"SCIENTIFIC TELEPATHY" WITH BRAIN SCANNERS

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

July/August 2010
www.ScientificAmerican.com/Mind

Music and Speech
A Deep Bond
page 36

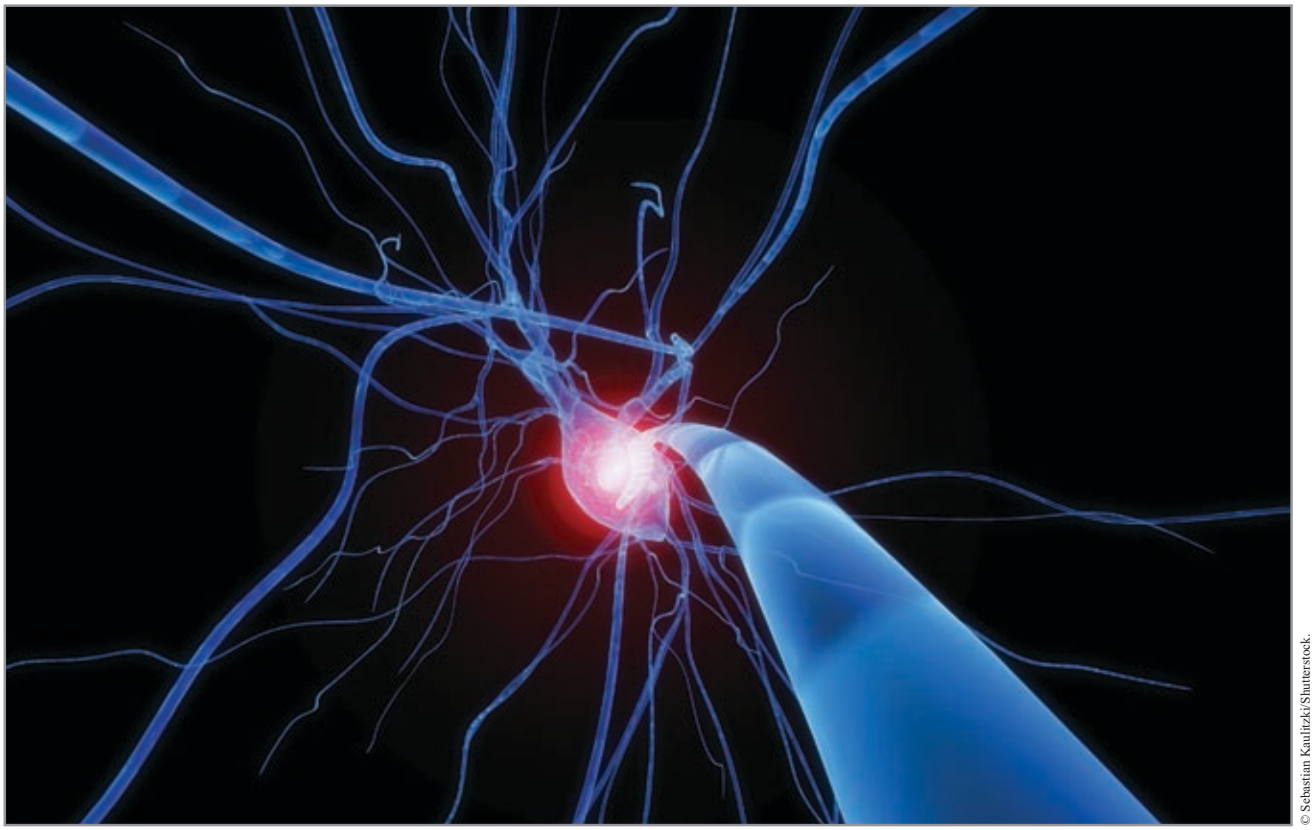
SPECIAL REPORT

The Sparks of Memory
How Brain-Cell Links Create Our Past—and Future
page 22

Plus:

What Makes You *You*?

Borderline Personalities



What are the Origins of the Human Mind?

For thousands of years, the human mind has been shrouded in mystery. Yet with the latest advancements in our understanding of the brain and the technology we use to look inside it, scientists have discovered answers to questions that have long perplexed humanity. **Origins of the Human Mind** is your guide to what today's neurobiologists, psychologists, and other scientists know about the workings of the mind: one of the hottest subjects in modern science.

Award-winning Professor Stephen P. Hinshaw—whose training as a psychologist straddles the science of the mind and its impact on individuals—approaches the development of the mind from both the evolutionary scale and the scale of an individual lifespan. Along the way, he explores provocative issues such as the nature-versus-nurture debate; the development of mental illness; and the roots of emotional bonds and brain plasticity.

This course is one of The Great Courses®, a noncredit, recorded college lecture series from The Teaching Company®. Award-winning professors of a wide array of subjects in the sciences and the liberal arts have made more than 300 college-level courses that are available now on our website.

Origins of the Human Mind

Taught by Professor Stephen P. Hinshaw,
University of California, Berkeley

Lecture Titles

1. Brains and Minds, Evolution and Development
2. How the Human Brain Works
3. Development of the Human Brain
4. Evolution and the Brain
5. Psychological Views of the Mind
6. Instinct, Learning, and Emotion
7. Microevolution, Culture, and the Brain
8. Infancy—Temperament and Attachment
9. Childhood—Stages and Widening Contexts
10. Adolescence—Rebellion, Identity, and Self
11. Adulthood—Aging, Horizons, and Wisdom
12. Influences of Sex and Gender
13. Parallels between Development and Evolution
14. Myths and Realities of Heritability
15. Genes and Environments Together
16. The Abnormal Mind—What Goes Wrong?
17. Rationality, Psychosis, and Schizophrenia
18. Emotion Regulation and Mood Disorders
19. Attention, Impulse Control, and ADHD
20. Empathy, Social Connections, and Autism
21. Evolution and the Paradox of Mental Illness
22. Roots of Religion, Aggression, and Prejudice
23. Bringing in Personal Narratives
24. The Future of the Human Mind

Order Today!
Offer Expires Monday, September 20, 2010

Origins of the Human Mind
Course No. 1663
24 lectures (30 minutes/lecture)

DVDs ~~$254.95~~ **NOW $69.95**
+ $10 Shipping, Processing, and Lifetime Satisfaction Guarantee

Audio CDs ~~$179.95~~ **NOW $49.95**
+ $10 Shipping, Processing, and Lifetime Satisfaction Guarantee

Priority Code: 40133

ACT NOW!

1-800-TEACH-12
www.TEACH12.com/5mind

THE TEACHING COMPANY®
The Joy of Lifelong Learning Every Day™
GREAT PROFESSORS, GREAT COURSES, GREAT VALUE GUARANTEED.™

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

COVER PHOTOILLUSTRATION BY AARON GOODMAN

A Singular Challenge

Faced with a dauntingly complex problem, scientists typically do the logical thing. They break it into component parts, to simplify and focus their efforts. After all, grappling with smaller facets lets you try to conquer, one piece at a time, a larger problem. But the brain's very nature resists this technique. In effect, it refuses to be compartmentalized. The more researchers may attempt to look at a single processing question, the more it turns out to be interrelated with many other things going on in the brain.

Take memory. It's tempting to think of recall as a video recording or some simple device. Far from existing in one discrete module, however, recollections develop from thousands of connections among neurons. In the first article of this issue's special report on memory starting on page 22, "Making Connections," by Anthony J. Greene, you will learn that neural connections underlie everything we know. As neurons light up together, they create links within which our memories lie. As Greene puts it, memories are "a web of connections between people and things." Events that have high emotional value are particularly crisp in our minds. The second article of our special report, on page 30, "Yearning for Yesterday," by Jochen Gebauer and Constantine Sedikides, explains how nostalgia, where we bask in the past, can actually be good for you.

Likewise, speech and music at first seem separate in nature. We talk to convey information. Music seems to come from a more emotional place. But perhaps you will not be surprised at this point to learn that, in fact, the brain areas responsible for these functions communicate with one another a great deal—and they develop together as well. Music and language turn out to be partners in the brain. "Indeed, in many respects, music and speech seem to be mirror images, with both playing integral roles in the development of the other—in the way we, as people, bond and communicate, in how we perceive the sounds around us, in our understanding of language and in the workings of our minds," writes Diana Deutsch in her feature, "Speaking in Tones." Turn to page 36 to find out why a song in your heart means you can talk the talk.

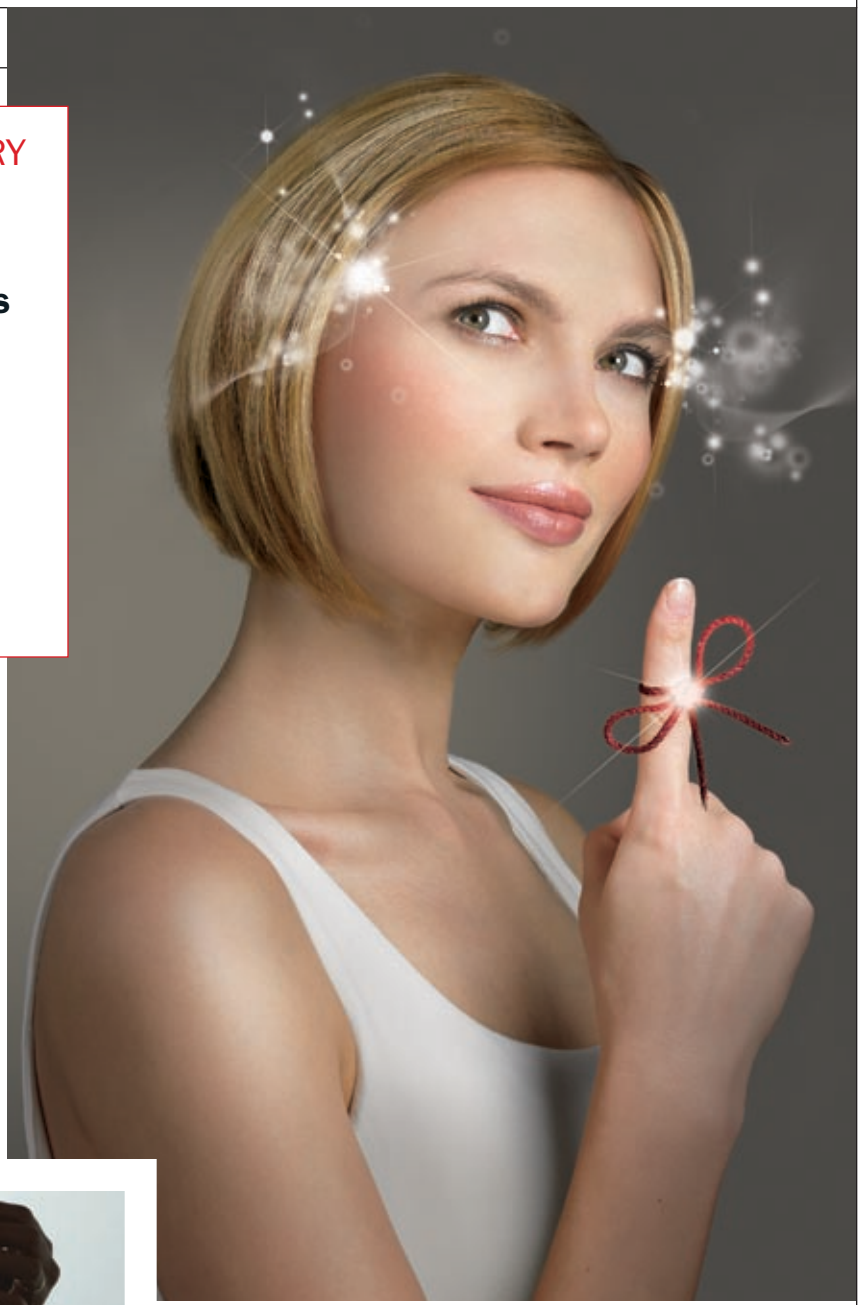
Mariette DiChristina
Editor in Chief
editors@SciAmMind.com

SCIENTIFIC AMERICAN MIND
Volume 21, Number 3, July/August 2010

FEATURES

SPECIAL REPORT: MEMORY

COVER STORY



DEPARTMENTS

Scientific American Mind (ISSN 1555-2284), Volume 21, Number 3, July/August 2010, 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.

SCIENTIFIC AMERICAN
MIND
BEHAVIOR • BRAIN SCIENCE • INSIGHTS

VICE PRESIDENT AND PUBLISHER: Bruce Brandfon
VICE PRESIDENT, MARKETING AND SALES DEVELOPMENT: Michael Voss
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
ASSOCIATE DIRECTOR, CONSUMER MARKETING: Anne Marie O'Keefe
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
VICE PRESIDENT, OPERATIONS AND ADMINISTRATION: Frances Newburg

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
fax: 646-563-7138
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
randp@SciAm.com
www.ScientificAmerican.com/permissions
Please allow three to six weeks for processing.

TAKING RESPONSIBILITY

I have a bone to pick, related to "The Power to Persuade," by Kevin Dutton. Too often people blame others for their bad decisions. In Mariette DiChristina's comments in her column From the Editor, she says that she could not figure out what the art salesperson had done to "make" her buy the pen-and-ink set, implying that she had had no option but to buy it. Persuasion may be potent, but it is not helpful to allow people to excuse themselves for not making a better decision. It reminds me of Flip Wilson's old line, "The devil made me do it!"

Sally Comer
via e-mail

A SICK POPULACE?

If more than one fourth of the population is considered ill by the psychiatric community, as Robert Epstein wrote in his article "Are You Mentally Healthy?" perhaps the definition of illness should be more carefully examined. For a bacterial infection, it is a patient's impaired functioning—not just the presence of bacteria in the body—that signals treatment is necessary. If my medical doctor continuously treated infections that created no disability, I'd eventually seek a second opinion.

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

WOLF JUSTICE

I think Marc Bekoff and Jessica Pierce's argument in "The Ethical Dog" that canine fair play can give insight into human morality is a good one, but I would limit the comparison to early humans living in small hunter-gathering bands. Once groups start to get larger, altering the tight interdependence necessary for survival, patterns of group behavior change. In other words, when you can start to benefit from my losses, I must play by different rules.

