to fend off behavioral and emotional challenges as he grows older. And while I can't exactly probe Jack's brain to see if he is sprouting neurons, I noticed an undeniable change in his focus as his new bond took hold. Small movements and sounds from Landon that went unnoticed by most people mysteriously captured Jack's attention. It is comforting to think that a small set of neurons might be tucked away in Jack's head solely dedicated to his son. M

(Further Reading)

- **Hit the Ground Crawling: Lessons from 150,000 New Fathers.** Second edition. Greg Bishop. Dads Adventure, 2006.
- **Family Guy.** Emily Anthes in *Scientific American Mind,* Vol. 21, No. 2, pages 46–53; May/June 2010.
- **Parenting and Plasticity.** B. Leuner et al. in *Trends in Neuroscience,* Vol. 33, No. 10, pages 465–473; October 2010.
- **The Role of the Father in Child Development.** Fifth edition. Edited by Michael E. Lamb. John Wiley & Sons, 2010.

© 2011 Scientific American



The Bilingual Advantage

Learning a second language can give kids' brains a boost

By Erica Westly

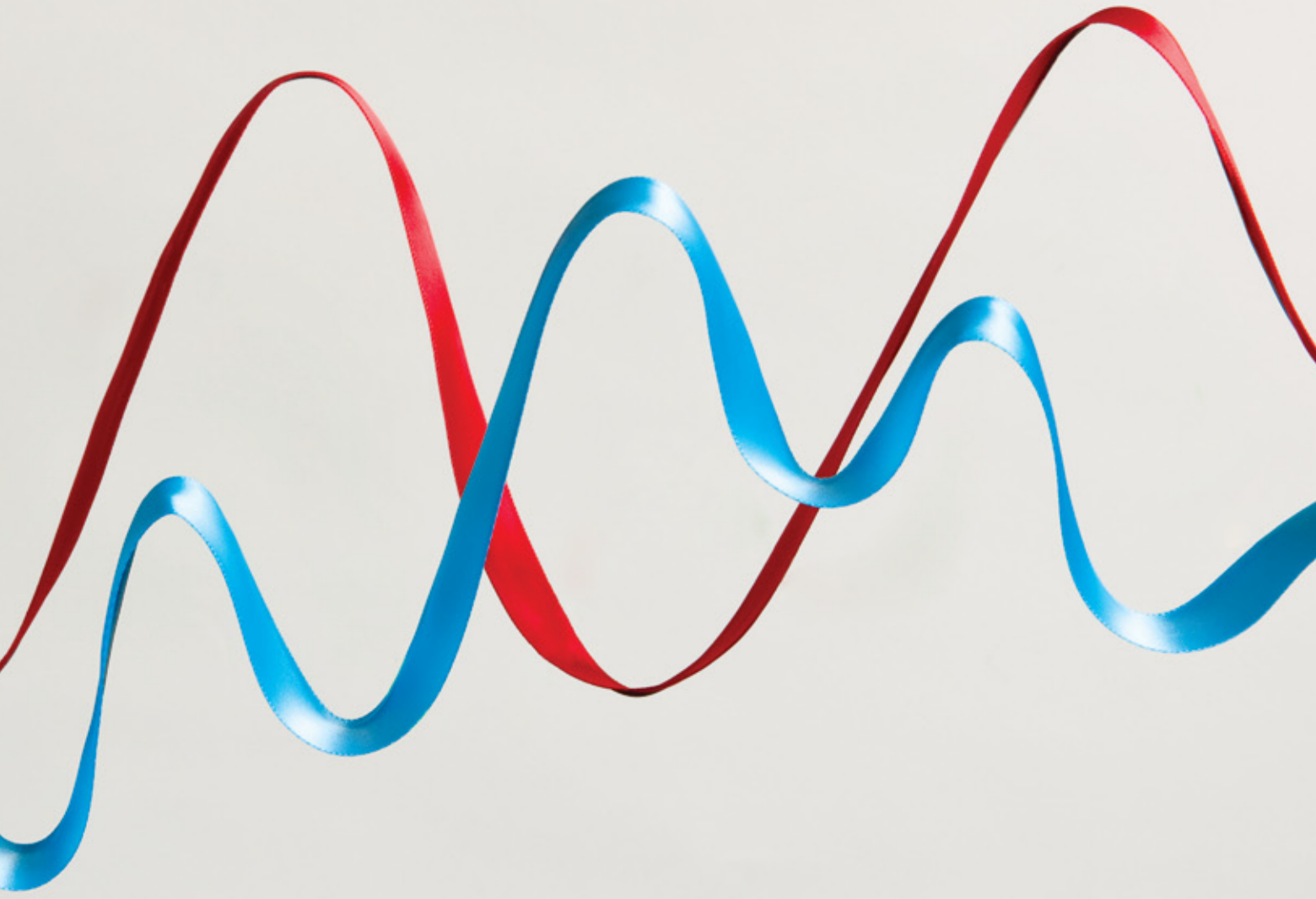
Many parents would like their children to master a second language, but few kids in this country do. Only 9 percent of adults in the U.S. are fluent in more than one language. In Europe that figure is closer to 50 percent. "The United States is a long way from being the multilingual society that so many of our economic competitors are," said U.S. Secretary of Education Arne Duncan at a meeting on foreign-language education last December.

Part of the problem is that American students are often not exposed to a second language until high school, and even then foreign-language training is rarely compulsory. Numerous studies have shown that children are more likely to learn a second language if they begin early, but in 2008 only a quarter of elementary schools in the U.S. offered some form of foreign-language instruction, according to the Department of Education.

This practice largely stems from the belief that teaching a child a foreign tongue too young could lead to verbal mistakes and delays because of interference between the two languages. In recent years, however, scientists have found the opposite: being raised bilingual may actually facilitate the development of certain language and cognitive skills. These aptitudes include mental flexibility, abstract thinking and working memory, a type of short-term memory essential for learning and problem solving.

KEVIN VAN AELST

© 2011 Scientific American



Mixed Messages

Until the mid-1800s, bilingualism was common in the U.S. But in the 1880s popular sentiment began to turn against immigrants, and psychologists proclaimed that exposure to more than one language rendered children intellectually inferior. Although researchers began to discredit these early studies in the 1960s, the idea that children needed to choose a dominant language persisted. "There was still this hypothesis that the brain is preset for only one language," says neuroscientist Laura-Ann Petitto, now at Gallaudet University in Washington, D.C.

According to this hypothesis, a bilingual child's mind is engaged in a constant tug-of-war, which leads to verbal delays and confusion over which language to use. But in a series of studies begun in 2001, Petitto and her colleagues found that children exposed to two languages before the age of 10 reached key language milestones, such as saying their first words and learning to read, at the same time as their monolingual peers and showed no signs of language contamination or confusion. "These kids understand that they have two different languages right from the start," she says. "They're not confused."

Recent research suggests that not only can children differentiate between two languages at any early age, the cognitive benefits from being exposed to a second language start as early as infancy. In a study in 2009 of "crib bilinguals," cognitive

(The Author)

ERICA WESTLY is a freelance science journalist based in New York City.

© 2011 Scientific American

Kids who learn a second language at school may accrue intellectual benefits from the linguistic training that extend far beyond the ability to converse with foreigners.

psychologists Agnes Kovács of Central European University in Hungary and Jacques Mehler of the International School for Advanced Studies in Italy used a visual test to measure what neuroscientists call cognitive flexibility in preverbal seven-month-olds. Kovács wanted to see how quickly the infants could adapt to changing rules. They taught the infants a pattern consisting of speechlike sounds. At the end of the sequence, a visual reward in the form of a puppet would appear in one part of a computer screen. The infants were expected to learn that a given sound pattern predicted the appearance of the puppet in that location. Both bilingual and monolingual infants showed that they associated the sound sequence with the puppet's location equally well by looking in the right place for the puppet to appear. But when Kovács modified the sequence—and moved the puppet—the bilingual infants adjusted, switching their anticipatory gaze to the new location. The monolingual infants, however, continued to look for the puppet in the original location.

Molding the Cerebrum

Other research suggests that being raised bilingual improves other cognitive skills once a child becomes verbal. In a study published in 2010, psychologist Esther Adi-Japha and her colleagues at Bar-Ilan University in Israel found that four- to five-year-old bilingual children showed more creativity than did their monolingual peers when asked to draw a fantastical house or flower. The monolingual children tended to draw flowers with missing petals or leaves, whereas the bilingual children drew imaginary hybrids, such as a "kite-flower" and a "robot-house," indicating a superior ability to grasp abstract concepts [*see illustration on opposite page*]. Meanwhile data from a 2008 study from Petitto's lab suggest that children from English-speaking homes who attended half-Spanish, half-English schools perform better on reading tests than those in English-only programs.

Several studies have also linked bilingualism to improved working memory, which is associated with both reading and math skills. "What's striking is how many of the benefits are nonverbal," says psychologist Ellen Bialystok of York University in Toronto. In unpublished research Bialystok and her collaborators at Nanjing University in China found that bilingual seven-year-old children outperformed their monolingual peers on two working memory tests—

FAST FACTS

Thinking in Tongues

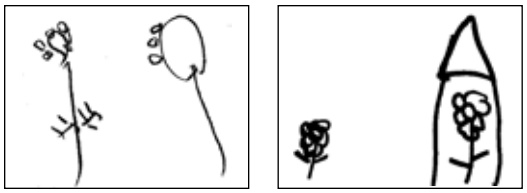
1» In 2008 only a quarter of elementary schools in the U.S. offered some form of foreign-language instruction.

2» Growing up bilingual does not lead to verbal delays as psychologists once supposed.

3» Bilingual kids top monolinguals on several cognitive measures; they show greater mental flexibility, a superior grasp of abstract concepts and better working memory.

LIBRADO ROMERO *Redux Pictures*

© 2011 Scientific American



When asked to draw a flower that does not exist, monolingual kids tended to omit flower parts (*left*). Bilinguals often added context, depicting, say, a flower as a door (*right*), a hint that their thinking is more sophisticated.

one requiring them to recall and rearrange a series of numbers and the other to retrace a pattern of hops made by an animated frog on a computer screen.

All these cognitive differences imply that learning a second language tweaks the structure of the developing brain. Although standard brain-scanning technology, functional MRI, is not generally recommended for young children, a relatively new noninvasive neuroimaging technique called functional near-infrared spectroscopy now enables scientists to compare the brains of bilingual children with their monolingual peers. So far studies indicate that the language areas of monolingual and bilingual brains develop similarly, but certain regions, such as the inferior frontal cortex, which is involved with both language and thinking skills, appear to be more active in bilingual children, particularly when they are reading.

Researchers say the best way to become proficient in a second language is to start young and practice often. "Language training has to be systematic," Kovács says. Daily exposure to the second language is ideal, experts note. Children growing up in multilingual environments can reach this level of exposure naturally, but those from monolingual backgrounds may need more intensive instruction. One solution may be immersion schools, which teach some classes in a nonmajority language, such as Spanish or Chinese. Funding and staffing these programs are difficult, but they are becoming more popular in the U.S. and Canada. "Some students come out fluent; others not as much. But the benefits are clear," Bialystok says. "Everyone should be allowed to be bilingual." M

(Further Reading)

- **New Discoveries from the Bilingual Brain and Mind across the Life Span: Implications for Education.** Laura-Ann Petitto in *Mind, Brain, and Education,* Vol. 3, No. 4, pages 185–197; 2009.
- **The Benefits of Multilingualism.** Jared Diamond in *Science,* Vol. 330, pages 332–333; 2010.

FROM "COGNITIVE FLEXIBILITY IN DRAWINGS OF BILINGUAL CHILDREN," BY ESTHER ADI-JAPHA ET AL., IN *CHILD DEVELOPMENT*, VOL. 81, NO. 5; SEPTEMBER/OCTOBER 2010

Words of Wisdom

By Lauren Migliore

Becoming fluent, or even just reasonably competent, in more than one language not only advances a child's thinking skills, it also confers cognitive gains in adulthood. In particular, something about being bilingual seems to bolster the brain against mental decline. In 2010 psychologist Ellen Bialystok and her colleagues at York University in Toronto reviewed the mental health and education records, including language training, of 211 patients diagnosed with dementia. They found that as a group, the 102 patients classified as bilingual had been diagnosed 4.3 years later (and reported the onset of symptoms 5.1 years later) than had the 109 monolinguals, despite all of them having roughly equivalent cognitive function and similar occupational demands while they were all healthy. These data, which confirm those from an earlier study, indicate that bilingualism may help delay the onset of dementia.

Knowing a second language somehow seems to moderate the effects of encroaching pathology in the brain. In work Bialystok's team described earlier this year, the researchers scanned the brains of 450 monolingual and bilingual patients diagnosed with Alzheimer's-like dementia for lesions and structural changes. The subjects all displayed a similar degree of cognitive function, but the bilingual subjects' brains showed more atrophy and damage in regions involved in long-term memory, language recognition and auditory perception. Bialystok hypothesizes that by virtue of being bilingual, the patients can somehow compensate for the greater structural damage.