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

When I started this article, I thought, "Humans have spent millennia selecting dogs for certain behavioral traits. What dogs do is not reflective of wild animals." When I saw that the study included widespread moral behavior in other canids, such as wolves and coyotes, I asked myself, "Have dogs influenced the selection of human behavioral traits?" In some societies, for example the Inuits of North America, dogs played an essential role in the survival of the people they lived with. Could these dogs have made choices, at critical moments, to help or abandon people that did not play by the rules of dog fairness?

Clearly, the power of dogs to select for human traits is not as strong as the power humans have over the breeding of dogs, but perhaps the influence is not negligible.

Spencer Murray
Saint Laurent, Quebec

BEKOFF REPLIES: *I think it is conceivable that during the course of the domestication of dogs, humans observed the way wolves socially interacted—and perhaps people noted that these wolves played fairly and abided by clear rules of social engagement. Although the idea is not testable in any empirical way, I think it is possible that early humans saw the animals' fairness, cooperation, empathy and other positive social behavior patterns and may have used these "social lessons" in their own interactions.*

A MANAGEABLE ILLNESS

Thank you for the article "Living with Schizophrenia," by Scott O. Lilienfeld and Hal Arkowitz, which conveyed the important social message that many schizophrenics can experience significant recovery and go on to lead relatively normal lives. It is good to state that even when patients do decline, the symptoms need not devastate friendships—and to point out that those patients with schizophrenia who unfortunately never fully recover should not be blamed for their condition.

Greg Westlake
Norfolk, England

ERRING TO SUCCEED

I believe that the technique described in "The Pluses of Getting It Wrong," by Henry L. Roediger III and Bridgid Finn—starting out with a hard test you're bound to fail—is indeed the best way to learn. I had a college math professor who would pose a question on a topic we hadn't learned yet. We would then spend the next half-hour trying to collectively come up with the solution as he shot down wrong answer after wrong answer. If you are so intent on finding the answer, when you finally get it, it sticks!

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

THE TROUBLE WITH MYTHS

It is easy to refute an overly simplistic statement about a complex topic, but doing so does not necessarily mean an opposing statement is true. In "Busting Big Myths in Popular Psychology," by Scott O. Lilienfeld, Steven Jay Lynn, John Ruscio and Barry L. Beyerstein, the authors imply that expressing anger is never therapeutically useful, based on studies of people pounding nails or playing violent video games. As a psychotherapist, I find that I can help patients defuse their anger by having them physically express it.

Similarly, negative emotions and attitudes, which might affect cancer and other illnesses, take hard work to root out and bring to consciousness. To claim that the link between emotions and cancer is a myth, based on studies of people who paper over deep-seated negativity with positive thinking, is analogous to concluding that it is a myth to say "vegetables are healthy" based on studying people who consume five servings per day of ketchup. And possibly as harmful.

Ted Riskin
via e-mail

THE AUTHORS REPLY: *We agree that there is a danger in oversimplifying complex psychological claims. Nevertheless, we must beware of the logical fallacy of the golden mean: the erroneous belief that the truth always lies in between two extremes. In the case of the myth of anger expression, we did not argue that "expressing anger is never therapeutically useful"; instead we maintained that expressing anger is likely to be helpful only when accompanied by constructive problem solving. Additionally, Riskin is mistaken that studies refuting the link between positive emotions and cancer focus on "people who paper over deep-seated negativity with positive thinking." As we noted in our article, well-controlled studies of support groups among breast cancer survivors—which do not encourage women to ignore their negative moods—show no effects of positive thinking on survival rates.*

In my experience, the display of anger has quite different purposes from the experience of uncontrollable emotion. What I read in this piece was that the authors haven't spent very long working in a biker bar, or in the noncommissioned ranks of a military force, or (here in the U.K.) on the terraces of a football match. I have found well-developed models for the purposeful and cathartic expression of anger in all these places.

So it is in the case of my letter: I was angry enough about this misrepresentation to write to you but not so enraged that I threw my laptop out the window!

Steve Cassidy
London

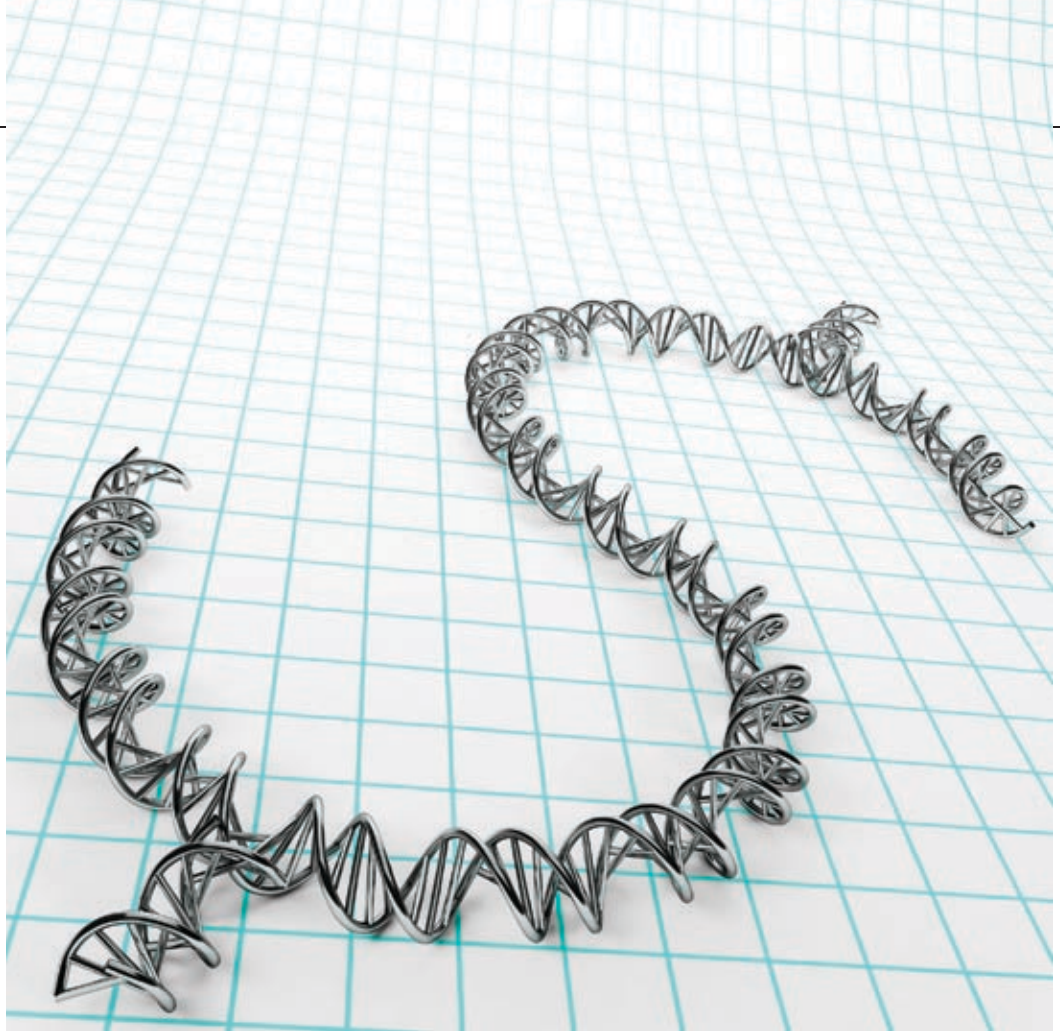
A CORRECTION CORRECTED

I hate to be picky, but although I appreciate the correction noting that I am a psychologist, rather than a pediatrician, somehow I became a man in the process!

Ms. Rahil Briggs
via e-mail

THE EDITORS REPLY: *It is absurd that we ran an incorrect correction regarding your attribution in "Daring to Die," by Karen Springen [January/February 2010]. We apologize for the error … again!*

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



SCOTT TYSICK Getty Images

>> MONEY

Born into Debt

A specific gene is linked to credit-card balances

When trying to understand why some people have trouble living within their means, we tend to blame factors such as high interest rates and irresponsible spending. Now researchers have found another possible culprit to add to the list: a gene linked to credit-card debt.

Earlier work has shown that genetics plays a role in how we handle money. But a recent study was the first to show that a particular gene affects financial behavior outside the lab. Researchers at the University of California, San Diego, and the London School of Economics looked at genetic data and questionnaires already collected from more than 2,000 young adults aged 18 to 26 as part of the National Longitudinal Study of Adolescent Health. In particular, they looked at whether these young adults said they had any credit-card debt and what version of the MAOA gene they had.

Monoamine oxidase A (MAOA) is an enzyme that breaks down neurotransmitters (signaling chemicals) in the brain. Previous studies have linked the low-efficiency versions of the MAOA gene—the variants that cause less MAOA to be produced by brain cells—to impulsiveness.

In the new study, people with one "low" MAOA gene and one "high" MAOA gene reported having credit-card debt 7.8 percent more often than did people with two "high" versions, the researchers found, even when they controlled for factors such as education and socio-economic status. For people with two "low" versions of the gene, that number jumped to 15.9 percent.

The researchers were surprised by the magnitude of the difference. "The effect is almost as big as financial literacy," meaning people's ability to digest complicated financial information, says Jan-Emmanuel de Neve, an author of the study.

But, de Neve cautions, an individual's version of the MAOA gene does not predict whether he or she is carrying debt. The gene affects credit-card debt the way other genes have been found to play a role in breast cancer: a particular version of the gene increases risk, but many other genetic and environmental factors are important, too. —*Valerie Ross*

>> BRAIN STRUCTURE

Ambidexterity and ADHD

People whose brains are too symmetrical are at risk for cognitive problems

One of the first things that anatomy students learn is that the brain is divided down the center. In most people, one half, or hemisphere, plays a dominant role. Handedness has long been a crude measure of hemispheric dominance, because each side of the brain controls the opposite side of the body. Right-handers, for instance, are likely to have dominant left hemispheres. Today researchers are realizing that studying ambidextrous children (who have no dominant hand) could yield insights into the consequences of an unusually symmetrical brain.

A team of European researchers recently assessed nearly 8,000 Finnish children and showed that mixed-handed

If a brain's halves look like mirror images of each other, communication and coordination between hemispheres may be impaired.

children are at increased risk for linguistic, scholastic and attention-related difficulties. At age eight, mixed-handed kids were about twice as likely to have language and academic difficulties as their peers. By the time the children were 16, they also were twice as likely to have symptoms of ADHD—and their symptoms were more severe than those of right- or left-handed students.

Ambidexterity is not causing these problems. Rather "handedness is really a very crude measure of how the brain is working," says Alina Rodriguez, a clinical psychologist at King's College London and the study's lead author. In typical brains, language is rooted in the left hemisphere, and networks that control attention are anchored in the right—but brains without a dominant hemisphere may be working and communicating differently.

Consistent with this theory, a 2008 study by scientists at the University of California, Los Angeles, found anomalies in cross-hemisphere communication in children with ADHD. On tasks that should be the domain of the left hemisphere—such as linguistic processing—children with ADHD seemed to be getting too much input from their right hemispheres. Rodriguez is quick to point out, however, that mixed handedness does not, by itself, indicate a malfunctioning brain and is "just one risk factor among many others."

So why do some kids have overly symmetrical brains? The answer may lie in epigenetics—the mechanism by which environmental influences affect gene expression. In 2008 Rodriguez found that women who experienced stressful life events or depression during pregnancy were more likely to give birth to children who became mixed handed, adding evidence to the idea that the experiences of a mom-to-be affect her fetus's brain development. [For more about prenatal influences on mental health, see "Infected with Insanity," by Melinda Wenner; Scientific American Mind, April/May 2008.] That means that handedness, Rodriguez says, "can be used with other markers to predict who's going to have problems with behavior" and give parents, teachers and doctors the opportunity to intervene at the first sign of trouble.

—Emily Anthes

>> MOTIVATION

Closing the Gap

When we judge distance, desired objects seem nearer

We often assume we see our physical surroundings as they actually are. But new research suggests that how we see the world depends on what we want from it.

People see desirable objects as physically closer than less desirable ones, according to a study in the January issue of *Psychological Science*. When psychologists Emily Balcetis of New York University and David Dunning of Cornell University asked people to estimate how far away a bottle of water was, those who were thirsty guessed it was closer than nonthirsty people did. This difference in perception showed up in a physical challenge, too. People tossing a beanbag at a $25 gift card were, on average, nine inches shy, whereas people aiming for a gift card worth nothing overshot by an inch.

As the brain evolved, people who saw distances to goals as shorter might have gone after what they wanted more often. This

error in perception was actually an advantage, leading people to get what they needed—and, perhaps, survive more often than their more accurate counterparts. "Seeing water as closer when you're thirsty might make it a little more likely you'll try to go get it," Balcetis says.

—Valerie Ross

CORBIS (*top*); STEVEN PUETZER Getty Images (*bottom*)

>> REWARD CIRCUITRY

Food for Thought

When you go to a fast-food restaurant, you expect to get your fries quickly. But thinking about fast food makes us impatient about other things, too, according to a recent study in *Psychological Science.* People who examined the aesthetics of a McDonald's or KFC logo were more likely to choose to take a smaller sum of money immediately (rather than waiting for a bigger payout a week later) than those who had critiqued the logos of inexpensive sit-down chains. After thinking about fast food, people were also more interested in time-saving products, such as 2-in-1 shampoo-conditioner, and they read a paragraph faster despite the fact that there was no time limit. Even when the task at hand has nothing to do with food, this study suggests, you act how you eat. —*Valerie Ross*

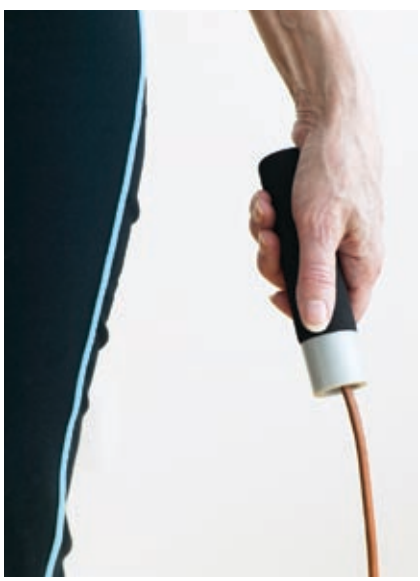
>> GENETICS

Two Sides of the Same Coin

A single DNA variation may contribute to both exercise addiction and obesity

The runner tethered to the treadmill and the couch potato gripping a bag of chips may seem like polar opposites, but new research suggests that a single alteration in the brain's reward system could cause both obsessions.

More than one third of regular gym-goers show signs of exercise dependence, continuing to exercise even when sick or injured or arranging their lives around working out. Nearly half of all people diagnosed with an eating disorder report excessive levels of exercise to control body shape and weight and to relieve stress and improve mood. Researchers have developed two opposing hypotheses to explain how someone could become addicted to exercise, eating or any other behavior. The first hypothesis states that these people's brains grow more sensitive to reward; they find exercise more pleasurable, so they seek it more. Alternatively, these individuals may grow less sensitive to reward; over time they begin to require more exercise to achieve the same level of pleasure.



People dependent on excessive exercise or food for pleasure may be insensitive to reward.

A new study, led by Wendy Mathes of the University of North Carolina at Chapel Hill, found that two strains of mice, bred for either excessive exercise or obesity, had the same malfunction in the brain's reward pathways. Genetic analysis of the two kinds of mice showed that they had lower-than-normal levels of activity in a gene that helps brain cells register the presence of dopamine, the neurotransmitter involved in reward. The finding suggests that excessively exercising mice and obese mice may be less sensitive to the rewards of physical activity and food, respectively. Researchers do not know yet how the same underlying problem could lead to such radically different outcomes, but Mathes suggests that other neurotransmitters may act on the dopamine-deprived brain cells to push the mice in one direction or the other. —*Carrie Arnold*

REUTERS/CORBIS (*McDonald's*); LWA-SHARIE KENNEDY *Corbis* (*jump rope*); CORBIS (*chips*)

Checking out a prospective employee's attributes on Facebook may be as reliable as a face-to-face meeting.

>> TECHNOLOGY

Honesty Online

Facebook profiles tend to be accurate reflections of people's personalities

Social-networking sites are a way to find out about people you're curious about but have never met—say, a prospective employee you're deciding whether to hire. But when you scan someone's profile, you probably expect a little fudging: an overly flattering photograph, a generously phrased blurb in the "about me" section. A study in the March issue of *Psychological Science*, however, suggests that Facebook users do not skew their profiles to reflect idealistic visions of themselves.

In the study, research assistants at the University of Texas at Austin and the University of Mainz in Germany viewed the Facebook profile of a study participant, then guessed how he or she would score on the "big five" common personality measures used in psychological research: extroversion, agreeableness, neuroticism, openness and conscientiousness. Next they compared the results based on Facebook with the actual personality test scores from the profile owner and the results from four of his or her "well-acquainted friends," who also rated the person's personality traits. The research assistants were successful on four of the five measures—all except neuroticism, which is notoriously hard to gauge in general.

Like any guess made from limited information about a person, the personality assessments were not spot on—but they were much closer to what the person thought about themselves than could be expected from chance. This moderate correlation is equivalent to how well people can judge someone's personality after a first impression, according to past research. So if you do check out that potential hire on Facebook before the interview, you may be able to guess whether you'll be giving her a tour of the office the next day or pointing her toward the door.

—Valerie Ross

>> LANGUAGE

Attuned to Feelings

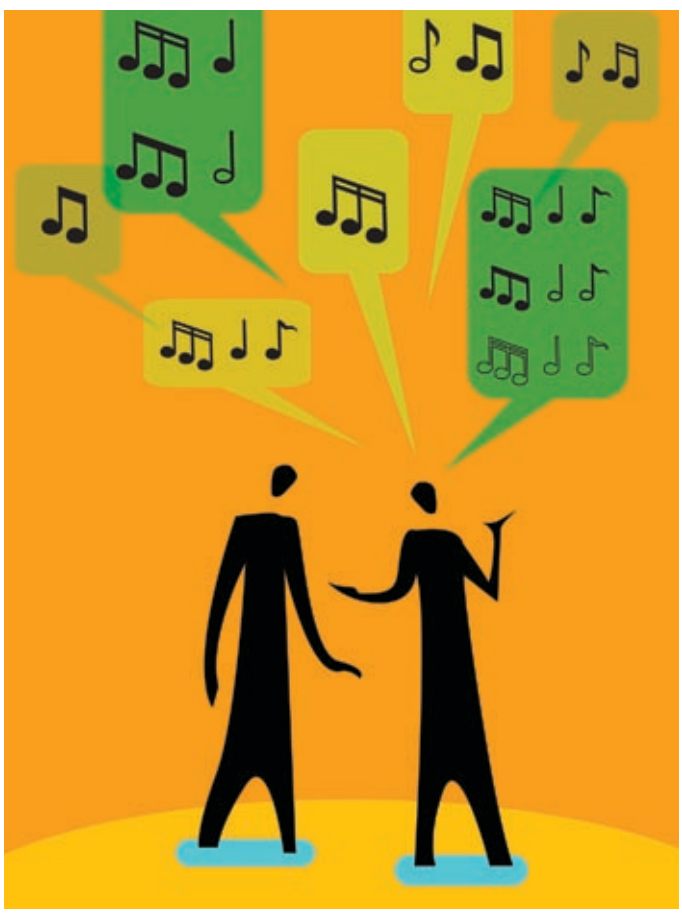
People who talk in a more melodic way can better identify with others' emotions

Unless you're a robot, your speech has a musical quality to it. This pitch-and-rhythm variation, known as prosody, conveys emotion. A new study suggests that people whose speech is most sing-songy may have a stronger ability to empathize with others.

Using functional MRI, scientists at the University of Southern California measured brain activity as volunteers perceived or produced speech with intonations that sounded happy, sad, questioning or neutral. They found that specific parts of the brain region known as Broca's area (a well-known speech center in the brain) are active both when listening to and when producing lilted speech. Subjects with the highest level of activity in these prosody-specific brain areas also tended to score highly on measures of empathy.

Unlike grammar, semantics and other properties of language, prosody is universal across cultures and even between species—pets understand human commands not because of the words spoken but rather because of emotional intonations, says Lisa Aziz-Zadeh, lead author of the study and an occupational scientist at U.S.C. "Prosody is an essential component of social communication," she says. [For more on the musical qualities of speech, see "Speaking in Tones," by Diana Deutsch, on page 36.]

—Allison Bond



KAREN BLEIER *Getty Images (top)*; IMAGES.COM/CORBIS *(bottom)*

COLORBLIND IMAGES/GETTY IMAGES

MENTAL HEALTH

Less Sleep Linked to Blues in Teens

Earlier bedtimes set by parents protect against depression

Despite kids' protests, enforcing early bedtimes may be good for their mental health. Teens who are allowed to go to bed later are more likely to suffer from depression—probably for the simple reason that they are not getting enough sleep, a recent study suggests.

Columbia University scientists found that depression was 24 percent more common in teens whose parents let them go to bed at midnight or later than in kids whose moms and dads required them to hit the pillow by 10 P.M. The night owls were also 20 percent more likely to have suicidal thoughts.

Teens with bedtimes of midnight or later got an average of seven and a half hours of sleep, whereas those with a lights-out of 10 p.m. or earlier got an average of eight hours and 10 minutes. Although the association between later bedtimes and depression was greater before controlling for parents' marital status and poverty level, it remained statistically significant after taking those things into account—as well as teens' perceptions of how much their parents cared about them.

The researchers looked at parent-enforced bedtimes—as opposed to simply logging hours slept—to rule out the possibility that depression was causing some kids to sleep less, rather than the other way around.

Earlier work supports the idea that too little sleep may lead to depression. Research at the University of London showed that children who suffer from insomnia are at increased risk of developing depression in their tweens and teens. And a University of Pittsburgh study of youth at risk for hereditary depression found that the one biological predictor of resilience—in other words, not getting depressed—was adequate sleep. Although too little sleep is unlikely to be solely responsible for a teen's low mood, in those with a genetic or environmental predisposition sleep loss may raise risk and satisfying rest may be protective.

Recent studies at Walter Reed Army Medical Center and the University of California, Berkeley, are starting to tease out why. During brain scans, sleep-deprived but otherwise healthy people showed increased activity in the amygdala (the brain's emotional center) and decreased activity in the prefrontal cortex (an area that puts our experiences in context, and by extension, makes us rational)—the same changes seen in people who are depressed. In one army study, subjects started to show symptoms of depression, and the Berkeley subjects became more distressed than rested participants when confronted with upsetting images.

All these neurobiological effects may hit teens especially hard, says psychologist William D. "Scott" Killgore of Harvard Medical School–affiliated McLean Hospital, a co-author of the army research. As teens cope with increasingly complicated daily life, they need more sleep than younger kids or adults, Killgore explains, and so "not getting enough sleep is especially problematic." —*Jordan Lite*

>> DEVELOPMENT

Too Much, Too Young

Excess brain growth may be the first sign of autism

The average age at which children are diagnosed with autism is between three and four, but scientists have long suspected that the disorder starts much earlier. A key piece of evidence is a phenomenon known as brain overgrowth. Autistic toddlers tend to have large brains for their age, and researchers have shown a correlation between the degree of excess growth and the severity of autism symptoms. Eric Courchesne, director of the Autism Center of Excellence at the University of California, San Diego, helped to pioneer the overgrowth hypothesis. Now he and his colleague Cynthia Schumann have published data that suggest the excess brain growth starts in the first year of life, if not sooner.

The study, published in a recent issue of the *Journal of Neuroscience*, is the first to evaluate brain growth and autism throughout early development. Using cross-sectional MRI scans, the U.C.S.D. researchers found overgrowth in autistic subjects as young as one and a half. At two and a half, the autistic subjects' brains were 7 percent larger on average than the control group's. Although why, exactly, excessive brain growth is related to autism remains a mystery, the new work helps to confirm that signs of the disorder appear early—knowledge that could lead to detection and treatments, such as behavior therapy, at a younger age. "The earlier the intervention, the better the outcome," Courchesne says. *—Erica Westly*

>> COMPETITION

Status Matters

People try harder to beat a weakling than to topple a higher-ranked opponent

The underdog creams a top-ranked opponent—and the crowd goes wild. But such a surge in the face of the odds is even more difficult than it appears, according to a recent study in the *Journal of Experimental Social Psychology*. If status is on the line, people try harder to win when they are pitted against lower-ranked opponents.

Psychologists Nathan Pettit of Cornell University and Robert Lount of Ohio State University asked Cornell students to perform simple tasks in teams—for instance, writing down as many possible uses for a knife as they could come up with. The researchers falsely told the students that they were competing against another university that was ranked higher or lower than Cornell—but they added that the tasks at hand were not indicative of academic performance, so the rankings should not predict which team would do better. When the students thought they were facing a lower-ranked school, they did better on the task.

"It could really be conservation of effort: I fight the battles that I can potentially win, but there are certain battles, no matter how hard I fight, I'm not going to win," Pettit says.

The new study contradicts earlier research showing that when faced with a superior opponent in similar creative language tasks, people tend to work harder. But unlike the current study, which involved competition between ranked schools, the earlier studies did not involve a threat to the competitors' preexisting real-world status. So another motivating factor for the students in the new study could be the fact that performing worse than people of lower rank can mean a loss of status, says psychologist Naomi Ellemers of Leiden University in the Netherlands, who was not involved in the study. *—Harvey Black*

GETTY IMAGES (*top*); MARK PETERSON *Corbis* (*bottom*)

>> PLANNING AHEAD

When I'm 64

The closer people feel to their future selves, the more money they save

How much money do you put away each month toward retirement? Maybe you sock away all you can, already dreaming of that Florida condo. Or maybe you can't even imagine where you'll be then, what you'll want to use the money for, even what you'll be like: when you think about yourself far in the future, it's almost like thinking about someone else. A growing body of work suggests that the more you feel your future self is really you, the more you'll put in his or her—whoops, your—bank account.

When making decisions, we often treat our future self the way we would treat another person, found a study in 2008 by Princeton psychologist Emily Pronin. People in the study often shied away from doing something helpful but unpleasant when they had to do it right at that moment. But when their help was needed a few months or a year down the line, they were more likely to sign up—just as likely as they were to suggest that someone else should help out.

Exactly how distant we feel from our future self varies from person to person, according to a 2008 study by psychologists Hal Ersner-Hershfield and Brian Knutson, then both at Stanford University. The researchers asked people to think about themselves now and in the future while scanning their brain with functional MRI. Previous studies showed that an area of the brain called the rostral anterior cingulate cortex is activated more when you think about yourself than when you think about another person; this study showed that it is also more active when you think about yourself now as compared with imagining yourself 10 years from now. Some people showed a smaller difference in activity, suggesting they saw their future self more as "me" than as "someone else."

Each participant in the study then had to pick between getting some amount of money immediately or receiving a larger sum in a certain number of days. The subjects varied in how much extra cash they required to make the reward worth the wait. That variation, the study found, matched the brain scans. The people who showed a smaller difference in brain activity when thinking about their current and future self needed less money to make the wait worthwhile.

These individual differences affect financial decisions outside the lab, too. In their next study, published last year, Ersner-Hershfield and Knutson found that people who saw their current and future self as more alike had real-world financial assets that were worth more—even when the researchers accounted for factors such as age and education. As Knutson put it, "the more similar you report feeling to your future self, the more savings you report having in your bank account."

Because those who feel identified with their future self make financial decisions with long-term benefits, Ersner-Hershfield says, encouraging people to imagine themselves in the future might help them save more. "Even thinking, 'if I were to call my future self right now, what would [he or she] think?' might affect the decisions you make in the present," he says.

—Valerie Ross

>> MOOD

Skip the Small Talk

Happier people have more meaningful conversations

Feeling down? Having a stimulating conversation might help, according to a new study published in *Psychological Science*.

Researchers at the University of Arizona and Washington University in St. Louis used unobtrusive recording devices to track the conversations of 79 undergraduate students over the course of four days. They then counted the conversations and determined how many were superficial versus substantive, based on whether the information exchanged was banal ("What do you have there? Popcorn?") or meaningful ("She fell in love with your dad? So, did they get divorced soon after?"). They also assessed subjects' overall well-being by having them fill out questionnaires and by asking their friends to report on how happy and content with life they seemed.