Speaking more than two languages may offer an even better defense. Also in 2011 researcher Magali Perquin of the Public Research Center for Health in Luxembourg and her colleagues reported evaluating the neuropsychological health of 230 elderly men and women who spoke two to seven languages. They found that the people who spoke three or more languages were one quarter as likely to be mentally impaired than those who spoke just two. That greater amounts of language learning seem to offer stronger protection buttresses the contention that this training is constructing some kind of cognitive shield.

Such findings fit with the more established idea that learning and education thwart intellectual decline by building up the brain's overall capacity for thought—its so-called cognitive reserve. Psychologist César Ávila Rivera and his colleagues at Jaume I University of Castellón in Spain reported in 2010 that bilingual adults are quicker and more efficient at certain tasks involving the use of skills known as executive functions, such as planning and problem solving. Of course, a person's mental capacity can influence his or her ability to learn a new language, raising the possibility that the bilingual speakers had better cognition to begin with. But other work has indicated that learning a second language can promote beneficial brain changes. For example, it can boost the neuronal cell density in certain areas important for cognitive functioning. And research underscoring the cognitive advantages of growing up bilingual [*see accompanying article*] reinforces the notion that something about learning to say *oui, sí* or *hai* helps to shore up the thinking parts of your brain.

Lauren Migliore is a freelance writer based in southern California.

© 2011 Scientific American

Thinking BY Design

The science of everyday beauty reveals what people really like—and why **By Helmut Leder**

© 2011 Scientific American

YUJI SAKAI Getty Images (paper); RYAN McVAY Getty Images (red couch); LEONID NYSHKO Alamy (white couch); ALAMY (purple couch)

Walking down a residential street in the evening, you might find yourself glancing through the brightly lit windows of the houses you pass. As you peek inside, you take stock of the occupants' selections: the mahogany chaise lounge with the curved armrests in one house, the sleek leather couches and minimalist paintings in another.

Each person's aesthetic taste seems distinct, and yet that perception belies a large body of shared preferences. Our team at the University of Vienna, among others, has sought to unravel the patterns and principles behind people's emotional reactions to objects. Although trends drive certain design decisions, scientists have identified fundamental properties of the mind that consistently dictate which products people tend to like and dislike. Psychologists are now better equipped than ever to explain how you came to choose your belongings in the first place. They can also begin to decipher why you continue to love certain purchases long after they have lost their initial shine, whereas others land in the trash.

Not only are our preferences predictable, they are also flexible. Using simple manipulations, researchers can watch you revise your aesthetic judgments in minutes. The essential idea surfaced in the late 1960s, when the late psychologist Robert B. Zajonc, then at the University of Michigan at Ann Arbor, proposed the mere exposure effect: seeing something repeatedly—be it a couch, a car or a coffeepot—boosts its attractiveness. But with repetition comes boredom, recent research suggests, and thus our appreciation for new or different designs. We can largely lose our interest in an object's appearance, even if we once assumed that looks were everything.

Individuals' design preferences may lead them to particular choices for living-room decor. But scientists are revealing a common psychology to explain consumer taste.

Big and Round

Product designers have long wanted to know what visual features have the power to draw us in or turn us away. Scientists probing the question have identified a handful of guidelines that serve as a starting point. For example,

© 2011 Scientific American

Humans gravitate toward rounded forms over sharp edges, perhaps because spiky objects such as thorns signal danger.

they have found that people prefer large objects to small ones, although no one is quite sure why. Individuals also tend to choose rounded forms over sharper shapes. In a study published in 2006 neuroscientists Moshe Bar and Maital Neta, both then at Harvard Medical School, reported that most consumers prefer curved sofas and watches to those with angular designs. A year later they proposed an explanation. They observed that sharp-edged forms activated neurons in the brain's fear hub—the amygdala—more strongly than rounded ones did, perhaps because angular objects such as thorns and knives signal danger [see "Building around the Mind," by Emily Anthes; Scientific American Mind, April/May 2009].

FAST FACTS

Looking Good

1» **People prefer big objects to small ones, round forms to sharp ones and complex designs to simpler renditions.**

2» **Observers often pick a prototype as prettiest, but these "average" examples of a face, coach or pattern can bore an expert or even someone in a good mood.**

3» **After a month of using a product, how the object feels is generally more important than how it looks.**

Humans are also attracted to symmetry. Ancient Chinese pottery and 20th-century Western paintings alike exhibit symmetrical shapes and patterns. People are known to prefer symmetrical faces, whose shape may suggest good health and reproductive fitness. In a series of studies psychologist Thomas Jacobsen of the University of Leipzig in Germany and his colleagues found symmetry to be the strongest predictor of beauty judgments among volunteers asked to evaluate basic shapes or abstract patterns.

Other factors, such as an object's complexity, can amplify visual appeal. We often find complex things prettier than simple ones, with complexity defined as the number of individual elements that make up a picture or shape. In a 2009 study psychologist Pablo P. L. Tinio, now at Queens College, City University of New York, and I documented how both symmetry and complexity figure into people's judgments of beauty. We asked 16 psychology students at the University of Vienna to evaluate the attractiveness of 160 two-dimensional black-and-white designs grouped into four categories: complex symmetrical, complex nonsymmetrical, simple symmetrical and simple nonsymmetrical [*see top illustration on opposite page*]. Confirming previous studies of symmetry and complexity, the complex symmetrical patterns were judged the prettiest. Simple symmetrical patterns received the next highest ratings, revealing that symmetry is more important to our impressions of beauty than complexity is. The results also support the idea that combining symmetry and complexity garners higher beauty ratings than does either factor alone.

Comfort Zone

A more subtle factor influencing our aesthetic judgments is our ingrained appreciation for the beauty of the prototype, which is often defined as the statistical average of all examples of that product or item. Because a prototype resembles many different examples of a type, it seems familiar to us even if it is in fact new. Thus, people are attracted to "average" faces—those that result from mathematically combining, say, a few dozen faces, making the proportions of the nose, mouth and eyes, as well as the distances between these features, match the average of the sample. Studies have also shown that we tend to like the aesthetic norm in general, including its appearance in furniture, works of art and even meaningless patterns of dots.

Some researchers have theorized that as with symmetrical faces, prototypes are pleasing because they exhibit no gross irregularities—an extension of our preference for people and animals that appear to

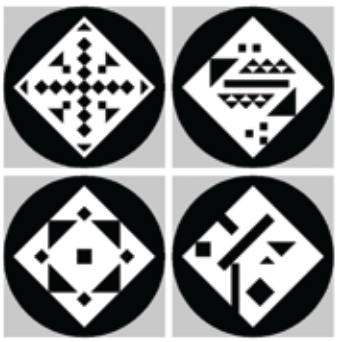
SEAN DUAN Getty Images

© 2011 Scientific American

FROM "JUST HOW STABLE ARE STABLE AESTHETIC FEATURES? SYMMETRY, COMPLEXITY, AND THE JAWS OF MASSIVE FAMILIARIZATION," BY PABLO P. L. TINIO AND HELMUT LEDER, IN *ACTA PSYCHOLOGICA*, VOL. 130, NO. 3; MARCH 2009. REPRINTED WITH PERMISSION FROM ELSEVIER; STIMULI CREATED BY THOMAS JACOBSEN *University of Leipzig (patterns)*; FROM "FUNDAMENTAL DIMENSIONS OF AFFECTIVE RESPONSES TO PRODUCT SHAPES," BY KUN-AN HSIAO AND LIN-LIN CHEN, IN *INTERNATIONAL JOURNAL OF INDUSTRIAL ERGONOMICS*, VOL. 36, NO. 6; JUNE 2006. REPRINTED WITH PERMISSION FROM ELSEVIER (*teakettles*)

The easier the object was to recognize, the better the participants liked it, the researchers found.

be in good health. But cognitive psychologists suggest another explanation, namely, that more typical faces or objects are easier to recognize, providing an efficiency advantage that may stimulate the brain's reward centers. In a study published in 2001 psychologists Piotr Winkielman, now at the University of California, San Diego, and John T. Cacioppo of the University of Chicago showed 16 volunteers 20 black-and-white drawings of items, such as a horse, dog, bird, house or airplane, they had manipulated to make more or less recognizable. Meanwhile the subjects rated how much they liked the image. To measure the participants' emotional responses, the researchers recorded the activity of the viewers' facial muscles with an electromyogram. Winkielman and Cacioppo found that the easier the object was to identify, the better the participants liked it—and the more activity they recorded in the facial muscles used in laughing. The results suggest that ease of recognition is an important factor in likeability.



People prefer complex patterns to simple ones. They also see beauty in symmetry. Thus, subjects liked the complex, symmetrical design (*upper left*) the best of these four.

But the power of prototypes may depend on context because shapes can play with our emotions. In a 2010 study Winkielman and his colleagues investigated whether prototypes might be comforting to people by manipulating the mood of 16 college students. They put some of them in a good mood by asking them to talk about a happy experience and others in a more solemn state by having them recall a sad event. If familiarity offers comfort and feelings of safety, the researchers reasoned, then it ought to be particularly appealing when someone is feeling down. Winkielman's group showed subjects 14 random dot patterns, all variations of a prototype, followed by a second series of patterns, some of which they had seen and some of which, including the prototype, they had not. In each case, participants rated their liking for the pattern.

The sad people preferred, and smiled at, the images they had previously seen, as well as the prototypes. But the cheerful people reacted differently: they neither preferred the patterns they recognized nor displayed positive emotional responses. They were also not particularly attracted to the prototype patterns. The researchers conclude that familiar forms provide reassurance or security when a person's mood signals an unsafe environment. Because happy people do not crave such comfort, such tried-and-true designs seem more prosaic than pretty.

Something Old, Something New

But you do not have to be incorrigibly jolly to like a taste of novelty. In 2003 a team led by Paul Hekkert, a professor of form theory at the Delft University of Technology in the Netherlands, reported asking three groups of volunteers, 79 in all, to evaluate various designs of electric sanders, teakettles, telephones and cars on their originality and beauty, as well as on how typical they looked. The participants rated the most conventional models as the least attractive, with only slightly warmer reactions to objects with such unusual shapes that their purpose was unclear. The top scores went to designs that coupled originality with classic forms—for instance, prototypes bearing one unusual feature. In other words, the most popular products look innovative while retaining a sense of the known, a principle that American designer Raymond Loewy called "most advanced yet acceptable."

Studies suggest that most individuals choose designs that bear a hint of originality but are based on a classic form.

Product designers may intuitively combine the tried and true with the new. For instance, car manufacturers often try to maintain some continuity of design for the purposes of brand recognition. In some cases, a brand even acquires a recognizable "mood" [*see box on next page*]: designers of the current model Aston Martin DB7 retained the mischievous facial expression of the classic James Bond mo-

(The Author)

HELMUT LEDER is professor of psychology at the University of Vienna in Austria, where he studies psychological aesthetics and cognitive ergonomics.

© 2011 Scientific American

Subjects who were repeatedly exposed to the drawings adjusted their preferences toward the innovative interiors.

bile of the 1960s. But manufacturers also tweak the designs with touches of complexity here and there to stave off buyer boredom—the Aston Martin and the new BMW 7 series, for example, have more lifelike "eyes" for headlights, complete with pupil and iris.

How much novelty a person likes in a particular product—or how easily a person is bored with a design—can depend on how much he or she knows about it. Experts can handle more originality than nonspecialists can. Hekkert and his colleagues have shown that those who know a lot about cars tend to favor unusually original designs. The more innovative a model, the more beautiful the specialists judged it. Similar studies of art connoisseurs suggest that expertise causes people to prefer more abstract or conceptual paintings, sculptures and drawings than amateurs do. Specialists, it seems, are more easily bored.

The expert effect, we reasoned, could result primarily from repeatedly seeing and evaluating a certain class of items. In a study published in 2005 psychologist Claus-Christian Carbon, now at the University of Bamberg in Germany, and I found some support for the idea that sizing up a particular product numerous times increases the liking for more novel, innovative instances of it. We presented 32 people with nine drawings of car interiors representing a range of classic and innovative designs. In each case, we asked a viewer to rate how much he or she liked the interior and how innovative it seemed on a scale of 1 to 7. To simulate repeated exposure, half the subjects looked at each drawing another 25 times, each time judging the degree to which it brought to mind a different adjective—disgusting, say, or pleasant, extravagant, stylish or ornamental. Meanwhile the other participants got a break from the drawings, instead answering unrelated questions about geography. Then we asked everyone again how well he or she liked each design.

In the first round of ratings, we saw that the more classic interiors were the most popular, a find-

The Car That Stares Back

Leonardo da Vinci noticed facelike images in objects, seeing eye-nose-mouth combinations emerge from the contours of a wall. You may have made out a human visage in a cloud, tree or other inanimate fixture of the environment. Because our brains are wired to recognize faces, we can imagine them almost anywhere. Some car designers take advantage of this phenomenon by deliberately fashioning the front of cars so that they bear specific "expressions." Some cars seem to smile, whereas others shoot an aggressive stare. Because faces elicit far stronger emotional reactions than nonliving objects do, embedding "faces" in consumer products is a way to draw people to these items in a uniquely powerful way.