The happiest subjects spent 70 percent more time talking than the unhappiest subjects, which suggests that "the mere time a person spends in the presence of others is a good predictor of the person's level of happiness," says co-author Matthias Mehl, a psychologist at Arizona. The happiest subjects also participated in a third as much small talk and had twice as many in-depth conversations as the most unhappy participants.

Mehl admits that he does not know whether interacting with others in a substantive manner makes people happy or whether happy people tend to engage in more frequent and intellectual conversations. To find out, he and his colleagues are conducting pilot studies in which they ask people to engage in different types of conversations and assess how the exchanges affect well-being. So far, he says, the findings suggest that adding five substantive conversations to your weekly social calendar could boost your spirits dramatically.

—Melinda Wenner Moyer

JEAN MICHEL FOUJOLS *Getty Images (left)*; HAENSEL/CORBIS *(right)*

RACISM

Color TV

On-screen body language toward black characters can increase unconscious prejudice in viewers

Watching how black characters are treated on television can affect attitudes about race both consciously and unconsciously, new findings suggest. In a two-part study, researchers at Tufts University examined nonverbal behavior toward characters of different races on television shows, then tested how clips from these shows affected viewers' prejudices.

First, the team found clips of mixed-race scenes from 11 popular TV shows with prominent black and white characters. In each clip, they blocked out one character to hide his or her race, turned off the sound, then asked volunteers whether the blocked-out character was seen by the other characters in a positive or negative light. The researchers found that in nine of the 11 shows—*Friday Night Lights*, *CSI*, *House*, *CSI: Miami*, *Scrubs*, *Greek*, *Heroes*, *Reno 911!* and *Grey's Anatomy* (*right*)—viewers thought the actors' body language and facial expressions were less favorable when they were responding to someone who was black. The only two shows without this bias were *Bones* and *Rob and Big*.

Then the researchers showed clips from all the shows, with the images restored to normal, to a new group of viewers who had no idea the study was about race. After watching clips in which black characters were treated less favorably than whites, the viewers' conscious attitudes about race did not change. But they were faster to associate white people with positive words such as "laughter" and black people with negative words such as "failure"—a sign that this implicit bias had found its way from the TV screen into people's behavior, the researchers say. After watching clips in which black characters were treated better than whites, however, viewers not only displayed less implicit bias toward blacks, they also showed improved conscious attitudes toward blacks as measured by a questionnaire.

***Grey's Anatomy* is one of several shows that exhibited subtle racism.**

Because these TV shows' bias in either direction is unintentional, suggests Tufts psychologist Nalini Ambady, one of the researchers working on the study, simply being aware of it might help actors and directors to counteract it or use it to a positive end.

—Valerie Ross

LEARNING

In Stroke Rehab, Skip the ABC's

People with damaged speech recover faster by focusing on harder words

When we learn, we usually begin with the basics and work our way up, mastering our do-re-mi's before launching into an aria. But when people have difficulty speaking and understanding language after a stroke—a condition called aphasia—they seem to improve faster when they start at a harder level.

Speech researcher Swathi Kiran of Boston University works with bilingual aphasia patients to help them relearn words. She has found that when patients practice the language they speak less fluently, their vocabulary grows in both languages. But when the patients study words in the language they are more comfortable in, only that language improves.

Although Kiran has not yet published a study on her bilingual patients, her observation is in line with her earlier, published papers and those of other researchers. These studies show that aphasics who speak only one language also benefit from more difficult practice. When aphasics study unusual words in a category—such as "parsnip" and "rutabaga" when relearning vegetable names—they also improve their fluency with common words in that category ("pea" and "carrot"). Likewise, practicing complex sentences helps aphasics handle simple ones.

This technique works because of the way that a healthy brain stores language, Kiran says. As we learn new information, the brain stores the words, languages and grammatical structures that we use most often in a way that makes them easy to access. Harder words are more like items at the bottom of a box—we must rifle through the items we use more often to reach the buried rarity. To retrieve an unusual word such as "rutabaga," then, we activate the easily accessible parts of our vegetable-naming network on our way to getting to the word itself, which strengthens our connections to common words such as "carrot," too.

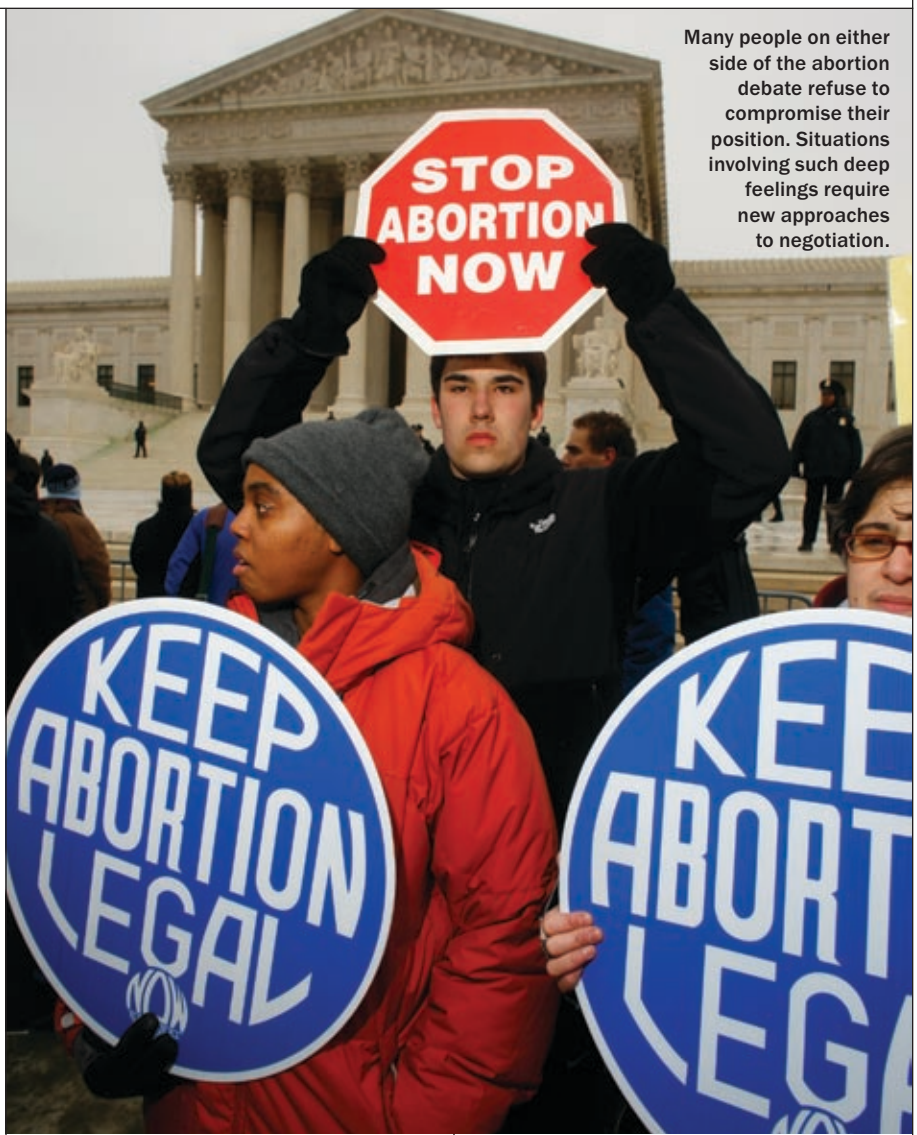
—Valerie Ross

ABC via Getty Images (*top*); JUPITERIMAGES (*bottom*)

A Taboo Exchange

Financial incentives backfire when negotiations involve deeply held beliefs

BY ADAM WAYTZ



Many people on either side of the abortion debate refuse to compromise their position. Situations involving such deep feelings require new approaches to negotiation.

MARK PETERSON *Redux Pictures*

CONSIDER the classic hypothetical: Your house is on fire, and you can rescue only three things before the structure is engulfed in flames. What would you take? Laptops and external hard drives aside, people's responses to this question differ wildly—from a hand-scrawled love note to a valuable coin collection or even a threadbare T-shirt that anyone else would consider worthless.

The tendency to consider commonplace objects worthy of reverence and protection—to treat rookie cards like rosaries—is a universal human experience. Such powerful emotions are not rooted in any specific faith or belief system; nevertheless, they have a spiritual quality—and many psychologists use the term "sacred" to describe objects toward which people proclaim an unbounded or infinite commitment.

If people ascribe sacred status to possessions, then it is no surprise they do the same with their moral stances. And just as a Beatles compilation is the pinnacle of music to one person, whereas to another it is an album from Justin Bieber, people differ in which values they consider sacred—a diversity that can breed substantial conflict. The abortion debate, for example, presents a divide between those who consider a woman's "right to choose" sacred versus those who hold a fetus's "right to life" sacred. A few recent studies have examined how people react when their most passionately held values are challenged. And because these values often play out in the political arena, the new psychological insights may help reframe bitter and long-standing international disagreements.

Your Money's No Good Here

A sacred value is more than just a strongly held belief; it is a moral stance on which the holder will not budge, no matter what the conditions. Psychologists determine who feels certain values are sacred by looking at how people behave when asked to compromise. For instance, psychologist Jeremy Ginges of the New School for Social Research and cognitive anthropologist Scott Atran of the University of Michigan at Ann Arbor asked Indonesian madrassa students if they thought in some extreme circumstances it would be permissible to accept that sharia (Islamic law) would not be the law of the land. The researchers considered students who answered "no" to such questions to hold the belief in sharia sacred. Others may have felt quite strongly that sharia should be upheld, but if they were willing to entertain the idea that in rare cases sharia could be compromised, they did not, by definition, consider the value sacred.

It makes sense that a value rooted in religious belief would be sacred, but people exhibit such boundless commitment to other values as well. Some consider it

People are more willing to **sell their body organs** for medical transplant when told it is the only way to prevent deaths.

unthinkable to root against their home team or vote against their political party—they would not do so for any inducement, even a large amount of money. In fact, when people are offered cash to relinquish a sacred value, they tend to display a particularly striking irrationality—they recoil viscerally, even though the proposition is not objectively immoral. Psychologist Philip E. Tetlock of the University of California, Berkeley, refers to these hypothetical exchanges as "taboo trade-offs," because people react to them with moral outrage; they express anger and disgust and become increasingly inflexible in negotiations.

Reframing the Debate

In 2007 Ginges and his colleagues discovered this backfire effect in studies of the Israeli-Palestinian conflict. They identified Israelis and Palestinians who possessed sacred values regarding key local issues such as who owns the West Bank and other disputed territories—these people viewed compromise as unacceptable under any circumstances. The researchers asked the subjects who held sacred values to respond to several hypothetical bargaining deals over issues central to the Israeli-Palestinian conflict. When the deals included receiving a monetary payout—for instance, billions of dollars in aid from the U.S. in exchange for giving up a disputed territory—both Israelis and Palestinians expressed more outrage and became more supportive of violence as a form of opposition. Opposition decreased, however, when the scenario included the other side compromising a sacred value of its own, such as Israelis formally renouncing their right to the West Bank or Palestinians formally recognizing Israel as a state.

Deep historical and religious traditions may be at the root of many inviolable values, but an intriguing new study suggests that even relatively recent issues can quickly become sacred to a population. Psychologist Morteza Dehghani of Northwestern University and his colleagues asked 75 Iranians how they would feel about the possibility of Iran giving up its nuclear program, giving them four response options on disarmament ranging from "definitely needs to happen" to "shouldn't be done no matter how great the benefits are." Those who chose the latter were classified as treating the matter of Iran's nuclear program as a sacred value.

The issue of Iranian disarmament has quickly become an inviolable value to many Iranians, causing them to feel anger and outrage in response to monetary offers to compromise.

After giving their opinions on Iran's nuclear program, all participants were asked to consider one of two deals for Iranian disarmament. Half the participants read about a deal in which the U.S. would reduce military aid to Israel in exchange for Iran giving up its military program. The other half read about a deal in which the U.S. would reduce aid to Israel and would also pay Iran $40 billion. After considering these proposals, participants predicted how much the Iranian people would support the agreement and how much anger they would feel toward the deal. In line with Ginges's studies, those who considered the nuclear program a sacred value expressed less support and more anger when the deal included money—even though that arrangement was objectively more beneficial to Iran. The other study subjects were more likely to appreciate the offer of aid.

The implication for international negotiation is clear: when a value becomes sacred, the rules change—offering money hurts instead of helps. Conflicts may be best resolved when both sides consider compromising something they hold dear. Choosing the right words may help, too—Tetlock's studies have shown that emphasizing the dire, necessary nature of a trade-off can facilitate conflict resolution. For example, people are more willing to sell their body organs for medical transplants when told it is the only way to prevent deaths. Initially, selling organs feels like a violation, but that gut reaction changes when alternative sacred values are invoked: altruism and saving lives. Whatever the subject of discussion may be, when sacred values are on the negotiating table, it pays to understand the psychology of the taboo trade-off. M

ADAM WAYTZ is a postdoctoral research associate in psychology at Harvard University.

(Further Reading)

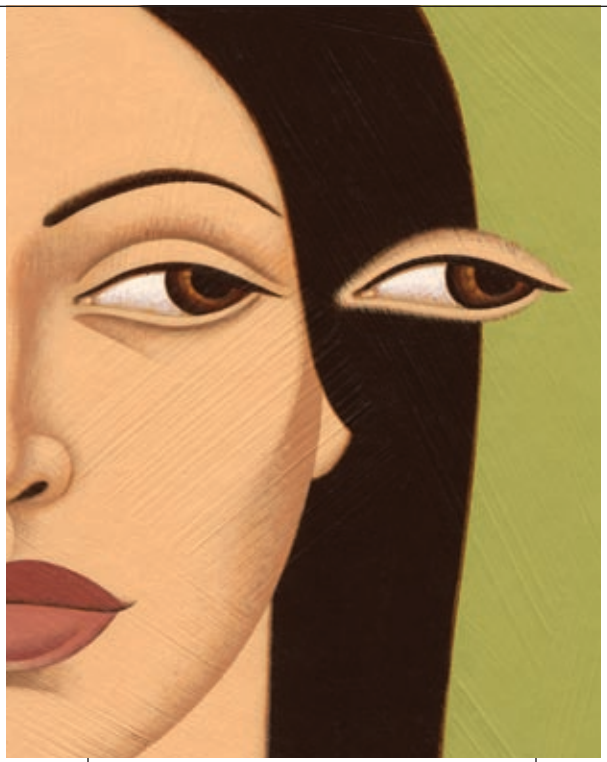
- **Sacred Bounds on Rational Resolution of Violent Political Conflict.** Jeremy Ginges, Scott Atran, Douglas Medin and Khalil Shikaki in *Proceedings of the National Academy of Sciences USA,* Vol. 104, No. 18, pages 7357–7360; May 1, 2007.
- **Emerging Sacred Values: Iran's Nuclear Program.** Morteza Dehghani, Rumen Iliev, Sonya Sachdeva, Scott Atran, Jeremy Ginges and Douglas Medin in *Judgment and Decision Making,* Vol. 4, No. 7, pages 930–933; December 2009.