This tactic now has some scientific backing: we have recently found that people process the front face of certain cars just as they do human faces. In 2010, along with my University of Vienna colleague anthropologist Sonja Windhager and others, I reported tracking the eye movements of 25 men and 25 women while they viewed side-by-side photographs of a face and of a head-on view of a car. We discovered that people scanned the car using the same pattern of eye movements as they did the face—first, directing their gaze to the headlights, as they did to the eyes on the face, and then to the radiator grille, the car's "nose," and the lower air inlets, which resemble the mouth.

When asked to compare the eyes, nose, mouth and ears (side mirrors) between a face and a car, people moved their eyes among the corresponding features, glancing from the headlights to the eyes, the radiator grill to the nose (or sometimes, the mouth), and so on, indicating that they interpret these car parts as elements of a face. What is more, just as people tend to focus on the eyes of others more than on any other feature, the test subjects were most frequently drawn to the headlights, fixing their eyes on them the greatest number of times. These results suggest that people's anthropomorphic assumptions seem to guide the manner in which they visually process information about the front of a car. *—H.L.*

Carmakers may engineer vehicles with facial expressions to draw in consumers. The look may even signal a brand: the 1965 Aston Martin that James Bond drove (*left*) has a mischievous grin like that of its modern (2002) counterpart (*right*).

ALAMY (*left*); MICHAEL WALD *Alamy* (*right*)

© 2011 Scientific American

ing consistent with our previous work. When we asked subjects to judge the pictures a second time, those who had seen each interior just once before stuck with their initial impressions. In contrast, the individuals who had been exposed to the drawings ad nauseam adjusted their preferences toward the more innovative interiors. The classic forms had lost their allure. This effect occurs fairly rapidly—after only about 20 minutes of exposure.

For consumers, these findings suggest that a well-informed buyer should spend some time with a product before committing—perhaps by test-driving a new car a couple times or walking around in a new pair of shoes. Even a relatively short experience with an item will likely reflect your long-term preferences better than your initial responses will, and the extra time invested may in fact turn your eye toward more innovative and fun products. For their part, designers may want to concentrate on adding unique features to those major purchases that consumers will own for a long time.

The Smell of Disappointment

Experience affects not just our desire for novelty but also our fondness for complexity. In our 2009 study Tinio and I also found that overexposure to complexity—in this case, viewing detailed black-and-white designs—creates a contrast effect. After repeated exposure to complex patterns, participants judged simple ones to be prettier; equivalently, massive exposure to simple patterns rendered people partial to complexity, making it the overriding factor in their judgment of attractiveness. Symmetry, on the other hand, turns out to be resistant to repetition—participants consistently liked the symmetrical designs.

The influence of long-term experience is not limited to how we see things. Contrary to the main focus of designers—and most scientific studies—looks are not always paramount. In a 2010 study Hekkert and psychologists Anna Fenko and Hendrik N. J. Schifferstein, both at Delft, asked 243 graduate students to report their experiences with a recently purchased product—say, a pair of shoes, a printer or a coffee machine—while buying it and then after the first week, the first month, and the first year of owning and using it. The students reported how much each of their senses contributed to their interactions with the product.

Averaging across 93 different products, the investigators found that an object's visual impact was strongest at the moment of purchase. After a month of using the product, however, how it felt to the touch became more important than its appearance, and after a year the look, feel and sound of the product were valued equally. "To avoid consumers' disappointment," the authors conclude, "retailers should think of ways to demonstrate the nonvisual properties of products at the buying stage (how a computer mouse feels, what kind of noise a coffeemaker makes, and so on)." Of course, the role of the different senses varies with the product—after a year hearing dominated for high-tech products, whereas for shoes their feel and look were equally important.

When a person is deciding to buy something, a product's appearance is paramount. After a month of using the item, however, how the object feels to the touch becomes more important. For shoes, comfort remains critical after a year.

RON BERG Getty Images

The large number of influences on our aesthetic judgment might seem to make it difficult to predict our eventual happiness with a purchase. But the research suggests easy guidelines for consumers to follow. We should consider the feel, sound or even smell of something when we are deciding whether to buy it, for example. We should think about our mood at the time: Did it influence our choice of the old-fashioned look over the modern one?

We might also perseverate a little over a potential purchase if it concerns a product we plan to own for a while. And when buying for a friend, bear in mind that your pal may like a more—or less—innovative item than you do if his or her expertise differs greatly from your own. So the next time you find yourself discreetly sizing up the neighbor's decor—and wondering about the particular objects that populate it—remember that, contrary to the old saying, there is some accounting for taste. M

(Further Reading)

- **Just How Stable Are Stable Aesthetic Features? Symmetry, Complexity, and the Jaws of Massive Familiarization.** Pablo P. L. Tinio and Helmut Leder in *Acta Psychologica,* Vol. 130, pages 241–250; March 2009.
- **Happiness Cools the Warm Glow of Familiarity: Psychophysiological Evidence That Mood Modulates the Familiarity-Affect Link.** Marieke de Vries et al. in *Psychological Science,* Vol. 21, No. 3, pages 321–328; 2010.
- **Shifts in Sensory Dominance between Various Stages of User-Product Interactions.** Anna Fenko, Hendrik N. J. Schifferstein and Paul Hekkert in *Applied Ergonomics,* Vol. 41, No. 1, pages 34–40; January 2010.
- **Priming Semantic Concepts Affects the Dynamics of Aesthetic Appreciation.** Stella J. Faerber et al. in *Acta Psychologica,* Vol. 135, No. 2, pages 191–200; October 2010.
- The Design & Emotion Society: **www.designandemotion.org**

© 2011 Scientific American

Outsmarting

Your intelligence affects your life span in several surprising ways

© 2011 Scientific American

Mortality

By Ian J. Deary, Alexander Weiss *and* G. David Batty

Illustrations *by* James Yang

© 2011 Scientific American

As Benjamin Franklin once wrote, "In this world nothing can be said to be certain, except death and taxes." Although some of us are clearly better than others at dodging the inevitable, in the end Mother Nature at least will always win. But along the path of life, people vary greatly in how often they get injured, incur illness or coast along in a comfortable state of health.

Considered at a distance, genetics and luck seem to explain a lot. But if we really understood why some people live longer than others, we would likely have diminished the gap by now. When epidemiologists and physicians discover some lifestyle choice or biological factor that leads to a longer and healthier life, they can then attempt to design intervention programs to ameliorate the health prospects of the population as a whole.

Some habits such as cigarette smoking have been identified as bad, but in general the search for answers has proved difficult. The reason is that every single one of us begins our journey through life with unique biological and environmental circumstances and then proceeds to make an uncountable number of lifestyle choices, any of which may or may not impact health. No study can take every factor into account—all the people in the world are not enough to run investigations of this scale.

In recent years research psychologists, including two of us (Weiss and Deary), have joined physicians and epidemiologists, such as one of us (Batty), in the search for predictors of well-being, illness and death. We often use data from health studies that span several decades. In these projects, hundreds, thousands or sometimes even a million individuals are regularly checked and examined over the course of many years. By sifting through such data, we and other researchers in this area have uncovered a new predictor of how long people live: the scores they obtain on an intelligence test when they are at a young age.

The findings are unequivocal, although few health practitioners are aware of them. The lower a person's measured intelligence, the greater that individual's risk of living a shorter time, developing both mental and physical ailments later in life and dying from cardiovascular disease, suicide or an accident. More surprising still is that low intelligence is a stronger predictor than several better-known risk factors for illness and death, such as obesity and high blood pressure.

Having found this unexpected facet of longevity, we had to ask why it exists. We and other researchers tried to explore whether factors other than intelligence might underlie our findings, such as people's socioeconomic status, education levels and employment. Scientists have already established that people who are less educated, work in manual rather than professional jobs, or have lower incomes suffer from more illnesses and tend to die earlier. So you could easily suppose, for example, that intelligent youngsters get more education, learn more about health through their schooling and thus live longer.

Indeed, the predictive power of intelligence for health and death diminishes after we control for the level of people's schooling. But testing these possibilities is not as straightforward as it might sound. Think of it this way: intelligence affects how well we do in school, so education levels might, in fact, just be a rough measure of intelligence.

For the sake of making the strongest argument possible, however, our work

FAST FACTS

Healthy Brains, Healthy Bodies

1» **Large population studies have revealed strong links between intelligence and both mental and physical health.**

2» **Lower scores on intelligence tests correlate with higher risk of developing personality disorders, depression and several types of cardiovascular disease, among other illnesses.**

3» **By acknowledging the role of intelligence in health disparities, public health specialists can intervene to help close the gap.**

© 2011 Scientific American

and studies by others treat education, socioeconomic status and similar factors separately. Our initial observation held—the magnitude of a person's measured intelligence still links up with a range of health outcomes.

If we can tease out the role of intelligence in health disparities, we might find ways to improve society's overall well-being. The eventual aim of this type of research, called cognitive epidemiology, is to reduce health inequalities across a population. To the extent that it is possible, cognitive epidemiologists want to help people maintain the best possible health throughout life regardless of how they perform on a handful of tests.

The Nature of Intelligence

For more than a century, psychologists have argued whether intelligence consists of many independent mental abilities or whether it is instead a single property that each of us possesses to one degree or another.

Our everyday experience offers some support for both interpretations. We all know people who seem to have obvious cognitive strengths and weaknesses. They may, for example, be poor at verbal reasoning but excellent at working out mathematical problems in their head. Or they might perform well at both these tasks and also excel—or fail—when confronted with a different set of mental challenges. But the data tell us a different story.

In 1904 British psychologist Charles Spearman discovered that if you test a group of people on a wide range of mental abilities, the scores form a clear pattern: subjects who do well on one type of cognitive task tend to do well on all the others. He called this phenomenon general intelligence, a term usually shortened to *g*. Countless studies using myriad mental tests have replicated this finding again and again. General intelligence is a fact of human existence.

It is not, however, the only component of smarts. Although *g* explains most of the differences underlying mental performance, the brain also recruits specific cognitive skills to carry out a task. People differ in three types of capability—general intelligence, broad domains of mental performance, and specific abilities. Unlike many things in life, here we can have things both ways: the idea of general intelligence is correct, but it is not the only key to being bright.

With respect to health, *g* is the aspect of intelligence that matters. How well

© 2011 Scientific American

we rate in *g* remains very stable across our lifetime. It also acts as a good predictor of a person's success in a wide range of domains, including employment, education, social life and everyday practical decision making. In data sets with tens of thousands of participants in England, intelligence at age 11 very strongly predicted performance in national school exams five years later. Later in life, social mobility and income also appeared tied to *g*.

Linking Intelligence and Health

Over a lifetime most human brains function reasonably smoothly: they process sensory information correctly, carry on social interactions and react appropriately to life's ups and downs. A small but significant percentage of individuals, however, will experience some form of mental illness.

Dozens of studies indicate that low intelligence is a slight, early indicator of a person's chances of developing a mental illness. One scientific report found that British children with lower intelligence scores at age 10 or 11 were more likely to say they had experienced psychological distress in early adulthood than their higher-performing counterparts. By middle age these same individuals were at a greater risk of hospital admission for any psychological disorder.

Another study followed a selection of Swedish schoolchildren for more than three decades. Children who tested lower in intelligence developed personality disorders once they reached adulthood more frequently than those with better scores. Research on a group known as the Vietnam Experience Study cohort confirmed the trends and also examined the reverse direction—it found that individuals suffering from more than one psychiatric problem had by and large fared poorly on intelligence tests.

Even more evidence comes from a survey of nearly one million Scandinavian men who were conscripted into national military service. Lower intelligence at around age 20 was associated with a greater risk of suffering by midlife from several psychiatric disorders that warranted inpatient care. These illnesses included schizophrenia, mood disorders such as major depressive episodes, and alcohol-related problems.

Lower intelligence also appears to magnify the risk of coming to physical harm, as the investigators studying the Swedish military conscripts found. The enlistees with lower intelligence-test scores were more likely to die of suicide; homicide mortality followed the same pattern. This surprising finding prompted the researchers to explore the link between intelligence and hospitalization for assault. Indeed, more intelligent men were less likely to experience an attack

MORE SCIENCE See the *Psychological Science in the Public Interest* article, "Intelligence and Personality as Predictors of Illness and Death: How Researchers in Differential Psychology and Chronic Disease Epidemiology Are Collaborating to Understand and Address Health Inequalities," on which this story for *Scientific American Mind* is based, at the Association for Psychological Science's Web site: **www.psychologicalscience.org**

© 2011 Scientific American

of any description. Likewise, the risk of being involved in a fight or brawl was more than eight times as great for the least versus the most intelligent members of the group. Data on unintentional injuries such as those received in traffic accidents also matched this trend, with a doubling of risk for individuals at the lower end of the intelligence range as compared with those at the top.