AFP/GETTY IMAGES

Looks Can Deceive

When you are facing a tricky task, your view of the world may not be as accurate as you think

BY CHRISTOF KOCH



ALL OF US, even postmodern philosophers, are naive realists at heart. We assume that the external world maps perfectly onto our internal view of it—an expectation that is reinforced by daily experience. I see a coffee mug on the table, reach for a sip and, lo and behold, the vessel's handle is soon in my grasp as I gingerly imbibe the hot liquid. Or I see a chartreuse-yellow tennis ball on the lawn, pick it up and throw it. Reassuringly, my dog appears to share my veridical view of reality: she chases the ball and triumphantly catches it between her jaws.

That there should be a match between perception and reality is not surprising, because evolution ruthlessly eliminates the unfit. If you routinely misperceive or even hallucinate and act on those misapprehensions, you won't survive long in a world filled with dangers whose avoidance requires accurate distance and speed assessments and rapid reactions. Whether you are diving into rocky waters or driving on a narrow, two-lane road with cars whizzing by in the opposite direction, small mistakes can be lethal.

You probably believe that your eyes register high-fidelity information about the absolute size, speed and distance of visible objects and that you respond based on these impartial data. But although we build robots in this manner—equipping them with sensors and computers to plumb the metric properties of their environments—evolution has taken a more complex route.

As psychologists and neuroscientists have discovered over the past several decades, our consciousness provides a stable interface to a dizzyingly rich sensory world. Underneath this interface lurk two vision systems that work in parallel. Both are fed by the same two sensors, the eyeballs, yet they serve different functions. One system is responsible for visual perception and is necessary for identifying objects—such as approaching cars and potential mates—independent of their apparent size or location in our visual field. The other is responsible for action: it transforms visual input into the movements of our eyes, hands and legs. We consciously experience only the former, but we depend for our survival on both.

When driving in the mountains, have you ever noticed a discrepancy between the slope described on the yellow road sign and your sense that the incline is actually much steeper? Psychologist Dennis R. Proffitt of the University of Virginia and his then graduate student Jessica Witt did. Being scientists and not philosophers, they designed an experiment to find out why. Proffitt and Witt stood at the base of hills on campus and asked passing students to estimate their steepness in two ways. Subjects had to align the diameter line on a flat disk to the slant of the hill. They also were asked to place the palm of one hand on a movable board that was mounted on a tripod and then, without looking at that hand, to adjust the board's slant until they felt it matched that of the hill [*see photographs on opposite page*].

In the first part of the test, which relied on visual cues alone, subjects badly overestimated, interpreting a 31-degree slant as a much steeper, 50-degree one. But when people's eyes were guiding their hands, subjects judged accurately, tilting the board an appropriate amount. Perhaps even more striking was the finding that people's tendency to overestimate on the strictly visual part of the test increased by more than a third when they had just run an exhausting race—but the hand estimates were unaffected. The same discrepancy occurred when subjects wore a heavy backpack, were elderly, or were in poor physical condition or declining health.

In another variant of the experiment, Proffitt had subjects stand on top of a hill on either a skateboard or a wooden box the same height as the skateboard. Participants were instructed to look down the hill and judge, both visually and manually, its grade. They were also asked how afraid they felt to descend the hill. Fearful participants standing on the skateboard judged the hill to be steeper than did the braver souls standing on the box. Yet the visually guided action measurement was unaffected by fear.

Proffitt argues that perception is not fixed: it is flexible, reflecting a person's

CHRISTOF KOCH (*Koch*); IMAGES.COM/CORBIS (*illustration*)

> Baseball players perceive the ball to be larger when they are hitting well and smaller when they are **on a losing streak**.

physiological state. Your conscious perception of slant depends on your current ability to walk up or down hills—hard work that should not be undertaken lightly. If you are tired, frail, scared or carrying a load, your assessment of the hill—the one that guides your actions—will differ from what you see. Not by choice, but by design. It is the way you are wired.

The Witt-Proffitt team published another report on the observation, well known in sports lore, that baseball players perceive the ball to be larger when they are hitting well and smaller when they are on a losing streak. Since then, Witt, now a professor at Purdue University, along with her student Travis Dorsch, has pursued this intriguing link between how success (or lack of it) in a task affects one's perception of the world.

Participants in a 2007 study judged the steepness of a hill by sight alone (*left*) and by both sight and touch (*right*). The results differed, suggesting that we do not see the world uniformly. One vision system plans actions and accommodates our physical abilities; the other recognizes objects and is less variable.

In their experiment, 23 volunteers had to kick an American football through the field goal from the 10-yard line. After a warm-up, participants were asked to judge the height and width of the goal by adjusting a handheld, scaled-down model of the goal made out of PVC pipes. They then each performed 10 kicks. Immediately after the final kick, participants repeated the perceptual measurement.

The result was striking. Before kicking, both groups had the same perception of the size of the goal (incidentally, an inaccurate one: everybody underestimated its actual width-to-height ratio). But after 10 kicks, the poor performers (those who scored two or fewer successful kicks) saw the goal as about 10 percent narrower than they had before, whereas the good kickers (those who scored three or more) perceived the goal to be about 10 percent wider. How well you have performed over the past few minutes influences the way you see the world! Not just metaphorically, but on a physiological level—it changes your actual perceptions.

After more data mining, the two psychologists discovered that the people who missed the goal because they tended to kick the ball too short perceived the crossbar as being higher than did their more successful peers, whereas those who missed because they kicked wide judged the upright field posts to be narrower.

So by now you may be thinking: How convenient! The perceptual system offers us self-serving justifications for bad performance. But there is likely some value here, evolutionarily speaking: if people perceive the goal as higher or smaller than it actually is, they will aim more precisely the next time. What happens in football also holds for softball and golf, Witt and her colleagues have found—and, most likely, for life in general.

Our conscious perception of the world, though relatively stable, is not static. We are incapable of being fully objective, even in our most mundane observations and impressions. Our awareness of the objects around us is informed and fine-tuned by any number of transient factors—our strength and energy levels, our sense of confidence, our fears and desires. Being human means seeing the world through your own, constantly shifting, lens. **M**

CHRISTOF KOCH is 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)

- **Perceived Slant: A Dissociation between Perception and Action.** J. K. Witt and D. R. Proffitt in *Perception,* Vol. 36, pages 249–257; 2007.
- **Kicking to Bigger Uprights: Field Goal Kicking Performance Influences Perceived Size.** J. K. Witt and T. E. Dorsch in *Perception,* Vol. 38, pages 1328–1340; 2009.
- **The Roles of Altitude and Fear in the Perception of Height.** J. K. Stefanucci and D. R. Proffitt in *Journal of Experimental Psychology: Human Perception and Performance,* Vol. 35, pages 424–439; 2009.

PHOTOGRAPHS BY CEDAR RIENER; FROM "EMBODIED PERCEPTION AND THE ECONOMY OF ACTION," W BY DENNIS R. PROFFITT, IN *PERSPECTIVES ON PSYCHOLOGICAL SCIENCE*, VOL. 1, NO. 2; MAY 23, 2006

Carried to Extremes

How quirks of perception drive the evolution of species

BY VILAYANUR S. RAMACHANDRAN AND DIANE ROGERS-RAMACHANDRAN

STEVE GREENBERG www.CartoonStock.com

IF SOMEONE SHOWED you a caricature of Richard Nixon—a man's face with oversize shaggy eyebrows, a bulbous nose and pronounced jowls—you would probably recognize the former president immediately, even though the drawing is not true to life. A cartoonist creates such a sketch by taking the average of many male faces and subtracting it from Nixon's face, then amplifying those distinctive differences. To an observer, the result looks more like Nixon than Nixon himself. Why is it that our brains respond so intensely to extremes?

When the cartoon's "Nixon-ness" jumps out at you, you are experiencing what scientists call "peak shift." To understand the concept, imagine, for argument's sake, that you want to teach a rat to distinguish a rectangle from a square. It's quite easy to do. Simply give the animal cheese every time it picks the rectangle, and it will soon learn to select the rectangle every time. Once the rat has developed this preference, let's say you show it a longer, skinnier rectangle. Inevitably, you will find that the rat prefers the exaggerated one to the original. What the rat has learned to recognize is not a particular rectangle but rather rectangularity itself: the more rectangular the better. The savvy rodent looks at the longer, skinnier quadrilateral and goes, "Wow, what a rectangle!" In scientific parlance, the rat's "peak response"—its strongest reaction—has shifted away from the original—hence the term "peak shift."

The sway that exaggerated characteristics hold over us is a special kind of illusion—and a powerful one, we believe. In the five years that we have been writing about perception for this magazine, we have described a range of illusions, from geometric patterns that seem to move because they activate our motion perception systems to optical tricks that arise because each of our eyes sees the world from a slightly different position.

Now we would like to make a daring suggestion: that illusions are not merely fascinating windows into our minds and the way we perceive the world. They help to drive the most powerful force that shapes life on earth: evolution.

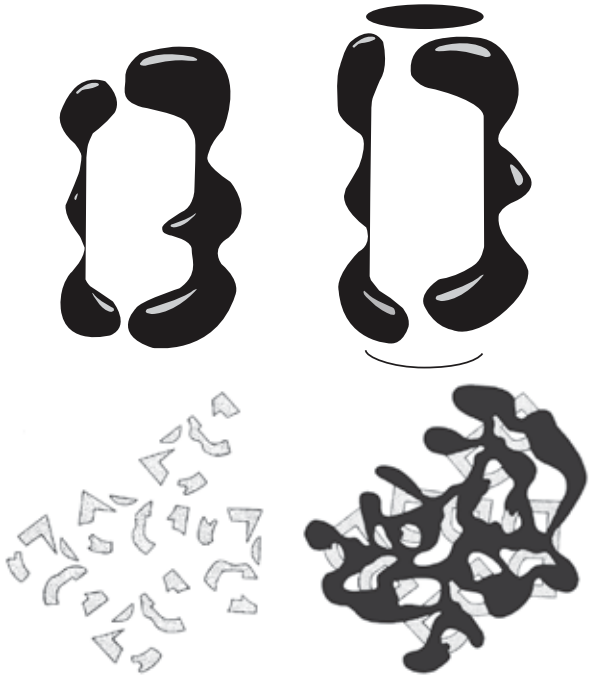
The standard theory of evolution is that animals that randomly inherited genes that produced beneficial traits—in the case of the giraffe, a longer neck, which made it easier to reach tall acacia trees—ate better, reproduced more often and passed these gene variants to their offspring. Hence the progressive lengthening of the giraffe's neck across successive generations.

What we are proposing is yet another mechanism of evolution. Our hypothesis involves the unintended consequences of aesthetic and perceptual laws that evolved to help creatures quickly identify what in their surroundings is useful (food and potential mates) and what constitutes a threat (environmental dangers and predators). We believe that these laws indirectly drive many aspects of the evolution of animals' shape, size and coloration.

Let's return to the giraffe. Giraffes need to recognize and mate with others of their own kind—and not, say, with antelopes or okapi. Wired into the animals' visual centers is a recognition system that automatically prefers mates that have more "giraffelike" characteristics. In this formulation, the longer necks were selected not because of any functional reason but simply because in scanning for desired traits, the visual system lights

upon exaggerated ones first. They stand out, like Nixon's prominent brows. Across successive generations, the long neck would have become an ever more reliable species marker for giraffeness, thereby enabling a partner to be spotted even from a great distance.

Our theory is not intended to replace Charles Darwin's but to point out that other powerful forces besides the natural selection of fitness-conferring genes may be involved. Darwin, of course, acknowledged as much when he observed that mating behavior—so-called sexual selection—can exert its own, often maladaptive, impact on evolution. Because female peacocks prefer males with large tails, big-tail genes multiply in the population, eventually culminating in modern peacocks' magnificent but absurdly impractical tails.



The brain seeks to construct whole objects from spotty visual cues. Hence, two blobs become one entity once they appear to encircle a cylinder (*top*), and fragments form five letter B's (*bottom*) once it appears that something is lying on top of them.

The aesthetic theory of evolution that we are proposing also revolves around mating behavior, but it differs from sexual selection. For one thing, sexual selection only explains why secondary sexual characteristics in males (the peacock's tail, the rooster's wattle, the unwieldy antlers of the Irish elk) become exaggerated. The peak-shift effect, in contrast, helps to explain extreme traits and behaviors that pertain to all members of a species (both male and female giraffes must identify potential mates, which helps to explain why both genders have long necks).

Because humans (taxonomists included) are diurnal and hence visual creatures, we tend to place a strong emphasis on appearances. But the principle of peak shift can apply as easily to nonvisual signals. For nocturnal critters such as rodents that use smells to find mates and interpret their world, attractions to strong scents could drive evolutionary change. These changes would be hard to see but just as real. If dogs were taxonomists, the evolutionary trees in their textbooks would look very different from ours.

The Gull Chick Principle

Other rules of aesthetics besides peak shift can also be invoked to explain the astonishing diversity of species. One is what we call the "gull chick principle."

Niko Tinbergen, a pioneering investigator of animal behavior, experimented with herring gulls 50 years ago, but the relevance of his work to evolutionary theory has not been widely appreciated. The adult herring gull has a long, yellow beak with a red spot near the tip. As soon as a chick hatches, it starts pecking at this spot, which triggers the parent to regurgitate food into the chick's mouth. How does the chick recognize its mother? Tinbergen found that it doesn't: chicks will peck as intently at a disembodied beak.