At first we struggled to come up with a convincing theory that could tie together all these varied outcomes. We derived one clue from a finding common to the studies. The connection between intelligence and all of the end points we just discussed is graded. That is, the difference in risk does not kick in just for below-average or very low intelligence-test scores. Instead the risk grows gradually as intelligence decreases.

Let us start by looking at how this point can help us flag the various causes contributing to mental illness. If we had seen the impact of intelligence on health only for people with the lowest scores, we might have supposed that sometimes the intelligence tests were reflecting undetected neurodevelopmental problems. Although that interpretation might explain some cases, now we can hypothesize that a subset of the population may be at an early stage of some psychiatric disorder that is reducing their intelligence, such that as the disease progresses, intelligence declines further.

A link between low intelligence and mental illness may also explain the suicide risk that researchers have observed. Conditions such as depression greatly increase the chances that a person will commit suicide. That risk may be aggravated by the possibility that lower intelligence limits an individual's capacity to resolve problems or personal crises, and suicide is thought of more prominently as a solution. Such speculations remain to be tested, however.

As for the connection between intelligence and both assault and homicide, researchers have put forward a number of hypotheses. We know that people with lower intelligence tend to be at a socioeconomic disadvantage. Therefore, the risks they encounter might simply reflect the downsides of living in poorer, more dangerous neighborhoods. Alternatively, the effects might emerge from differences in a person's ability to perceive risk; people who are higher in intelligence might be more aware of their surroundings and less likely to, say, take shortcuts through dark alleyways.

The risk of getting in a fight or brawl was more than eight times as great for the least versus the most intelligent members of the group.

A third possibility, based on the fact that intelligence is strongly related to verbal skills and reasoning, is that people who are less intelligent might not be adept at ending arguments by "jaw-jaw" rather than "war-war," to paraphrase Winston Churchill. As for the statistics on unintentional injury, lower intelligence might signal a fuzzier perception of risk or slower reaction times, both of which track with intelligence. An accurate appraisal of a risky situation and speedy reactions certainly seem like useful things in avoiding accidents.

From Brainpower to Blood Flow

Later in life, low intelligence-test scores continue to have strong implications for an individual's health. The studies described earlier assessed mental health no later than middle age. They did not explore the various forms of dementia that typically occur in older age. With a demographic shift toward a more elderly population and an absence of successful treatments, understanding the causes of dementia and identifying it early are crucial to minimizing its impact.

In 2008 researchers had the rare opportunity to investigate whether intelligence can also predict dementia. They followed up on a landmark study known as the Scottish Mental Survey of 1932, which tested the intelligence of almost all children born in 1921 and attending school in Scotland on June 1, 1932. It tested 87,498 children—about 95 percent of the target population. The scientists reported that having a lower score on a childhood intelligence test was a risk factor for late-onset vascular dementia but not Alzheimer's-type dementia.

Here we find another important clue. Vascular dementia and Alzheimer's disease manifest themselves with similar symptoms—in both disorders, patients show severe cognitive impairment. But unlike Alzheimer's, the causes of vascular dementia are more closely tied to physical health: diabetes, cardiovascular disease and hypertension are all risk factors. The finding from the Scottish survey suggests that the pathway between early-life intelligence and later cognitive decline in-

(The Authors)

IAN J. DEARY and ALEXANDER WEISS are psychologists at the University of Edinburgh. G. DAVID BATTY is an epidemiologist at University College London and holds an honorary post at Edinburgh.

© 2011 Scientific American

volves vascular processes—the body's ability to effectively circulate the blood—rather than, say, a person's mental resilience to brain damage.

In fact, several studies have linked lower intelligence, as measured during the participants' youth, with later cardiovascular disease, an umbrella term that encompasses coronary heart disease and stroke. In Western populations that are middle-aged and older, the most common cause of death and disability is cardiovascular disease. Coronary heart disease in particular is the leading killer in the U.S. It occurs when fatty deposits block the coronary arteries that supply blood to the heart. If blockage takes place, heart muscles die and the person has a heart attack.

The most likely explanation for the role of intelligence in predicting cardiovascular disease is a straightforward one. Across the board, lower intelligence appears to be related to lifestyle choices that harm health. Cigarette smoking, excessive alcohol consumption or alcohol abuse, physical inactivity and poor diet—all of which likely elevate the risk of cardiovascular disease—are more common in men and women whose scores on intelligence tests in childhood and early adulthood are lower.

These health-impairing habits may also have further physiological consequences—namely, the metabolic syndrome. This illness describes a combination of characteristics related to diabetes and cardiovascular disease risk: abdominal obesity and higher body mass index, fasting glucose, triglyceride levels and blood pressure. In layman's terms, think of it as having a beer belly, weighing too much for your height and coping with high blood sugar and elevated cholesterol. A 2008 study found that the metabolic syndrome explained about one third of the now reasonably well-established association between intelligence and death from cardiovascular disease.

Deciphering the Data

These findings begin to paint a picture of how higher intelligence may better equip some people to stave off poorer physical health and earlier death. But researchers in cognitive epidemiology still strive to integrate the data to form a broader scientific story of how thinking power relates to illness.

One possible narrative is known as the system-integrity hypothesis—basically that differences in our bodies are to blame. The idea is that intelligence tests

© 2011 Scientific American

not only reflect the efficiency with which a brain operates but also indicate more generally a well-put-together body, one that is best prepared to respond to life's challenges. Measures of a person's reaction times, and therefore the information-processing efficiency of that person's brain, also appear to predict longevity. Faster reaction times mean longer life.

In fact, if we control for reaction time, the effect of intelligence is no longer a predictor of mortality at all. If a brain's processing speed reflects the overall integrity of the nervous system—and possibly a good physical composition—we might have another possible explanation for the connections we see with cardiovascular disease, vascular dementia and such seemingly unrelated phenomena as accidental injury. But without a full understanding of why intelligence and reaction times correlate so strongly, interpreting the mechanisms remains a guessing game.

Another possibility is that we are observing the powerful effects of the environments in which we live. As we noted earlier, higher intelligence scores are associated with both educational success and socioeconomic achievement. People who perform less well on intelligence tests tend to occupy lower socioeconomic rungs. As a result, these individuals may face a lifetime of additional challenges and stressors—as well as a greater risk of becoming the victim of a crime—that their more intelligent counterparts simply do not encounter.

Whether one road or many connect our respective intelligences to our longevity, the numerous health-related choices we make in our lifetimes may well pave them all. Should I try smoking? Do I see my doctor about this funny feeling in my chest? Do I take a taxi or bus home at night, or do I brave walking through a rough neighborhood? More intelligent individuals may be making better choices that promote well-being and an extended life.

Naturally, anywhere between none and all these hypothetical scenarios may explain the connection we have been describing. More possibilities probably exist. What is important is that this research has provided valuable insights and brought out new ideas that future experiments can test. But only by studying people across long periods can we amplify what we have learned so far.

The pathway connecting early-life intelligence and later mental decline appears to involve the body's ability to circulate its blood.

Why It Matters

Studies of twins and other genetic relatives have shown that genes play a major role in determining just how intelligent you are. But we think that knowing more about the impact of intelligence opens up the possibility of improving and maintaining the health of individuals across all ability levels.

For example, as with patients who have a family history of cardiovascular disease, patients lower in intelligence could be advised to have their heart's health monitored more regularly. If research establishes that people with lower intelligence are less likely to receive adequate screening, comply with medication regimens and have follow-up examinations, special efforts could be made to engage them in such activities.

Because several highly reliable and valid measures of intelligence for younger age groups exist, health care professionals and teachers might be able to intervene early on and help individuals make more health-promoting decisions. We can also use this information to tailor educational programs for kids across a range of abilities.

Finally, teaching all children and adults, regardless of intelligence, techniques for maintaining a healthy lifestyle, developing nutritious eating habits and avoiding stressors could minimize the overall accumulation of cellular defects that impinge on longevity and long-term mental functioning. Indeed, the findings of cognitive epidemiologists such as ourselves bolster what all of us have known all along—that instilling good habits and healthy behaviors may lead to a lifetime of protection from the ravages of age. We emphasize, too, that *being* intelligent may not be the key ingredient for longevity. Instead *acting* and *deciding* as intelligent people do may be the crucial factor. For cognitive epidemiologists—and anybody else concerned with health—this distinction is a liberating thought. M

(Further Reading)

- **Human Cognitive Abilities: A Survey of Factor-Analytic Studies.** John B. Carroll. Cambridge University Press, 1993.
- **Intelligence: Knowns and Unknowns.** Ulric Neisser et al. in *American Psychologist,* Vol. 51, No. 2, pages 77–101; February 1996.
- **Intelligence: A Very Short Introduction.** Ian J. Deary. Oxford University Press, 2001.
- **The Mental Wealth of Nations.** John Beddington et al. in *Nature,* Vol. 455, pages 1057–1060; October 23, 2008.

© 2011 Scientific American

© 2011 Scientific American

POP STAR PSYCHOLOGY

Movies and TV shows can encourage risky behavior in children and teenagers, but teen idols have positive effects, too

By Sandra Czaja

Video games, movies and television, Facebook and Twitter—for a couch-potato child, digital culture is rarely more than a fingertip away. Young Americans spend on average about seven and a half hours a day with digital media. In fact, they often multitask, using many devices simultaneously to pack in some 10 hours and 45 minutes' worth of content every day, according to a recent Kaiser Family Foundation report. With kids devoting more free time to media than many adults spend at their full-time jobs, you would not be alone in wondering what they are taking away from the experience.

Of course, hand-wringing over how TV and the Internet are warping young brains is hardly new. Even for kids bedazzled by tweets and text messages, video—whether on a smartphone, at a movie theater or on an actual TV—still dominates the digital landscape. Indeed, recent studies show that children and teenagers develop beliefs directly influenced by the movie characters and TV stars they observe.

At first glance, TV seems decidedly troublesome. A Senate committee determined in 1999 that the average American child sees 200,000 violent acts—including 16,000 murders—on TV by the time they reach the age of 18. Somehow squeezed in between all the bludgeoning and bloodshed, nearly two thirds of all TV shows also manage to air overtly sexual material, the Kaiser Family Foundation reports.

To date, though, the research on whether movies and TV shows are a bad influence is still mixed. Many studies have demonstrated that exposure to sex, drugs and violence on-screen can make all three seem more acceptable in real life. But a growing body of work indicates that children also learn valuable lessons from television, long after their *Sesame Street* years have passed. As with any potential threat, parents need to offer guidance—reality checks that put "reality" shows in context.

(The Author)

SANDRA CZAJA is a science journalist living in Dortmund, Germany.

GETTY IMAGES

© 2011 Scientific American

Openly gay characters, such as Kurt Hummel on *Glee,* seem to foster acceptance of homosexuality among young viewers. Surveys show that students who watch a lot of prime-time TV tend to be more comfortable with alternative lifestyles.

ADAM ROSE *The Kobal Collection*

Switched On

First, the bad stuff. In 2002 Madeline A. Dalton and her colleagues at Dartmouth Medical School decided to investigate the thread connecting children, the media and risky behaviors by analyzing the impact of R-rated films. They surveyed approximately 4,500 students aged 10 to 14 and collected data on numerous factors affecting their lives, such as parenting characteristics, school performance and general rebelliousness. Of those whose parents let them watch R-rated films, 35 percent had smoked and 46 percent had tried alcohol. The teens who had not watched R-rated films—only 16 percent of the sample—appeared to be at one-third the risk of experimenting with drinking or smoking, when all other factors were accounted for.

Dalton's group then became curious about how those vices emerge over time. She and her colleagues asked some 3,500 middle schoolers—none of whom had ever smoked—to identify which movies they had seen from a list of 50 films, all featuring characters who lit up. They reinterviewed these same preteens 13 to 26 months later. By then about 10 percent of them had puffed on their first cigarette. The scientists found that the kids who had seen the most smoke-filled flicks were more than twice as likely as their peers to have tried smoking. They also noticed that smoking in movies made a stronger impression on teens whose parents did not smoke.

To look into the question of teen sexuality, in 2006 L. Monique Ward and Kimberly Friedman of the University of Michigan at Ann Arbor showed 244 high school students clips from popular TV sitcoms, some of which illustrated one of three stereotypes: "sex is relaxing," "women have to look good" or "men only think about sex." They found that the heaviest TV watchers in their sample were most likely to agree with the stereotypes and to have had sexual experiences at an earlier age. Amy Bleakley and her colleagues at the University of Pennsylvania reported similar findings in 2008. They surveyed 500 adolescents aged 14 to 16 and discovered that kids exposed to more on-screen sex tended to become sexually active younger. What is more, sexually active teens preferred more risqué programming.