Why is a beak sufficient? The purpose of vision is to identify and interpret objects and events while expending the least amount of mental processing power. Through millions of years of evolution, the chick's brain has acquired the wisdom that this long thing with a red spot always has a mother, not an inquisitive ethologist, attached to it, and it makes an interpretive shortcut.

Newborn gulls instinctively peck at the red spot on an adult's beak—or, it turns out, at anything with a red spot.

Tinbergen next found that a beak is not even required. He held out a long, yellow stick with three red stripes on it, and the chicks pecked it—more, in fact, than they would have pecked at a real beak. Tinbergen had stumbled on a superbeak!

Why does this happen? Clearly, there are neural circuits in the visual pathways of the chick's brain that are specialized to detect the red spot on a beak as soon as the chick hatches. Perhaps the neurons' receptive field embodies a rule such as "the more red contours the better." So even though the stick does not look like a beak—maybe not even to the chick—this strange object is more effective than a real beak at activating the bird's beak-detection system. Hence, we predict that a species of gull will emerge that has two or even three red beak stripes instead of just a bigger red splotch. Another, even more striking example of the gull chick principle is the idiosyncratic preference (demonstrated in the lab) that guppies show for potential mates that have been painted blue—even though in nature guppies are not blue. Again, we anticipate the emergence of a new species: the blue guppy. It's not often in evolutionary theory that one can make such specific predictions.

The gull chick principle may apply widely, because the visual system of every animal is wired to use specific characteristics to identify others of its species. If a potential mate diverges from the standard in a way that more optimally excites "species-identifying" brain circuits, the genes that pro-

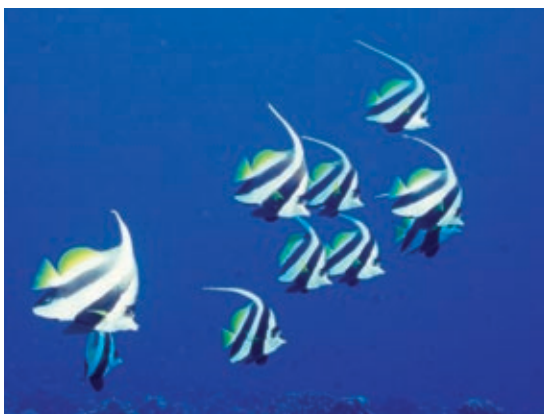
PETER ULRIC TSE (*top illustration*); COURTESY OF ALBERT S. BREGMAN *Department of Psychology, McGill University* (*bottom illustration*); MICHAEL QUINTON *Minden Pictures* (*gulls*)

If dogs were taxonomists, the evolutionary trees in their textbooks would look very different from ours.

mote such supertraits will flood the population. Unlike the peak-shift principle, no obvious parameter is being exaggerated (such as a long neck); the changes in appearance are selected because of idiosyncratic aspects of neural wiring. Even the florid, almost comical, exaggeration of dance rituals in some bird species may be influenced by this principle.

Marian Stamp Dawkins, an animal behavior expert at the University of Oxford, has championed the idea that aspects of sensory processing can influence the evolution of communication signals; for example, a nocturnal species whose predators are color-blind would not evolve colored warning splotches. Our idea complements hers but takes it further, by arguing that higher-order principles of perception may also play a role.

Another principle that may affect evolution is known as grouping. The visual system has an obsessive desire to make whole objects from fragmentary evidence—such as a lion largely obscured by leaves and shadows. Like-colored fragments are interpreted as bits of a single object that is partially hidden by another, closer object [*see top illustration on preceding page*]. As naturalists have long recognized, this tendency is cunningly exploited by reef fish, which evolved bold colored splotches that "break" their outlines and confuse predators seeking continuous contours.



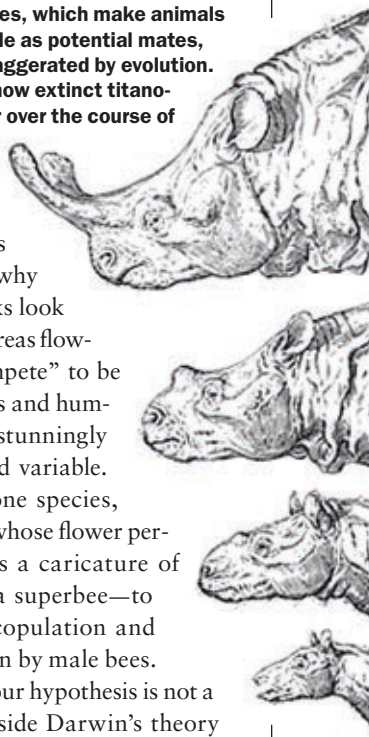
Evolution has turned certain animals into living illusions, for purposes of camouflage or attraction. The stripes of butterflyfish confound predators, which scan for color and outline continuity. This orchid practices another ruse, posing as a larger-than-life female bee to entice males.

Proofs of Concept

If perceptual laws influence the development of species, what would evolutionary biologists expect to see? For one, the progressive "caricaturization" of easily recognizable physical traits over time. And indeed, such trends are commonly seen in the evolution of mammoths, ankylosaurs, titanotheres and other animals [*see illustration at right*].

Another prediction from the theory is that unseen parts—internal organs—would not be subject to perceptual selection pressures and hence should diverge considerably less. Overall, this appears to be true. A rhesus monkey's liver doesn't look much different from a human one.

Finally, because plants do not have sophisticated sensory systems, they should vary less in appearance than animals do, except when selection has been done for them by animals. This would explain why leaves and trunks look much alike, whereas flowers, which "compete" to be visited by insects and hummingbirds, are stunningly conspicuous and variable. There is even one species, the bee orchid, whose flower perfectly resembles a caricature of a female bee—a superbee—to attract pseudocopulation and cross-pollination by male bees.



Distinctive features, which make animals easily recognizable as potential mates, often become exaggerated by evolution. The horns of the now extinct titanotheres grew bigger over the course of 20 million years.

Ultimately, our hypothesis is not a mechanism outside Darwin's theory but an unexpected interaction *within* it. His principle of natural selection leads to the emergence of brain mechanisms that enable an animal to quickly detect healthy sexual partners of the same species. But inevitably these cognitive processes have side effects. They evolved to increase a species' fitness but may lead to perceptual quirks that do not promote fitness—and may even work against it. Thus, the study of visual illusions—and the laws they exploit—offers clues to certain otherwise mysterious trends in evolution. 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)

- **On the Origin of Species.** Charles Darwin. John Murray, London, 1859.
- **The Descent of Man.** Charles Darwin. John Murray, London, 1871.
- **Sensory Bias and the Adaptiveness of Female Choice.** Marian Stamp Dawkins and Tim Guilford in *American Naturalist,* Vol. 148, pages 937–942; November 1996.
- **Phantoms in the Brain.** V. S. Ramachandran and Sandra Blakeslee. HarperCollins, 1998.

GERALD NOWAK *Getty Images (fish);* BOB GIBBONS *SPL/Photo Researchers, Inc. (orchids)*

(calendar)

July

7–10 Upon winning a gold medal, most Olympic athletes have identical emotional reactions—tears of joy, passionate hugs and glowing smiles. Psychologist David Matsumoto of San Francisco State University noticed, however, that after the initial rush wears off, athletes exhibit a range of emotional expressions. He attributes this variation to cultural differences. For instance, Americans are more likely to maintain their jubilant demeanor, whereas Japanese athletes will try to cover up their emotions—say, by neutralizing their joy with a straight face. At the **20th Congress of the International Association for Cross-Cultural Psychology**, Matsumoto, who is the keynote speaker, and other presenters will explain how and why expressions of emotion differ among cultures.
Melbourne, Australia
www.iaccp2010.com

28 A devastating earthquake hit Tangshan, China, on this day in 1976, killing more than 242,000 people and disabling 164,000. Thirty-four years later, to the day, Chinese film director Feng Xiaogang is releasing a drama about the event, **The Aftershocks**, in Imax theaters. The film, adapted from Zhang Ling's novel *Aftershock,* centers on the trauma experienced by a seven-year-old girl who survives the incident. The film depicts the girl's life for 32 years following the quake, as she copes with untreated anxiety and painful flashbacks, suffering from what is probably undiagnosed post-traumatic stress disorder.
Nationwide and China
www.imax.com

August

24 Join hundreds of cyclists in the **2010 Memory Ride**, organized by the Massachusetts/New Hampshire chapter of the Alzheimer's Association. By doing so, take charge of your health—exercise can lessen the risk of developing Alzheimer's disease. Moreover, a study published in March by researchers at the Rush University Medical Center in Chicago found that people who felt more purpose in life reduced their risk of Alzheimer's by 50 percent. The investigators defined a sense of purpose as a "psychological tendency to derive meaning from life's experiences and to possess a sense of intentionality," which can arise by increasing a social network, making plans with friends and trying new activities. You might have a chance to do all three at the Memory Ride, which has raised more than $2 million for Alzheimer's research in its 14-year existence.
Devens, Mass.
www.kintera.org/faf/home/default.asp?ievent=332880

30 Recently psychologists have demonstrated that excess worry can weaken the heart muscles [see "Why We Worry," by Victoria Stern; SCIENTIFIC AMERICAN MIND, November/December 2009]. At the **15th World Congress of Psychophysiology**, which spans six days, Ohio State University psychologist Julian Thayer will discuss the neural pathways associated with worry and how they affect cardiovascular health. Conference-goers will also learn about new neuroimaging techniques and explore whether brain scans can accurately detect lies or diagnose brain ailments such as bipolar disorder and seasonal mood disorder.
Budapest, Hungary
www.world-psychophysiology.org/iop2010

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

See, Hear, Touch

Explore your sensory world at museum exhibits on human perception.

Through September 6

How do magicians convince audiences that a metal spoon has turned to rubber? Many familiar tricks exploit shortcuts the brain uses to process information more efficiently. The spoon ploy works because of an anomaly in the visual cortex that causes two sets of neurons to produce different estimates about the spoon's movement, making it appear to bend. Visitors to **Magic: The Science of Wonder**, a new show at the Houston Museum of Natural Science, will deconstruct some of the most infamous tricks of greats such as Harry Houdini and Penn & Teller.
Houston
www.magician.org/portal/node/925

Ongoing

In the **Hall of Human Origins** exhibit at the Smithsonian Institution National Museum of Natural History, visitors learn how humans evolved unique characteristics such as storing decades' worth of information and creating abstract images. The exhibit houses ancient artifacts and fossilized bones dating back 350,000 years and explains how our brain development has helped us acquire complex abilities.

Washington, D.C.
http://humanorigins.si.edu

Which one of these yellow lines is longer? If you're familiar with this illusion, you'll know that the lines are the same length. Even so it may be hard to override your impression that the "railroad tracks" are receding into the distance—suggesting that the upper line is farther away and, therefore, must be bigger. This optical trick demonstrates that the brain judges (or misjudges) an object's size based on its context. At **Seeing Is Deceiving**, an exhibit at the Museum of Science, visitors can delve into the cognitive principles that underlie such tricks.

Boston
www.mos.org

AFP/GETTY IMAGES (*Bode Miller*); KEREN SU *Getty Images* (*bicycle race*); SMITHSONIAN INSTITUTION (*Homo heidelbergensis*); SCIENTIFIC AMERICAN MIND; SOURCE: TONY PHILLIPS *NASA* (*tracks*)

Making Connections

The essence of memory is linking one thought to another

By Anthony J. Greene

Many people wish their memory worked like a video recording. How handy would that be? Finding your car keys would simply be a matter of zipping back to the last time you had them and hitting "play." You would never miss an appointment or forget to pay a bill. You would remember everyone's birthday. You would ace every exam.

Or so you might think. In fact, a memory like that would snare mostly useless data and mix them willy-nilly with the information you really needed. It would not let you prioritize or create the links between events that give them meaning. For the very few people who have true photographic recall—eidetic memory, in the parlance of the field—it is more burden than blessing.

For most of us, memory is not like a video recording—or a notebook, a photograph, a hard drive or any of the other common storage devices to which it has been compared. It is much more like a web of connections between people and things. Indeed, recent research has shown that some people who lose their memory also lose the ability to connect things to each other in their mind. And it is the connections that let us understand cause and effect, learn from our mistakes and anticipate the future.

The things we remember are the ones that experience teaches us will help us make predictions; the newest work in our laboratory reveals how we make use

PHOTOILLUSTRATION BY AARON GOODMAN

To a mind that can't make connections, each instant fleeting and unrelated, each precept without relevance,

of this predictive ability. Other recent studies show that imagining the future involves brain processes similar to, but distinct from, those involved in conjuring the past. We also tend to remember the people and events that resonate emotionally, which is why forgetting an anniversary is such an offense: it is fair evidence that the date is not as important as the ones we do remember.

The discovery that memory is all about connections has revolutionary implications for education. It means that memory is integral to thought and that nothing we learn can stand in isolation; we sustain new learning only to the degree we can relate it to what we already know. The modern theory of memory can help us as we organize our experiences, teach our children and support those with learning problems.

Creating Memories

When a memory forms in the brain, it alters the connections between nerve cells, such as these from a sea slug, *Aplysia*. A sensory neuron (*left*) loses most of its connections, or synapses, to an adjacent motor neuron when the slug learns that two things or events are no longer related (*center*). New synapses form when repetition reinforces an association (*right*), creating a memory as neurons that fire together wire together.

The History of Memory

For millennia, metaphors for memory have marched in lockstep with the technology for recording thought. References in ancient Greece likened memory to tracings in a wax tablet, in the Middle Ages to parchment, and later to books, files, photos, videos, audio recordings and computer hard drives. Modern scientific dialogue still sometimes refers to memory as a trace (as in a wax imprint or a rubbing). Lately we compare human memory to computer memory, and we draw from the same taxonomy. We speak of encoding and storage for the learning of new memories, retrieval for the act of remembering, address for the location of a memory in the brain, and output for a remembered event—metaphors that persist even as our understanding of memory evolves.

The modern view of memory has its roots in the 1930s and 1940s, when a series of discoveries, most notably by psychologist Karl Lashley of the University of Chicago and later Harvard University, revealed that learning and memory are not sequestered in their own storage banks but are distributed across the entire cerebral cortex. Lashley set out to discover the location of the learning center of the brain by systematically disconnecting different regions of the cerebral cortex in a number of different rats. To his surprise, all the rats showed some degree of mild learning impairment, but none was seriously impaired.

The significance of these findings is profound. It means that memory is dispersed, forming in the regions of the brain responsible for language, vision, hearing, emotion and other functions. It means that learning and memory arise from changes in neurons as they connect to and communicate with other neurons [*see illustration above*]. And it means that a small reminder can reactivate a network of neurons wired together in the course of registering an event, allowing you to experience the event anew. Remembering is reliving.

Another piece of the puzzle fell into place in the 1950s, after some surprising observations of a few individuals

FAST FACTS

Linking and Learning

1» **Brain cells that fire together during an experience can form permanent connections.**

2» **Those connections let the same network of brain cells refire later on, which we experience as memory.**

3» **New experiences can lead a network of cells to develop further connections, adding to a memory and helping us learn but sometimes modifying a recollection and creating false memories.**

4» **Because knowledge derives from connections, the optimal strategy for learning involves making meaningful associations among topics.**

FROM *AN INTRODUCTION TO BRAIN AND BEHAVIOR*, THIRD EDITION, BY B. KOLB AND I. Q. WHISHAW, WORTH PUBLISHERS, 2009

is an isolated event without continuity, each thought each person a stranger, every event unexpected.

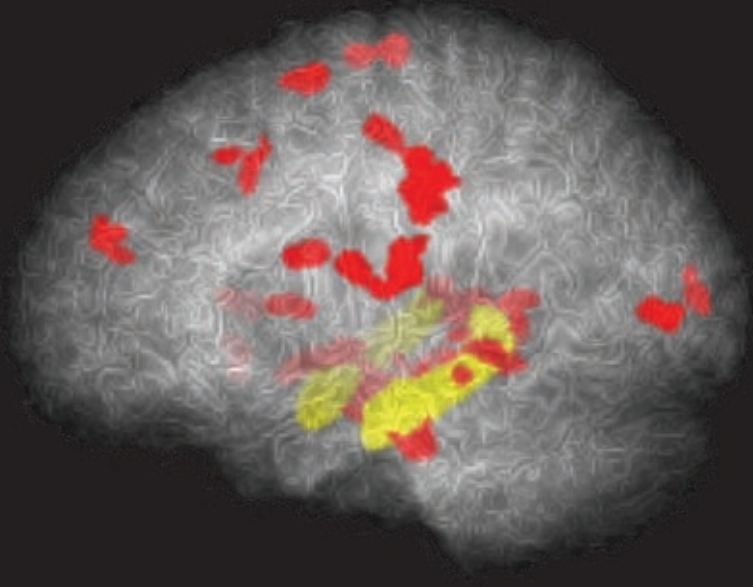
with almost complete amnesia. In the most compelling case, a 27-year-old Connecticut man, known as HM but identified as Henry Gustav Molaison after his death in 2008, had severe epilepsy that was not responding well to medication. It was a sadly common practice in those days to treat epilepsy by removing or disconnecting substantial portions of brain tissue. The performance of a brain resection on HM resulted in one of the most extreme cases of amnesia ever recorded. His case and others revealed that damage to the hippocampus, a wishbone-shaped structure located deep below the surface folds of the cerebral cortex, leaves people almost completely unable to acquire new memories or to learn complex associations. Their minds remain frozen at the time of the neural insult; the greater the damage, the more severe the amnesia.

At first, this finding appeared to contradict the discovery that learning and memory are distributed across the brain. The hippocampus, though, turned out to be not the source or storehouse of memory but rather an essential mediator in its formation. In a very small brain, every neuron might be connected to every other neuron. But a human brain that worked on this model would require that each of hundreds of billions of neurons be linked to every other neuron, an impossibly unwieldy configuration. The hippocampus solves this problem by serving as a kind of neural switchboard, connecting the distant cortical regions for language, vision and other abilities as synaptic networks take shape and create memories [*see illustration below*].

Recent amnesia research paints an even bleaker picture of the condition, while yielding some startling insights into what memory really is. Hippocampal amnesiacs appear to have impairments that go well beyond the loss of memory creation. They also have severe difficulty imagining future events, living instead in a fragmented, disconnected reality. In a study published in 2007 psychologist Eleanor Maguire and her research team at University College London asked participants with amnesia and those with normal memories to elaborate on hypothetical scenarios of short, simple vignettes. (The researchers gave participants a cue card summarizing the main dramatic elements to ensure that no one would forget the setup.)

In one scenario, participants were to imagine they were standing in the main hall of a museum with many exhibits. Those with normal memory could generally develop a coherent narrative about people and their activities. Amnesic participants typically could visualize only a few details, which were often disconnected and lacking in spatial and temporal coherence. One typical narrative: "Well, there's big doors.... There'd be the exhibits.... I don't know what they are.... There'd be people." What is lost in amnesia, then, is the capacity to connect things to one another and find any meaning in them. To a mind that cannot make connections, each instant is an isolated event without continuity, each thought fleeting and unrelated, each precept without relevance, each person a stranger, every event unexpected.

A Neural Switchboard



From its central location, the hippocampus (*yellow*) connects far-flung regions of the cortex (*red*) that are involved in a particular recollection. The image, in which the brain is rendered semitransparent, superimposes a functional MRI image of the cerebral activity on an MRI of its structure.

MATHEW VERBER *Medical College of Wisconsin*

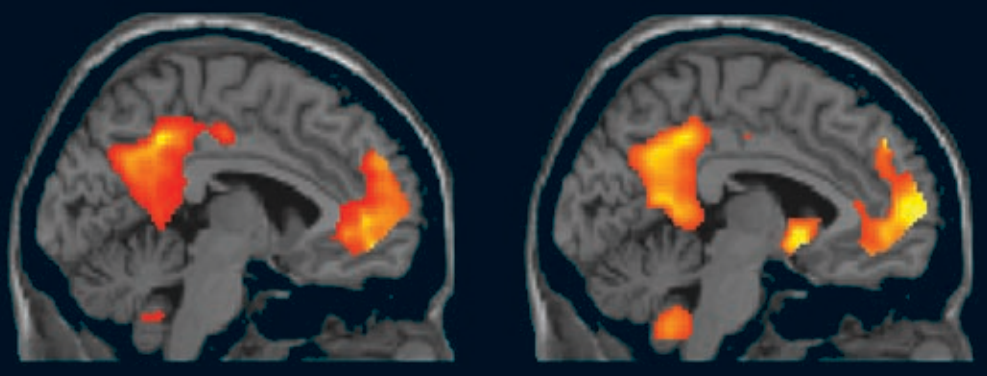
(The Author)

ANTHONY J. GREENE is associate professor of psychology at the University of Wisconsin–Milwaukee, where he runs a learning and memory lab.

The ability to form and retain connections makes this critical aspect of learning: "I put two and two

Reimagining Is Reliving

These two fMRIs show a few differences but great overlap in the regions of the brain involved in recalling a past event and imagining a future one. In each case, a network of neurons fires across the cerebral cortex.



Remembering the past

Imagining the future

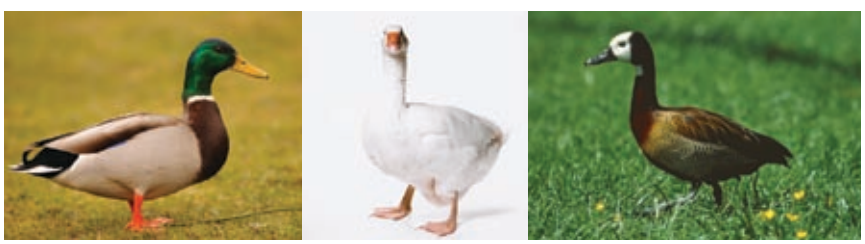
The connections across the brain also help us conceive the future, as recent imaging studies have shown. Functional magnetic resonance imaging detects changes in blood oxygen in various regions of the brain. When participants perform memory tasks, the areas of the brain that use more oxygen are assumed to be involved. In 2007 a team led by psychologist Kathleen McDermott of Washington University in St. Louis and, separately, by psychologist Daniel L. Schacter of Harvard and his colleagues showed that a mosaic of brain areas similar to those involved in memory is active when participants imagine details of hypothetical or prospective events. In McDermott's study, participants were told they would be asked to imagine some future event. Once the subjects were inside the scanner, a researcher would announce a keyword—"birthday," say—and the participants would then think (to themselves; talking is not permitted during a scan) about how and where and with whom they would celebrate a future birthday. Just as memories do, those imaginings elicited activity in the hippocampus as well as multiple regions of the cerebral cortex.

In a 2009 experiment with a similar setup, Schacter's team asked people to recall an experience instead of inventing a new one. The researchers found that although the subjects' brain activity was similar to that of people imagining a new scenario, the patterns were clearly distinct, suggesting that anticipating the future is not simply a matter of recasting past experiences into a novel or hypothetical form [*see illustration above*]. Every new event has some novel element to it even if experienced under similar circumstances, so the pattern of neuronal firing will be different each time. Our brain has evolved not just for learning and memory but for the management of relations: past, present and future.

Memory as Connection

The ability to form and retain connections gives us not just a record of events but also the foundations of comprehension. We have plenty of clichés to express this critical aspect of learning: "I put two and two together" or "I just connected the dots." We make use of these connections thousands of times a day. And knowing how they work is crucial to understanding how we learn.

Connections progress from simple relations between things to ever more complex cascades of inferences. Links between things, events, people and our actions—so-called item associations—are the reason certain objects evoke reminiscence and become keepsakes. Visiting your alma mater, catching a whiff of burning leaves or finding a letter from a loved one can bring back vivid memories



The neural connections that make up our memories also help us generalize and discriminate. Generalization helps us see the common elements in, say, all waterfowl but blinds us to the differences between the mallard (*left*), the goose (*center*) and the white-faced whistling duck (*right*). In time, we learn to tell one similar creature from another.

comprehension possible. Plenty of clichés express together" or "I just connected the dots."

Getting the **Most** from Your Memory

Rather than cluttering your mind with arbitrary facts, try these techniques for using your memory more effectively. You will understand concepts in greater depth and have more confidence in what you know.

- Think about relevant connections between what you wish to learn and what you already know. Build as many meaningful connections as you can.
- Make sure you thoroughly understand what you want to learn. If you try to memorize a formula, a foreign phrase or a passage you have not fully grasped, you will soon forget it and will create a cul-de-sac for future learning.
- Explain things to yourself as if you were teaching them to someone who was unfamiliar with the subject. You will clarify and consolidate your own understanding.
- Organize your thinking, outlining complex topics. Ensure that the outline is as logical as you can make it.
- Summarize what you wish to learn so that you establish the main points. Then elaborate on them to establish depth and breadth.

- Never cram or rush yourself. Spread out your learning. There are no known upper limits on how much human beings can learn, but there are significant limits on how much they can learn at the last minute.
- Practice early and often.

—*A.G.*

of events you might not have thought about in years. Item associations let us remember that Italy has good wine, and they help us connect people's names to their faces. Items can also be retrieval cues. A buzzer reminds us that dinner is still in the oven. The sight of a co-worker in the hall prompts us to mark a meeting on the calendar.

Put enough of these item associations together, and you will create a web of connections that can help you make predictions and navigate the world more effectively over time. At their simplest, predictive associations remind us that wet snow will clog the snowblower and that lewd humor will upset some people. But many predictive associations are more nuanced. Your boss might get upset if you tell a crude joke in the office but not when you are out for a beer and even then may check to see who else is there before deciding to laugh. Making predictions requires us to weigh multiple variables, which in turn takes a brain big enough to learn all the relations involved. Indeed, social interactions can pose our greatest predictive challenges and may well have been a major impetus, among our prehuman ancestors, for the evolution of astounding learning abilities.

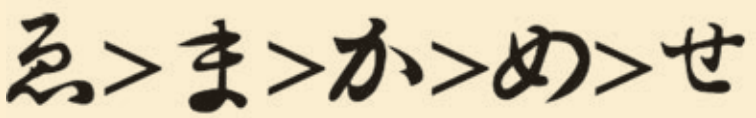
At the root of the flexibility of learning and memory is generalization. My one-year-old son recently had a wonderful time feeding some ducks and soon was able to point out a duck with no trouble, whatever its color or age. He also overgeneralizes: in his lexicon, geese and swans are also ducks. Eventually he will learn to discriminate among waterfowl and perhaps in time among different types of ducks, as he will later learn to tell a cabbage from a lettuce and one sort of lettuce from another. Generalization and discrimination are the yin and yang of learning and memory—complementary processes that ultimately work together to shape our associations.

As we amass knowledge over the course of our life and connect events in our memory, we learn to model complex contingencies and make inferences about novel relations. In my own lab, we have been exploring the ways people use learned relations to make predictions. In one experiment, published in 2006, participants lying inside a functional MRI machine viewed a computer screen on which we displayed various pairs of unfamiliar shapes, drawn from the Japanese *hiragana* alphabet [*see top illustration on next page*]. For each pairing, we asked participants to click on one shape or the other, eliciting a message—"correct" or "incorrect," depending on the choice—letting them learn which symbol in a given pair was preferred. Then we showed them novel pairings and asked them to click on the one they thought was correct,

JEFFREY COOLIDGE *Getty Images*

Experiments reveal how easy it is to create false incorrect information about a car accident, many

Symbol Solutions



People were trained to recognize which of these symbols from the Japanese *hiragana* alphabet was the "preferred" one in a series of pairings. Then the participants tried to pick the "correct" symbol in new pairings. The learners who were able to *infer* a hierarchy of symbols from the original symbol sets made more correct choices later on and displayed greater activity in the hippocampus.

based on the hierarchy implied during the learning phase. Those who scored well—the ones who used inference—displayed much greater activity in the hippocampus than those who scored nearer the level of chance—the ones who merely guessed—suggesting memory networks are fully engaged across the brain when people use what they know to make predictions. This study and others like it give insight into how we cobble together bits of information learned over many years and use them to navigate our course through life.