Some 57 percent of Bleakley's respondents listed popular media as a main source of information about sex, trailing behind only friends, teachers and mothers. Based on this statistic, Bleakley, along with her colleagues Amy Jordan and Michael Hennessy, published an editorial in 2010 in the *Philadelphia Inquirer* urging the media to do a better job at presenting sex and its attendant risks. "Characters should discuss contraception," they wrote. "Unplanned pregnancies should not always be resolved with a convenient miscarriage. Plotlines that show romantic relationships should model conversations about testing for sexually transmitted diseases."

Ward has found evidence that more realistic scripts could help kids make better decisions. When she interviewed more than 500 teenagers who regularly watched the TV series *Friends,* 60 percent said the show had taught them how to say "no" when pressured sexually. Just less than half of the teens said that watching the show had made it easier for them to discuss safe sex with their partners.

Another study centered on *Friends* looked into the impact of one plotline in greater depth. Rebecca L. Collins of Rand Health found that teens gained valuable information from a 2003 episode in which a character discovers she is pregnant. Among the fans she questioned, 65 percent remembered the key fact from the episode—namely, that condoms are only 95 percent effective at preventing pregnancy. About one in 10 of those interviewed said they

FAST FACTS

Consumed by Culture

1 » According to media researchers, adolescents frequently look to celebrity role models for guidance on fashion, attitudes and behavior.

2 » Kids who see a lot of drugs and sex on-screen tend to drink, smoke and become sexually active sooner in life.

3 » Consuming media in a social environment can mitigate its negative effects. Young people can gain valuable insights by watching or discussing troubling stories with friends or family.

© 2011 Scientific American

The bonds that viewers forge with TV characters can be so significant as to substitute for actual friends.

talked to an adult about condoms after seeing the episode.

Television shows also may have the power to foster social tolerance among young adults. In 2009 Ward and Jerel P. Calzo, also at Michigan, polled attitudes about sexual orientation among more than 1,700 college students, almost all of whom identified themselves as heterosexual. The responses revealed that students who watched a lot of primetime television tended to be significantly more accepting of homosexuality—a subject that currently appears in about 15 percent of American sitcoms and series, according to Deborah Fisher of the Pacific Institute for Research and Evaluation. The influence of popular culture, however, is not limited to TV. Music video fans in the survey tended to be more comfortable with homosexuality, too.

Friends in TV Land

How can it be that screen personalities, who are often fictional, hold such power to change children's attitudes and behaviors? The answer lies in the bonds that teens—and, in fact, viewers of all ages—frequently forge with TV characters. Donald Horton and R. Richard Wohl first described these one-sided, or parasocial, relationships in a seminal paper in the journal *Psychiatry* in 1956. More recently, Tilo Hartmann of the Free University of Amsterdam described parasocial ties in more detail. As Hartmann sees it, fans do not simply like a character—they try to guess his motives and how other characters will react to him, much as they would with a real person. They know the character is not real, but they nonetheless perceive him as part of their social environment. Jaye Derrick and Shira Gabriel of the University of Buffalo and Kurt Hugenberg of Miami University in Ohio have shown that parasocial interactions can be so significant as to substitute for actual friends.

For teens, parasocial relationships can be especially meaningful. By identifying with favorite characters and observing how they navigate sticky on-screen situations, kids can learn strategies to handle problems they may feel uncomfortable discussing with family or friends. There can also be genuine benefits for adolescents who adopt celebrities as role models. Canadian psychologist Albert Bandura, who pioneered the theory of observational learning in the 1960s, found that adolescents tend to choose role models who exhibit positive traits—such as power, attractiveness and popularity—that the teens believe also describe themselves. Not all role models are created equal, but even seemingly undesirable ones, for example, ones who reject authority, may help teenagers establish independence, a crucial developmental step during puberty.

Karin Lenzhofer, a media researcher at the University of Klagenfurt in Austria, argues that current films, TV shows and music videos offer an abundance of positive role models, particularly for young women. She believes that seeing strong, self-possessed female performers and pop icons has a subliminal and largely positive effect on the self-image of girls. Claudia Wegener of the Konrad Wolf School for Film and Television in Potsdam, Germany, found evidence that supports that idea. In 2008 she interviewed more than 3,000 people between the ages of 12 and 20 and found that the die-hard fans among them were usually well integrated and socially engaged. For most, idol worship does not overshadow normal, everyday interactions.

Real-world relationships may in fact temper the influence of media role models. "Adolescents are not watching in an isolated environment," Wegener says. They often discuss specific characters with friends and family and form opinions based on those conversations. Indeed, today's teens want to talk: a study conducted in 2007 by Frank N. Magid Associates, a media consulting group, revealed that 93 percent of the teenagers surveyed had good relationships with their mothers, significantly higher than two decades ago. In keeping, the Nielsen Company has found that roughly a third of the primetime viewers of ABC Family, a network with several series about teens facing difficult circumstances, are women aged 18 to 49, suggesting that mothers and daughters are watching together. When adults help children make sense of what they see, read and hear, the media can be a powerful teaching tool. M

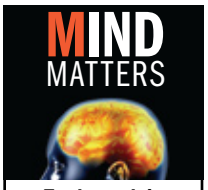
(Further Reading)

- **Social Learning Theory.** Albert Bandura. Prentice Hall, 1977.
- **Mass Communication and Para-Social Interaction; Observations on Intimacy at a Distance.** Donald Horton and R. Richard Wohl in *Psychiatry,* Vol. 19, pages 215–229; 1956. Republished in *Particip@tions,* Vol. 3, No. 1; May 2006.
- **Generation M^2: Media in the Lives of 8- to 18-Year-Olds.** V. J. Rideout, U. G. Foehr and D. F. Roberts. Kaiser Family Foundation, January 2010.
- **Television and Children.** Kyla Boyse. University of Michigan Health System guide. Available at **www.med.umich.edu/yourchild/topics/tv.html**

© 2011 Scientific American

Strain on the Brain

A stressful life may fuel Alzheimer's and Parkinson's disease **By Brian Mossop**



Each week in Mind Matters, www.ScientificAmerican.com/mind-and-brain, researchers explain their disciplines' most notable recent findings. Mind Matters is edited by Gareth Cook, a Pulitzer Prize–winning journalist at the *Boston Globe*, where he edits the Sunday Ideas section.

In 2007 Nobel laureate James Watson eyed his genome for the very first time. Through more than 50 years of scientific and technological advancement, Watson saw the chemical structure he once helped to unravel now pieced into a personal genetic landscape that lay before him.

There was one small stretch of DNA on chromosome 19, however, that he chose to leave under wraps. That region coded for the *apolipoprotein E* (*APOE*) gene. Since the early 1990s *APOE* has been a telling genetic marker of Alzheimer's risk: certain forms of it correlate strongly with the development of the disease. Watson's grandmother suffered from Alzheimer's, but without any reasonable treatments or proved preventive strategies, the discoverer of the double helix decided the information was too volatile, its revelation creating more potential harm than good.

Watson's apprehension is understandable. Treatments for Alzheimer's have consistently failed. But as scientists learn more and more about the brain, they have come to realize that genetics alone rarely dictates the course of an illness. Instead brain disorders result from a complex interaction between our genes and the environments to which we are exposed. Indeed, a set of recent studies has just uncovered an important environmental instigator of neurodegenerative disease: stress.

(The Author)

BRIAN MOSSOP holds a Ph.D. in biomedical engineering and has had postdoctoral training in neuroscience. He also writes for *Scientific American*, *Wired*, *Slate* and *The Scientist* and is the community manager at the Public Library of Science (PLoS).

Researchers have catalogued the effect of stress on numerous psychological conditions, including depression and chronic anxiety. The idea that stress may figure into neurodegenerative diseases, however, is relatively new. Although the notion that our high-pressure jobs and hectic lives might be doing additional damage could be worrisome, stress is at least something we can theoretically control. That is, trying to relax might be a first step toward raising the chances of keeping your brain free of disease in old age.

Tight Quarters

Since Alois Alzheimer first documented "presenile dementia" in a patient at the beginning of the 20th century, doctors have often observed that the disease runs in families. But not until the early 1990s, about the same time the *APOE* link surfaced, did researchers glean hints that nongenetic factors contribute to it.

Epidemiologist Brenda Plassman of Duke University and her colleagues teased out this environmental effect by studying identical twins, who share virtually the same genetic material. If a disease is driven purely by genetics, then when one twin develops it, the other will be stricken as well. By analyzing data from a large cohort of identical twins (all of them male veterans of World War II) collected by the National Academy of Sciences and the National Research Council, Plassman and her coworkers reported in 2000 that when one twin developed Alzheimer's, the other twin developed the

GERALD SLOTA

© 2011 Scientific American

© 2011 Scientific American

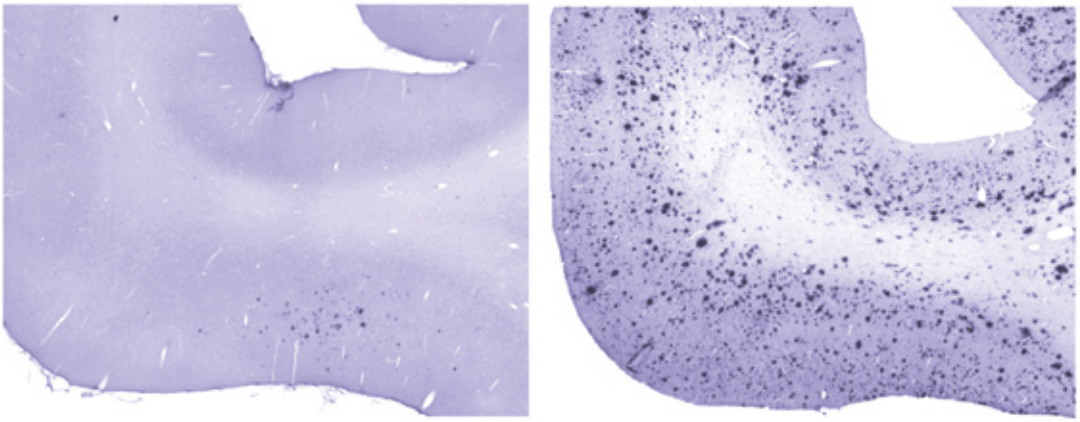
disease only 40 percent of the time. Concluding that factors besides genetics must be at play, the investigators have since been searching for those contributors. Among the possibilities: subtle medical conditions, occupational characteristics and physical activity levels.

Of course, your job and the amount you exercise both have an effect on your level of psychological stress, the mind and body's response to challenge and change. But only this year did evidence suggest that stress might be a key ingredient in the recipe for cognitive decline. To explore how different environments might affect the development of Alzheimer's, neuroscientist Mark H. Tuszynski of the University of California, San Diego, and his colleagues examined the brains of aged rhesus monkeys that had spent their early lives in either small or standard-size cages. Tight quarters have been shown to stress these animals, elevating levels of glucocorticoid hormones in their blood. The exact cause of this hormonal rise—whether it comes from a feeling of being trapped or an inability to get adequate exercise, or both—is still an open question.

Cortisol, a glucocorticoid hormone released when humans experience stress, influences the brain through specialized molecular receptors on neurons in a number of brain regions. When cortisol binds to its receptor, the interaction triggers molecular events that reduce communication at synapses, the junctions between neurons, which may ultimately cause the connections to wither away. Using protein stains that adhere specifically to synapses, enabling them to be seen, Tuszynski's team determined the relative number of synapses in all the monkeys. Using a similar method, the researchers also assessed the amount of sticky amyloid plaques, a pathological hallmark of Alzheimer's.

Compared with the monkeys raised in standard-size cages, those that lived in smaller cages had, on average, a significantly higher density of plaques and fewer synapses in one part of their brain—the same pattern seen in the brains of Alzheimer's patients at autopsy. The finding suggests that the size of an animal's cage—and perhaps the amount of stress it endures as a result—may shape that animal's brain in a way that affects its vulnerability to certain types of degeneration as it ages. Interestingly, the amount of plaque riddling the brains of the monkeys housed in smaller cages varied a lot, indicating that stress affects individuals differently. After all, we all know people who seem to take even mildly negative events to heart as well as others in similar situations who take their plight in stride.

The evidence from Tuszynski's group has its limitations. Observations in monkeys living in labs do not precisely mirror the human condition. In addition, these findings correlate only one aspect of early-life experience with pathological signs of degeneration. We do not know that the stress *caused* the changes, nor do we know whether those changes re-



Environmental stress can spur pathology reminiscent of Alzheimer's disease. The brains of monkeys raised in cramped cages were packed more densely with amyloid plaques (*dark spots, right*) than were those of animals reared in more spacious abodes (*left*).

FROM "ASSOCIATION OF EARLY EXPERIENCE WITH NEURODEGENERATION IN AGED PRIMATES," BY DAVID A. MERRILL ET AL., IN *NEUROBIOLOGY OF AGING*, VOL. 32, NO. 1; JANUARY 2011. REPRINTED WITH PERMISSION FROM ELSEVIER

FAST FACTS

Be Smart: Relax

1» **A recent wave of research has unveiled an important environmental player in the genesis of neurodegenerative disease: stress.**

2» **Pairs of identical twins developed Alzheimer's disease in concert only 40 percent of the time, showing that factors other than genetics must contribute to the disorder.**

3» **Stress seems to impede the ability of certain brain cells to recover from insults, triggering or aggravating the symptoms of disorders such as Parkinson's.**

© 2011 Scientific American

sulted in true cognitive slipups, because the scientists could not test the animals' cognitive function.

Toxic Tension

Nevertheless, additional studies in rodents suggest that even intermittent strain can tip the scales toward dementia, even if it does not lead to cognitive breaks on its own. In March 2010 neuropharmacologist Karim Alkadhi of the University of Houston and his colleagues put rats at risk for dementia by injecting them with very low concentrations of beta-amyloid peptides, the molecules that form plaques in humans. The researchers then stressed some of the animals by placing an intruder rat in their home cage. As expected, blood levels of corticosterone, a glucocorticoid, rose in the stressed rats.

Then the scientists placed each rat in a water tank containing a maze. A rat had to find the path that led to a platform to escape the water—a rodent test of learning and memory. Usually after a few tries, a rat will remember the correct route; it will then swim directly to the platform, even a day or two later. Most of the experimental rats—including those that had been given amyloid injections and those forced to face intruders—performed well. The rats that had received both the shots and the unwanted visitor, however, had difficulty. So although stress alone does not degrade memory, it does seem to push at-risk animals over the edge, making them less able to learn and remember new things.

Other work hints that stress may hasten the onset of Parkinson's disease, a neurodegenerative disorder characterized by motor difficulties rather than cognitive deficits. The loss of brain cells that produce dopamine, a neurotransmitter essential for voluntary movement, causes Parkinson's patients to shake, become rigid and lose coordination.

To re-create these deficits in rats, behavioral neuroscientist Gerlinde A. S. Metz and her colleagues at the University of Lethbridge in Alberta infused a toxic drug into a brain area rich with dopamine neurons. Some of these animals were put into a Plexiglas tube for 20 minutes a day for two weeks, producing a temporary boost in stress hormone levels. Another group received corticosterone shots, which kept the animals' stress hormones high throughout the experiment. Metz's team then tested the motor skills of all the animals. In one exercise, for example, the rats had to slip their paws through a narrow opening in a Plexiglas box to extract a small food pellet, an action that requires precise and careful movements.

The Metz team's toxic treatment is transient; usually the treated rats' motor skills improve with time. But the animals with elevated corticosterone levels—both the ones that spent time in a stressful environment and those that received hormone shots—continued to struggle with the pellet extraction task long after the other animals had recovered. The results suggest that stress impedes the ability of dopamine cells to recover from insults, triggering or aggravating Parkinson's symptoms.

Although **stress alone** does not degrade memory, it does seem to push at-risk animals **over the edge**, making them less able to learn and remember new things.

Indelible Mark

Using such eye-opening studies as these, scientists are learning that stress is more than a fleeting emotional setback. Rather, in certain situations, stress can leave an indelible mark on our brain.

But there is good news, too. Stress is a contributor to neurodegeneration that can be controlled. Just as many individuals with high cholesterol levels now take preemptive action to stave off heart disease, one day people may use, say, their *APOE* status to motivate them to adjust their lifestyles. Evidence suggests that simple interventions such as exercise, meditation and getting enough sleep can help reduce the stress of life's encounters. Such measures might even ease the anxiety of knowing which *APOE* stamp adorns your genome. M

(Further Reading)

- **Acute Stress Modulates Genotype Effects on Amygdala Processing in Humans.** Helena Cousijn et al. in *Proceedings of the National Academy of Sciences USA*, Vol. 107, No. 21, pages 9867–9872; May 25, 2010. **www.pnas.org/content/107/21/9867.full**
- **Association of Early Experience with Neurodegeneration in Aged Primates.** David A. Merrill et al. in *Neurobiology of Aging*, Vol. 32, No. 1, pages 151–156; January 2011.
- Metz Behavioral Neuroscience Lab: **http://people.uleth.ca/~gerlinde.metz/home.htm**

© 2011 Scientific American

Deranged and Dangerous?

Severe mental illness alone is not generally enough to cause violent behavior

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); TERRY VINE *Getty Images* (*blurred woman*)

EARLIER THIS YEAR a 22-year-old college dropout, Jared Lee Loughner, shot Arizona congresswoman Gabrielle Giffords through the head near a Tucson supermarket, causing significant damage to Giffords's brain. In the same shooting spree, Loughner killed or wounded 18 others, including a federal judge and a nine-year-old girl.

Information from Loughner's postings on YouTube and elsewhere online suggests that he is severely mentally ill. Individuals with serious mental illnesses have perpetrated other recent shootings, including the massacre in 2007 at Virginia Tech in which a college senior, Seung-Hui Cho, killed 32 people and wounded 17. These events and the accompanying media coverage have probably fed the public's perception that most profoundly mentally ill people are violent. Surveys show that 60 to 80 percent of the public believes that those diagnosed with schizophrenia, in particular, are likely to commit violent acts.

Although studies have pointed to a slight increase in the risk of violent behaviors among those afflicted with major psychiatric ailments, a closer examination of the research suggests that these disorders are not strong predictors of aggressive behavior. In reality, severely mentally ill people account for only 3 to 5 percent of violent crimes in the general population. The data indicate that other behaviors are likely to be better harbingers of physical aggression—an insight that may help us prevent outbursts of rage in the future.

A Tenuous Tie

Not all psychological and emotional disorders portend violence, even in society's eyes. In this column, we refer only to severe mental illness—meaning schizophrenia, bipolar disorder or psychotic depression. Symptoms of schizophrenia include marked disturbances in thoughts, emotions and behaviors; delusions (fixed false beliefs); hallucinations (perceiving things that are not physically present); disorganization; and withdrawal from social activities. Bipolar disorder is usually characterized by swings between depression and mania, which involves euphoria and grandiosity, a boost in energy and less need for sleep. Psychotic depression includes acute depressive symptoms, along with delusions or hallucinations, or both.

Most researchers investigating the

© 2011 Scientific American

An individual with a severe psychological disorder is **more likely to be a victim** than a perpetrator of violence.

question of aggression in the mentally ill have found a small but telling association between violence and significant psychological disturbance. In a 2009 meta-analysis, or quantitative review, of 204 studies exploring this connection, psychologist Kevin S. Douglas of Simon Fraser University and his associates found a slightly greater likelihood of aggressive behaviors among those with severe mental illnesses.

Yet this connection is much weaker than the public seems to believe it is and does not necessarily mean that these serious disorders cause violence. The causation could be in the reverse direction: engaging in chronic aggression (stemming from some other source) may create stress that triggers the illness in those predisposed to it. Alternatively, a third factor could spawn both a psychiatric condition and violence.

Rather than thinking of people with severe mental illness as generally dangerous, scientists are now pinpointing those other factors that might augur violent behavior more reliably. One strong candidate is drug abuse. Revealing results from the MacArthur Violence Risk Assessment Study in 1998, sociologist Henry J. Steadman of Policy Research Associates and his colleagues reported that almost a third of severely mentally ill patients with substance abuse problems engaged in one or more violent acts in the year after they left the hospital. For discharged patients who did not abuse drugs, the corresponding figure was only 18 percent. (That figure suggests that less than one fifth of severely mentally ill individuals without other issues are dangerously aggressive.)

In its meta-analysis, Douglas's team also flagged drug abuse as one of several factors that contributed to the connection between mental illness and violence. In addition, it found the link was even stronger for patients who suffered from delusions, hallucinations or disorganized thinking. Thus, a mentally ill person is more at risk of committing an act of aggression when that individual is also abusing a drug and shows particular symptoms.

Substance abuse may be a better predictor of violent behavior than mental illness.

Substance abuse greatly boosts the chances of violent behavior in healthy subjects, too, suggesting that drug use may be a much better predictor of violence than mental illness. What is more, proper treatment of mental illness can effectively eliminate the small risk of violent behavior posed by a grave disorder. In the MacArthur study, Steadman's team found no difference in the prevalence of violence between the severely mentally ill who were on their medications and mentally healthy people, whereas unmedicated patients lashed out at significantly higher rates. Of course, sick individuals who stop taking their medications could represent more difficult cases. Nevertheless, these results suggest that improving adherence to treatment may lessen the chances that severely ill people will behave violently.

Victims, Not Perpetrators

The stereotype of the crazed individual killing multiple strangers in public simply does not hold up to scrutiny. Although some noteworthy tragedies fit this description, these instances are quite rare. In fact, given how few mentally ill people become violent, a person with a severe psychological disorder is more likely to be a victim than a perpetrator of violence.

Mentally ill people are victims in their own right. A severe psychiatric condition is a terrible burden, even without being treated with suspicion by the community. A widespread belief that the afflicted are violent contributes to the stigma of mental illness and as such may interfere with their seeking and obtaining appropriate assistance. Debunking this misconception will likely lead to progress in helping troubled individuals and, by making treatment more broadly accessible, greatly reduce the threat that a small number of these individuals may pose to society. M

HAL ARKOWITZ and SCOTT O. LILIENFELD serve on the board of advisers for *Scientific American Mind*. Arkowitz is a psychology professor 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)

- **Violence by People Discharged from Acute Psychiatric Inpatient Facilities and by Others in the Same Neighborhoods.** Henry J. Steadman et al. in *Archives of General Psychiatry,* Vol. 55, No. 5, pages 393–401; May 1998.
- **Psychosis as a Risk Factor for Violence to Others: A Meta-Analysis.** Kevin S. Douglas, Laura S. Guy and Stephen D. Hart in *Psychological Bulletin,* Vol. 135, No. 5, pages 679–706; September 2009.

GETTY IMAGES

© 2011 Scientific American

The Partner Paradox

Why buddying up to help achieve goals may backfire

BY WRAY HERBERT

MY WIFE AND I go to spinning class a couple of mornings a week. It is something we like to do together, and I feel that I benefit from having a regular workout partner. Some days I am just lazy or I do not want to venture out in the predawn cold, but having a supportive partner motivates me. She bolsters my self-discipline when it flags.

Or does she? Is it possible that having a supportive partner might create the opposite and paradoxical effect, actually undermining effort and commitment to health and fitness goals over the long haul? Perhaps we conserve our limited supply of self-control, "outsourcing" our effort when we know that a close friend or partner is in the wings, helping us achieve a goal.

Two psychological scientists have been exploring this novel idea in the laboratory. Gráinne M. Fitzsimons of Duke University and Eli J. Finkel of Northwestern University suspected that moral support might have a flip side: namely, emotional dependence. If we know someone has our back, perhaps we unconsciously rely on that support to encourage us to reach our goals—and thus slack off.

Making a pact with your spouse to work out together may inspire you at first, but you could end up slacking off, relying on his or her nudge of encouragement to get moving.

MATT MENDELSON (*Herbert*); ANTHONY NAGELMANN Getty Images (*couple in bedroom*)

Honey, Help Me Exercise

Fitzsimons and Finkel recruited a group of women in their 30s, all of whom were in a romantic relationship, for an online experiment. The researchers gave half of them a tricky typing exercise intended to deplete them mentally, and the other half got an easy typing task. Then the scientists asked some of the women to think of an example where their partner had helped them achieve a current long-term health and fitness goal—such as picking up the slack at home or being a workout partner. (The researchers used women because past studies show most women have health and fitness goals that they care about—Fitzsimons and Finkel wanted to be sure the people in their study were thinking about goals that actually mattered to them.) The other group of women also thought about their partners' support but not specifically in the area of health and fitness; these women served as controls. Then, finally, the scientists asked all the volunteers a series of questions about their commitment to health and fitness and how much time and effort they

Knowing they had support seemed to make students less concerned about depleting their energy on mere entertainment.

© 2011 Scientific American

The women who outsourced their health and fitness efforts to a significant other were **more committed** to that partner.

planned to spend on such objectives the following week.

The idea was to see if thinking of a partner's support depleted personal effort and commitment—and that is just what the scientists found. Those who were aware of a partner's helping hand planned to commit less time and effort to their health and fitness. What is more, this effect was strongest among those who had been mentally depleted, suggesting that the women were outsourcing the work when they had less self-discipline in reserve to draw on.

I'll Do It Later

The scientists wanted to double-check these findings, and they did so in an interesting way. They recruited both male and female college students and asked some of them to think about how their romantic partners helped them achieve their academic goals. Other students thought about how their partners contributed to their recreational efforts, such as getting better at a sport, and still other students simply thought about something they liked about their partner.

Then the researchers gave the students the choice to either work on a tough academic exercise that they were told was designed to improve future test-taking skills or to procrastinate on an entertaining—but unproductive—puzzle. The results were consistent with the first experiment: the students who were aware that they had a reliable partner waiting in the wings procrastinated much more than did the students who had focused on their partner's likability. Knowing they had support seemed to make students less concerned about depleting their mental energy on mere entertainment.

A Combined Effort

These experiments make it sound as if having a wingman (or -woman) is a disadvantage. But not so fast. Fitzsimons and Finkel ran one more online experiment with a group of women in relationships, but in this one they also measured the volunteers' level of commitment to their partner. As reported in the online version of the journal *Psychological Science*, the researchers found that the women who outsourced their health and fitness efforts to a significant other were more committed to that partner. In other words, relying on a partner for help with meeting a goal might diminish the personal effort we devote to that target—but doing so benefits the relationship overall.

Even if the emotional dependence that comes from a partner's support undermines personal efforts, in the end the long-term relationship may benefit as shared goals are prioritized.

This last result has important implications for how we think about dependence in relationships, according to Fitzsimons and Finkel. We tend to think of dependence in terms of intimate and sexual needs, but these findings suggest that dependence might also arise from a partner's unique ability to assist with life's goals. Indeed, long-term partners may develop a shared self-regulatory system, relying on one another for support with mustering the discipline needed to face life's challenges. In the short term, relying on a partner for help with self-control in one arena means we could be undermining our commitment to that specific aim. But Fitzsimons and Finkel suggest there could a surprising trade-off: because we are investing more in our relationships, we might well end up possessing *more* discipline for a couple's shared goals. In the end, the partnership benefits. 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)

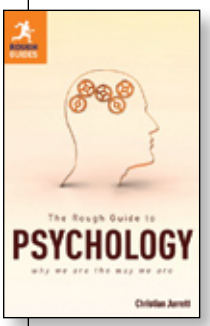
- **Outsourcing Self-Regulation.** Gráinne M. Fitzsimons and Eli J. Finkel in *Psychological Science*. Published online February 8, 2011.

RONNIE KAUFMAN/LARRY HIRSHOWITZ *Corbis*

© 2011 Scientific American

books

QUICK PSYCHOLOGY



The Rough Guide to Psychology

by Christian Jarrett. Rough Guides, 2011 ($18.99)

In the U.S., the ubiquitous For Dummies book series got its start with computer manuals and has since expanded to thousands of titles on everything from composing to composting. In England, a company called Rough Guides made its name selling travel books but has now branched out with about 70 reference books with titles such as *The Rough Guide to the Beatles.* Its latest entry is a 376-page, paperback-size book called *The Rough Guide to Psychology,* written by Christian Jarrett, a journalist who works for the British Psychological Society.

"We're all psychologists at heart," Jarrett writes, in the sense that we all want to understand human behavior. But real research psychologists, he says, are different from the rest of us "because they know what they don't know." They are skeptics, relying heavily on the methods of the natural sciences to find truth. An educator might believe, for example, that the best way to deal with troublemakers is with punishment; a researcher would test that idea by comparing the effects of teachers who punish with those of teachers who do not.

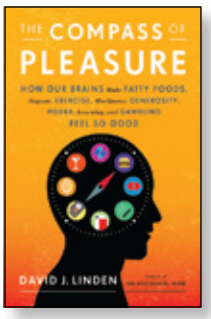
With this idea as its foundation, Jarrett takes us on a research-driven journey through intriguing topics: how memory is organized, why people make bad decisions, how genes set limits on intelligence, what science says about love, where prejudice comes from, and much more. Throughout, he describes experiments or surveys that support every point.

The range of topics is similar to that of an introductory textbook in college, but this volume is about a tenth the size and the writing is consistently lively. In effect, Jarrett has given us a book of psychological nuggets, often delivered in shaded blue boxes that tell us things such as: yes, people overestimate both their driving skills and head size; no, women do not talk more than men, but they do use kisses to size up potential mates more than men do; yes, the brain lights up in distinctive ways when people are experiencing religious feelings, but a "God spot" probably does not exist.

Having taught introductory psychology classes for many years, I was prepared to nitpick this admittedly rough look at the field, but the book holds up. It is accurate, up-to-date and easy to read. My only gripe is that it contains no references; if a passage on sleepwalking or autistic savants grabs your attention and you want to know more, you are on your own. That said, for a rough guide, this book is smooth.

—Robert Epstein

INNATE JOYS



The Compass of Pleasure

by David J. Linden. Viking Press, 2011 ($26.95)

The dog masturbating, the bird scouring for berries, the porcupine hunting for hallucinogenic plants, the human slamming quarter after quarter into a slot machine. Sure enough, animals are hardwired to seek pleasure. But when taken too far, this innate inclination can become an addiction.

In his book *The Compass of Pleasure,* David J. Linden draws on recent scientific findings to explain how pleasure manifests in the brain. Linden, a professor of neuroscience at Johns Hopkins University, provides a primer on the brain's pleasure circuit, walking the reader through examples of how highly addictive behaviors, such as gambling and doing drugs, as well as more mundane activities, such as exercising and playing video games, exploit reward pathways in the brain. In a strange twist of fate, the exact same brain circuits that allow us to enjoy life also fuel bad habits.

But addicts derive little pleasure from their vices. For them, Linden explains, it is the hunt for these experiences that becomes more pleasurable than the high itself. The intensity of the craving remodels those pleasure circuits,

» Roundup: Morality, Hypocrisy and Consciousness

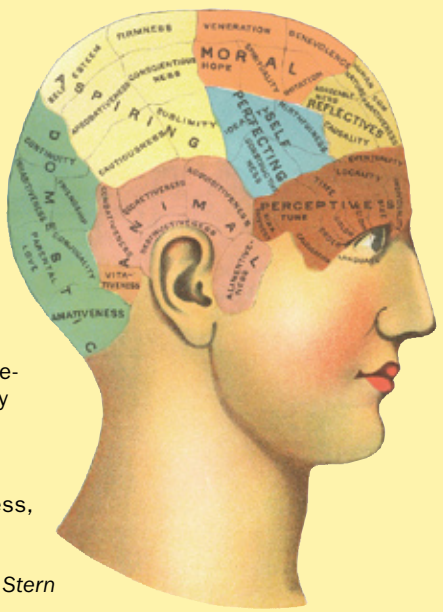
Three books explore these innate human traits.

What is morality? Where does it come from? According to neurophilosopher Patricia S. Churchland in her book **Braintrust** (Princeton University Press, 2011), morality originates in the brain. She argues that over time the human brain evolved to feel social pain and pleasure. As humans evolved to care about the well-being of others, they also developed a sense of morality.

Robert Kurzban believes that we are all hypocrites. But not to worry, he explains, hypocrisy is the natural state of the human mind. In his book **Why Everyone (Else) Is a Hypocrite: Evolution and the Modular Mind** (Princeton University Press, 2011), Kurzban asserts that the human mind consists of many specialized units, which do not always work together seamlessly. When this harmony breaks down, people often develop contradictory beliefs.

How is consciousness possible? In **Soul Dust: The Magic of Consciousness** (Princeton University Press, 2011), psychologist Nicholas Humphrey, a leading figure in consciousness research, proposes a startling new theory. Consciousness, he argues, is merely a magic show we stage inside our heads. This show has allowed humans to become aware of themselves and their surroundings.

—Victoria Stern



ALAMY

© 2011 Scientific American

causing desire to outpace pleasure. The same experiences that most people seek out for happiness, addicts need to feel normal.

Overall, the book serves as a status check on the neuroscience of pleasure. Although Linden scatters anecdotes and humorous personal experiences throughout his book, at times it reads more like a textbook, delivering accurate yet overly detailed descriptions of the brain's anatomy and biochemistry. His thoroughness has its perks, however—Linden does not shy away from pointing out the flaws or limitations in the research he presents.

Although recent boosts in techniques and technology have allowed scientists to look deeply into the brain for answers, Linden explains that the brain is endlessly complex and that we still have substantial ground to cover to fully understand pleasure and addiction. Our behavior will never be explained by one brain circuit—or one book, for that matter. But Linden has provided the first stalwart steps into this new frontier.

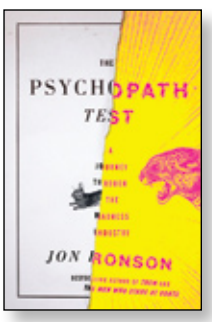
—Brian Mossop

UNCOVERING SANITY

The Psychopath Test: A Journey through the Madness Industry

by Jon Ronson. Riverhead Books, 2011 ($25.95)

It is easy to convince people that you are mentally ill. Claim to hear voices, threaten to hurt yourself, stop showering … basically if you just freak out enough people over time, you can probably be guaranteed a fresh new drug prescription and maybe even a few days in a psychiatric unit. But how would you go about convincing people that you are sane? That is a much harder task.



SANDRA VAN DER STEEN *iStockphoto*

In his new investigative adventure *The Psychopath Test,* journalist and filmmaker Jon Ronson does not just question the definition of insanity, he also expresses reservations about current methods used to diagnose it.

The book begins with a mystery so juicy it reads like fiction. A group of academics invite Ronson to help them figure out who sent them a partially constructed manuscript riddled with cryptic clues and an anonymous letter that taunts, "Good luck!"

Inspired to discover what kind of mind would pull such a prank, Ronson sets out on a journey to understand what defines insanity. Along the way, he meets a patient in a psychiatric hospital who claims he lied his way in to avoid a prison sentence and is now stuck inside after receiving a high score on a psychopath assessment checklist. The man's insistence that he is sane is perceived as a symptom of his madness. Is he a victim of a psychiatric system hell-bent on "defining people by their maddest edges," or is he indeed a psychopath weaving a twisted tale for his own amusement?

Determined to tell the difference, Ronson turns to psychology's most influential experts to teach him the art of diagnosing and spotting a psychopath. Armed with his new understanding, he practices on CEOs, politicians, war criminals—even himself. But instead of making things clearer, his sharpened perspective seems to have muddied the water further. He begins to wonder whether in the quest to categorize abnormality, the field of psychiatry has lost track of the many shades of normal.

The book is a page-turner. Ronson is charming and tackles poignant issues. "Should we define people by their madness or by their sanity?" he asks. How many so-called mental illnesses are just normal behaviors by another name? How permanent are the labels we assign? The line between sanity and illness has never seemed so blurred, but Ronson walks it with style.

—Samantha Murphy

event

SIXTH SCENT

Brain: The Inside Story

Through August 14, 2011

American Museum of Natural History

Admission: $24 ($14 for children), www.amnh.org

It is easy to identify a rose by sight and sometimes even by touch—but you might be surprised at how few people can identify it by scent. On February 23, when attendees of the sold-out lecture "Smell (and Taste) the Roses" at the American Museum of Natural History in New York City—an accompaniment to the museum's new Brain: The Inside Story exhibit—were asked to blindly identify the scent of a rose, only seven out of 105 people did so correctly. Some of the other guesses: wood, molasses, beeswax and papaya. "People differ in how they perceive many, if not all, odors," explained perfume expert and speaker Mandy Aftel. "Everyone's olfactory world is a unique, private world."

The evening's event, which included talks by Northwestern University neurologist Jay Gottfried and *New York Times* columnist and food author Harold McGee, ended up as a haphazard but fascinating introduction to the confusing world of olfaction and taste. Even though we are not terribly good at identifying scents, key behaviors such as hunting, maternal bonding and mating choice "all have odors at their heart," Gottfried said. Animals "largely depend on smell for their survival." One possible reason we struggle to name scents, Aftel suggested, could be because the olfactory parts of the brain are far from its language centers.

In addition, Gottfried explained, our perception of what we smell is strongly affected by our expectations. Case in point: when Gottfried uncorked a bottle of what he described as a smelly yellow liquid and asked the audience to raise their hands when they began to smell something, dozens did—only to find out later that the liquid was simply dyed water. "We are very susceptible to external clues and expectations about what we should smell," Aftel said.

So why is smell so complicated? Part of the reason is that it is closely tied to our emotions. As Gottfried described, the olfactory system projects directly to the amygdala and the limbic system, regions responsible for mitigating emotions and behavior, which are complex and largely unique to an individual. With so much still to learn about human odor perception, be prepared for more surprises.

—Melinda Wenner Moyer

© 2011 Scientific American

askthe**Brains**

What happens in the brain when we experience a panic attack?

—Davide Razzoli, Italy

***Paul Li**, a lecturer of cognitive science at the University of California, Berkeley, explains:*

BEFORE GOING onstage to give a presentation, you notice your breathing becomes heavy, your hands tremble and you feel faint. Though frightening, these symptoms are not life-threatening; rather they are indicative of a panic attack.

We know a fair amount about the physiology of a panic attack, but we have only recently started to understand how it affects our brain chemistry. Panic attacks are episodes of intense fear or apprehension. Sufferers often report thinking that they might be dying, choking or going crazy. They may also feel like they are experiencing a heart attack or about to black out. These episodes usually begin abruptly, reach their peak within 10 minutes and end within half an hour.

When people feel stressed, their sympathetic nervous system typically revs up, releasing energy and preparing the body for action. Then the parasympathetic nervous system steps in, and the body stabilizes to a calmer state. If the parasympathetic nervous system is somehow unable to do its job, a person will remain fired up and may experience the heightened arousal characteristic of a panic attack.

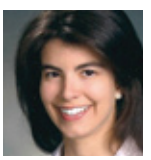
Recently researchers have identified certain regions of the brain that become hyperactive during a panic attack. These regions include the amygdala, which is the fear center of the brain, and parts of the midbrain that control a range of functions, including our experience of pain. A study performed by scientists at the Wellcome Trust Center for Neuroimaging at University College London used functional MRI to locate which specific brain regions kick in when a person senses an imminent threat. They found activity in an area of the midbrain called the periaqueductal gray, a region that provokes the body's defensive responses, such as freezing or running. Dean Mobbs, the lead author on the study, wrote: "When our defense mechanisms malfunction, this may result in an overexaggeration of the threat, leading to increased anxiety and, in extreme cases, panic."

By identifying brain regions involved in panic attacks, such studies can improve our understanding of anxiety-related disorders and in turn help researchers find better treatments.

Certain brain regions become hyperactive during a panic attack—the amygdala, our fear center, and parts of the midbrain that control our feelings of pain.

Why did the absence of the corpus callosum in Kim Peek's brain increase his memory capacity?

—A. Goze, via e-mail



***Jeannine Stamatakis**, instructor at Ohlone College and other colleges in the San Francisco Bay Area, responds:*

I MET KIM PEEK when he gave a presentation at Ohlone College in October 2009, just a few weeks before his passing. During the talk, Peek astonished my students by showcasing his remarkable talent for calendar calculations. Just from knowing my students' birth dates, Peek was able to determine the day of the week they were born and could recall the front-page news that day.

Known as a mega savant or a "Kimputer," Peek had one of the most impressive memories people have ever seen. Physicians who examined Peek discovered that he had damage to the cerebellum, a brain region that regulates attention and language, as well as emotional reactions, such as pleasure and fear.

Perhaps most notably, physicians found that Peek had no corpus callosum, the bundle of nerves that connects the brain's right and left hemispheres. They speculated that the absence of this critical structure allowed Peek's neurons to make new and unusual connections between his right and left hemispheres. These novel connections most likely explain his abnormal memory capacity.

According to Peek's father, Peek could memorize every word in the books they read before he was two years old. Peek progressed to reading two pages simultaneously. Although how he did so remains a mystery, some have theorized he read the left page of a book with his left eye and the right page with his right eye.

Peek could soak up material in any subject and became an expert in history, sports trivia, geography and music. He memorized zip codes, area codes and phone books. He could tell if a musician was "off" by a few notes in an orchestra setting—and would even call them on it.

Peek's unique abilities inspired the character Raymond Babbitt, played by Dustin Hoffman, in the 1988 movie *Rain Man*. To accurately portray Peek, Hoffman met him and other savants; however, unlike Peek, Babbitt was portrayed as having autism. M

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

COURTESY OF PAUL LI; COURTESY OF JEANNINE STAMATAKIS

© 2011 Scientific American

Head Games

Match wits with the Mensa puzzlers

1 WORD SQUARE

Complete the following word square, in which four words appear twice each, once in the rows and once in the columns. When you are done, the square should contain four Ls; two each of W, I, S and E; and one each of O, A, N and D.

O	W	L	S
W			
L			
S			

2 CAREER CHANGE

Transfer from the NAVY to the ARMY in eight steps, by changing one letter at a time to create a real word at each step.

N A V Y

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

_ _ _ _

A R M Y

3 TRIPLE ANAGRAM

Rearrange the nine letters shown below three different times to make three legitimate English words.

E T A S R E H T I

4 DISTRIBUTION OF ASSETS

After a successful day at the lemonade stand, Susie and Bobby found it difficult to split the profits evenly. Susie had 75 cents plus 75 percent of what Bobby had, and Bobby had 50 cents plus half of what Susie had. How much should Susie hand over to make the split fair?

5 MYSTERY NUMBER

Find the four-digit number in which the first digit is twice the third, the second is the remainder of the fourth minus the third, and the third digit is one-third the product of the multiplication of the second and fourth, and the fourth digit is the sum of the second plus the third.

6 POCKET CHANGE

You have an equal number of nickels, dimes and quarters in your possession, totaling $2.40. How many of each coin do you have?

7 LETTER SWAP

For each pair of words, find one letter that can be swapped for the third letter in each word to make two new common English words. Write that letter on the line between the words. For example, if the pair were "Cute" and "Dive," you would write "r" on the line between them. When you have finished, you will have an anagram of the name of a flower.

Boon _ Cold	**Cope _ Dole**	**Core _ Ruse**	**Done _ Gale**
Lot _ Ponder	**Moan _ Style**	**Ride _ Wire**	**Roam _ Step**

8 PATTERN PROBLEM

Which two numbers come next in the following series?

2 20 3 31 4 42 5 53 6 64 7 75 ? ?

9 ODD ONE OUT

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

SSAAARNK GINMYOW EEEENNTSS XMCIOE

10 HIGH-WIRE ACT

Make a sensible sentence by filling in the blanks with nine-letter words that are anagrams of each other (they contain the same nine letters).

The _____ audience watched carefully as the tightrope walker took his first _____ steps across the chasm.

Answers

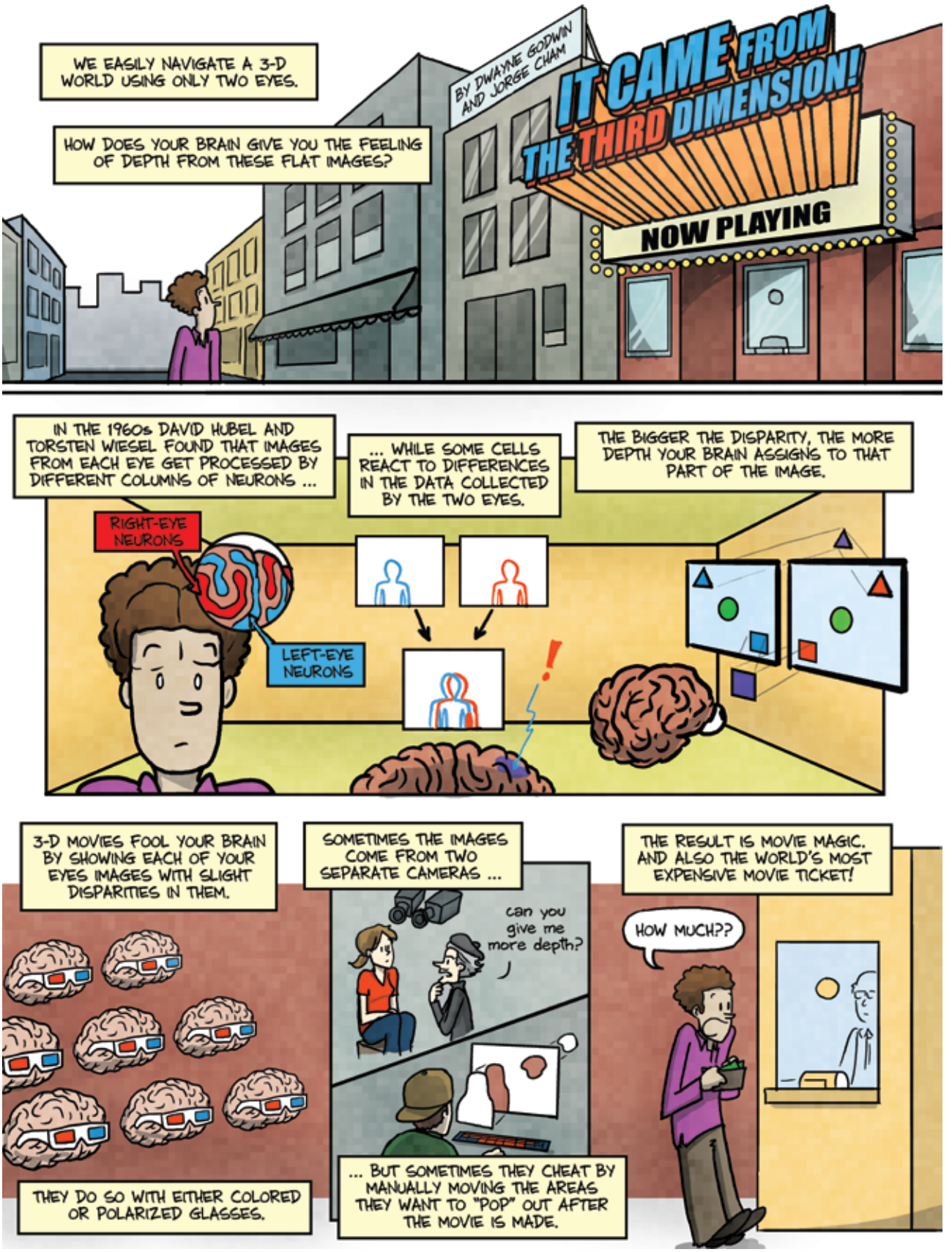
1.

O	W	L	S
W	A	I	L
L	I	N	E
S	L	E	D

2. Navy, Nary, Wary, Wiry, Airy, Airs, Aims, Arms, Army. (There may be other solutions.)
3. Earthiest, Heartiest, Hesitater.
4. 20 cents. (Susie had $1.80, and Bobby had $1.40.)
5. 8,246.
6. Six of each.
7. Anagram is RNDPWOSO; the flower is a snowdrop.
8. 8, 86. (There are two series interminged; the first starts at 2 and counts up, and the second starts at 20, adding 11 to get each subsequent number.)
9. Mexico. The others are U.S. states: Wyoming, Arkansas and Tennessee.
10. Attentive, Tentative.

© 2011 AMERICAN MENSA LTD.

© 2011 Scientific American



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.*

© 2011 Scientific American

Think Naturally.

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. All-natural Cognizin® Citicoline is nature's way of keeping the brain's energy-producing centers firing. Clinically tested for efficacy, Cognizin delivers a pure, safe form of Citicoline that supplies your brain with the energy it needs to stay sharp.* So look for Cognizin brand Citicoline on the ingredient panel of your favorite supplements to help keep your mental edge—naturally.*

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.

Cognizin® is a registered trademark of Kyowa Hakko Bio Co., Ltd.
Copyright ©2011 Kyowa Hakko U.S.A., Inc.

Look for Cognizin® Citicoline in these fine brands.

AOR · Ecological Formulas · Healthy Origins® Healthy Value from Reliable Origins · Jarrow Formulas® · Balance Your Life JoMar Labs® amino acid source · LifeExtension® · Metabolic Maintenance · NS® Nutraceutical Sciences Institute® · nawgan® · New Vitality® Helping People Live Longer and Look Younger · Pathway To Healing · SomaLife · Swanson® Health Products · TianChi® Brighten Your Mind

Actual size is 40.6 mm

Millions are scrambling for the 2011 Silver Eagle...But we're giving it away TODAY at our lowest price!

The economic crisis has sparked a huge demand for U.S. Mint Silver Eagles. Collectors, investors, dealers and the public alike are scouring the country to obtain them, creating a serious national shortage. But today, as a special offer to new customers you can own these HEFTY Silver Dollars at our lowest price—*only $55.14!**

You Cannot Buy This Coin From the Mint!

The U.S. Mint does not sell Silver Eagle Dollars direct to the public. You can only obtain them through an authorized distributor. We have just reserved a fresh shipment of 2011 U.S. Mint Silver Eagles—the current U.S. Silver Dollar. These massive and attractive coins contain one full troy ounce of silver and feature the historic image of Miss Liberty draped in a U.S. flag walking boldly into the future.

No, We're Not Crazy!

Why are we giving away this silver dollar at our lowest price? Because we want to introduce you to what hundreds of thousands of our satisfied customers have discovered since 1984—***we're your best source for coins worldwide.*** That's why we're giving away this 2011 U.S. Silver Eagle to you—for just $55.14**—to put you on the ground floor of great values like this—values our customers enjoy every day.

Highest Demand Ever for 2010 Eagles. Act Before The 2011s Disappear!

We've never experienced such demand for Silver Eagles as we did in 2010. We predict the same for the 2011 Silver Eagles. So please hurry! They're available RIGHT NOW. And with the current financial crisis they could easily sell out.

Don't Miss Out! Limit 3 Per Customer

At our lowest price, we must set a strict limit of 3 coins per customer. The allure of silver is timeless, and the precious metal is a proven hedge against economic uncertainty. Don't miss out! Call immediately, toll free, 1-888-870-8528 to add these elusive Silver Eagles to your holdings!

TOLL-FREE 24 HOURS A DAY

1-888-870-8528

Offer Code ESL173-04
Please mention this code when you call.

GOVMINT.COM
YOUR ONE BEST SOURCE FOR COINS WORLDWIDE

14101 Southcross Drive W., Dept. ESL173-04
Burnsville, Minnesota 55337

www.GovMint.com

**plus a nominal shipping and handling charge*

Note: GovMint.com. is a private distributor of government and private coin and medallic issues and is not affiliated with the United States Government. ***Prices and availability subject to change without notice.*** ©GovMint.com, 2011

***Price based on spot market silver price of $43.98.

BBB ACCREDITED BUSINESS