The accretive and adaptive quality of memory can sometimes cause us problems by altering our memories instead of augmenting them. During the 1990s psychologist Elizabeth Loftus, now at the University of California, Irvine, produced an impressive amount of research showing how easy it is to create false memories of past events. In one study, participants watched a film of a car accident. Researchers asked some subjects how fast they thought the cars were going when they "smashed into" each other and asked other subjects how fast the cars were going when they "hit" each other. The subjects who heard the word "smashed" gave significantly higher estimates of the speed. In other experiments, subjects were fed incorrect information about an accident after watching the film; they might, for instance, be asked repeatedly whether a traffic light had turned yellow before the collision when in fact the light was green. Many then remembered a yellow light that never existed—which is why eyewitness testimony after police interrogation can be so unreliable. To avoid this kind of malleability, smart lawyers tell clients to write down what happened as soon as possible and before discussing it. [For more on the reliability of eyewitness testimony, see "Do the Eyes Have It?" by Hal Arkowitz and Scott O. Lilienfeld; Scientific American Mind, January/February 2010.]

Teach, Memory

In my own early education during the 1970s, schools often taught through rote memorization. I was told to memorize multiplication tables, the Preamble to the U.S. Constitution, and poetry that I did not understand at all. Although the days of learning by repeating things over and over are finally on the wane, educators still rely on old-school methods such as the arbitrary mnemonic device—an unrelated acronym used as a memory cue. This is not to say that facts need not be learned. Some, such as phone numbers and people's names, are inherently arbitrary, and for them rote learning may be appropriate. But the message of modern memory research is that the brain is wired to recognize and organize coherent connections, not arbitrary ones. By tying new learning to existing associations—by engaging in contextual learning—we greatly improve results.

Say, for instance, you were teaching students about a historical novel such as *The Scarlet Letter*. Before you uttered the name "Hester Prynne," you might first discuss how Puritan society mirrored truths your students already know: religious leaders do not always live up to their convictions; the judgment of peers is weighty and lasting; concealed shame eats at the soul. You could next intro-

New brain insights suggest that rote learning is usually ineffective. Students are more likely to retain new information when they can relate it to what they already know.

FROM "AN FMRI ANALYSIS OF THE HUMAN HIPPOCAMPUS: INFERENCE, CONTEXT, AND TASK AWARENESS," BY A. J. GREENE, W. L. GROSS, C. L. ELSINGER AND S. M. RAO, IN *JOURNAL OF COGNITIVE NEUROSCIENCE*, VOL. 18; 2006 (*top*); WILL & DENI McINTYRE *Corbis* (*bottom*)

memories of past events. When people were fed remembered a yellow light that never existed.

duce ways in which the Puritan universe was different: living on the verge of survival necessitated collective conformity; technology was primitive; religious convictions were a community affair. Your students can then engage their imaginations to paint a picture of the characters' way of life, from family relations to dogs chasing pigs down the streets. As their knowledge of the story's setting deepens, they can begin to take in abstract ideas, such as the political and legal structures of Puritan society. By this time, the students will have formed an intricate web of associations that will let them weave the lessons of the book into their own thinking. They can live the story and grasp its significance.

Contextual learning can even help with tasks that seem intractably a matter of rote memorization, such as learning the times tables. You can better teach a child that 3 times 4 equals 12 by bringing the idea into the real world. Ask a girl who likes cars how many wheels she would need for three racers with four wheels apiece. As she memorizes the tables, she will learn what multiplication actually does, which will help her solve related problems later on. When rich in context, science becomes an extension of a student's natural curiosity to figure out how things work, just as history, as collective memory, connects students to the continuum of civilization, and fine arts connects them to the mind of the artist. If the connections between subject matter and students are relevant and personal to them, the learned material becomes part of their beings.

The lessons of associative learning can also give educators a fresh approach to early learning and to teaching children with learning deficits. Simplified contingencies can help everyone in the first stages of learning. For example, a young child who thinks that all swimming birds are ducks may later learn conditions that distinguish one kind of swimming bird from another, and from there exceptions to those conditions, and in time more complicated relations still.

Rather than learning multiplication tables by endless repetition, students should figure out how many wheels they would need to equip a fleet of cars.

Connections help us anchor an ever more complicated body of knowledge about how the world works and negotiate the complex structures all around us. Memory is a dynamic aspect of our intellect. And as our understanding of memory grows deeper, we see that the connections we make between the people, places and things in our lives, between the past, present and future, do not themselves spring from memory. Memory springs from the connections.

Despite our imperfect metaphors, we must have long known that memory was more than a mere repository of experience. Consider the ancient Greeks. The muses were not simply the goddesses who inspired poetry, music and all forms of artistic creativity and for whom temples were erected. They were also patrons of the liberal arts and the wellspring of philosophy, knowledge, thought and wisdom. And the mother and queen of all the muses? Mnemosyne, the muse of memory. M

(Further Reading)

- **Metaphors of Memory: A History of Ideas about the Mind.** Douwe Draaisma. Translated by Paul Vincent. Cambridge University Press, 2000.
- **Contextual Teaching and Learning: What It Is and Why It's Here to Stay.** Elaine B. Johnson. Corwin Press, 2002.
- **Synaptic Self: How Our Brains Become Who We Are.** Joseph LeDoux. Penguin Books, 2002.
- **What's New with Amnesic Patient HM?** Suzanne Corkin in *Nature Reviews Neuroscience,* Vol. 3, pages 153–160; 2002.
- **From Conditioning to Conscious Recollection: Memory Systems of the Brain.** Howard Eichenbaum and Neal J. Cohen. Oxford University Press, 2004.
- **The Science of False Memory.** C. J. Brainerd and V. F. Reyna. Oxford University Press, 2005.
- **The Hippocampus Book.** Edited by Per Andersen, Richard Morris, David Amaral, Tim Bliss and John O'Keefe. Oxford University Press, 2007.

JEFFREY COOLIDGE *Getty Images*

Yearning for Yesterday

Dwell on the past. It's good for you

By Jochen Gebauer and Constantine Sedikides

Do you have wistful memories of the cookies that came from your grandmother's oven? Do you enjoy recalling the jokes and pranks that you and your school friends used to find hilarious? On a restless night, does the whoosh of a train on a long-ago journey linger in your mind? If your recollections sometimes evoke a sentimental yearning for the past, then you know what it means to experience nostalgia.

You are in good company, too. In a 2006 study conducted at the University of Southampton in England, 79 percent of the 172 students surveyed said that they have nostalgic thoughts at least once a week; 16 percent reported having such moments every day. Nostalgia is not limited to any culture, stage of life or state of mental health. Our Southampton team has found the emotion in healthy adults and children, as well as patients suffering from dementia.

What may surprise you, though, is that nostalgia has an important function. Rather than being a waste of time or an unhealthful indulgence, basking in memories elevates mood, increases self-esteem and strengthens relationships. In short: nostalgia is a source of psychological well-being.

Systematic research into nostalgia was unknown until about 30 years ago, but physicians have used the term since the 17th century. It derives from the Greek words *nóstos* ("return") and *àlgos* ("pain"), so that nostalgia means, literally, the suffering that results from a desire for return—to a place, to a time, to a way of life. Swiss physician Johannes Hofer coined the term to describe the behavior of Swiss mercenaries in the service of European monarchs. These soldiers were reportedly plagued

by an obsessive longing for their homeland, which manifested itself in hysterical fits of crying, anxiety, heart palpitations, diminished appetite and insomnia. Hofer considered nostalgia a disease.

In the 19th century nostalgia took on a Freudian cast. Psychoanalysts interpreted sentimental yearning as a pathological form of melancholy. Some called it "immigrant psychosis," a now discredited disorder of recently transplanted people; others attributed it to unresolved grief and depression. A number of these dour characterizations remained in currency as recently as the 1980s.

Stories of Redemption

The turning point in psychologists' understanding of nostalgia came in 1979, when American sociologist Fred Davis discovered that people associate nostalgia with positive words such as "warm," "old times" and "childhood"; in contrast, homesickness has predominantly sad connotations. Yet it was not until 2006 that scientists first examined nostalgic thoughts in detail. A research team that included one of us (Sedikides) and that was led by Dutch psychologist Tim Wildschut, our colleague at Southampton, analyzed articles published in *Nostalgia*, an American magazine dedicated to portraying life in the mid-20th century. The investigators next asked students to summon a nostalgic memory and describe it as precisely as possible. Then they categorized the students' statements by subject matter and compared them with a similar breakdown of the magazine articles.

The analyses of the magazine articles and the students' responses both yielded similar results. Nostalgia, it appears, is a specific form of autobiographical memory: most people give themselves the starring role in nostalgic flashbacks. These glances back often focus on relationships: a third of nostalgic thoughts involve other people. And nostalgic memories quite often feature a so-called redemption theme or mastery sequence—a story line that begins with a bad experience out of which something good ensues. For example, one of our study subjects wrote: "My Nan died that weekend, and even though it was awful, it was a type of relief for my Nan and us. When I look back at this in my mind, I feel so proud of my Mum and the way she coped; it showed her immense love and devotion to her own mother." Another example of an experience that might become a nostalgic memory: an apprehensive student calls the university for his exam results, learns that he passed, and feels tremendous joy and relief. When describing nostalgic memories, people were much less apt to report promising beginnings and disastrous ends.

Those who had read the sad article clung more tenaciously to the past—particularly to thoughts of people they were close to.

Because mastery sequences occurred much more frequently than deterioration sequences, the Wildschut team classified nostalgia as a primarily positive emotion. And the spontaneous self-assessments of the test subjects confirmed this conclusion: they perceived most of their memories as pleasant. This statement from one study participant neatly sums up the positive biographical and social nature of nostalgic memory: "I felt like I was really important to him and that no one else was as close. We had our own sort of 'code' and would talk to each other so no one else knew what we were saying."

Thoughts Born of Sadness

Like any emotion, nostalgic feelings must be triggered by some external or internal event. One way to investigate its triggers is simply to ask people to describe the circumstances and mental states under which they experience the emotion. When Wildschut and his team put this question to participants in their study, the most commonly cited precursor of nostalgia, mentioned by 38 percent of the respondents, was dysphoria—a depressed, anxious or irri-

FAST FACTS

The Good Old Days

1» Nostalgia, a sentimental yearning for the past, consists of particularly intense, complex and vivid memories.

2» Although nostalgia was once considered an unhealthy preoccupation, new research reveals that it improves people's moods and is a sign of emotional well-being.

3» Nostalgia can promote a sense of social integration in people who are sad or feel alone.

PRECEDING PAGES: NINO MASCARDI Getty Images (clothesline and window); MARILYN MARTIN Monsoon/Photolibrary/Corbis (army jacket); SHAUN LOWE iStockphoto (television); VASILIKI VARVAKI (hands holding photograph); CORBIS (woman with projector); JULIANN ITTER iStockphoto (bicycle); JON HELGASON iStockphoto (hopscotch); SERGEY DUBROVSKIY iStockphoto (Ferris wheel)

The story line of many nostalgic memories involves finding the silver lining in a painful event or triumphing over adversity—such as when an underdog sports team makes a glorious comeback.

table mood—and 34 percent of the dysphoric participants cited loneliness as their trigger.

To test whether nostalgia does occur more frequently when a person is sad, the Wildschut team invited 62 psychology undergraduates to its lab. The subjects were randomly assigned to read one of three newspaper articles. A third of the subjects read an article about the birth of a polar bear at a zoo, selected to put them in a happy frame of mind. Another third read a depressing article, about the tsunami that hit Asia and Africa in December 2004. The remaining subjects read an article with neutral content, about the landing of the Huygens probe on Titan, one of Saturn's moons. The volunteers were then asked to report how much they missed certain aspects of their past. Among the choices were "the way people were," "holidays I went on," "my pets," "past TV shows and movies," and "feelings I had." Those who had read the sad article clung more tenaciously to the past than did those from the other groups—particularly to thoughts of people they were close to: their family, someone they loved, their friends.

Feelings of abandonment can also trigger nostalgia. In a later experiment, the Wildschut team asked the test subjects to fill out a questionnaire and told them it had been designed to assess how lonely they were. The researchers then gave the participants bogus feedback about their responses. Half of the volunteers were told that their answers reflected a sense of abandonment; the other half were told the opposite. Manipulated this way, both groups filled out a nostalgia checklist to see how much they missed 18 elements of their past, such as family, schools and childhood toys.

The results were almost identical to the findings of the previous study. The test subjects who were convinced they felt lonely showed the same yearning for past relationships as did the people who had read the sad article.

These studies yield a consistent picture: people tend to become nostalgic when they feel low-spirited or lonely. But why should this be the case? Does sadness lead people to dwell unproductively on the contrast between their present situation and earlier, happier times? Or do people use nostalgia as a kind of mood enhancer? We decided to find out.

Connecting to Others

In 2006 the Southampton team conducted an experiment focusing on how nostalgia affects psychological well-being. Wildschut and his colleagues first asked the test subjects to recall circumstances that were particularly tinged with nostalgia. Then, as a measure of how these reveries affected their disposition, participants reported their current emotions, specifically the degree to which they were feeling "loved," "protected," "significant," "high self-esteem," "happy," "content," "sad" and "blue." The most nostalgic of the subjects showed high scores in the three measures of happiness, social integration and self-esteem. In other words, nostalgic thinking—which we had earlier found was often triggered by sadness and feelings of disconnection—breeds happier moods.

Our co-workers suspected that one factor in particular accounted for the positive effect of nos-

(The Authors)

JOCHEN GEBAUER and CONSTANTINE SEDIKIDES are social psychologists at the University of Southampton in England. Sedikides is director of the university's Center for Research on Self and Identity.

AGE FOTOSTOCK

Research shows that indulging in nostalgic thoughts makes people feel more confident of the support of their friends and family.

JAMIE GRILL *Getty Images*

talgia on mood: the feeling of social integration. We set out to test whether nostalgia makes people feel a sense of belonging. In our laboratory, we asked participants to evaluate their social competence in three areas: their adeptness in building relationships; their openness with other people about their feelings; and their ability to give a friend emotional support. The participants most likely to engage in nostalgic thinking did better in all three measures of social skills than those in the control group.

This social-glue effect appears to be a universal phenomenon and not simply an artifact of how nostalgia plays out in Western culture. For a 2008 study the Southampton team collaborated with researchers at Sun Yat-sen University in Guangzhou, China. The experimental setup was similar to the earlier study in Southampton, except now with Chinese undergraduates as the test subjects. The researchers asked some of the students to indulge in nostalgic reverie and others to conjure an ordinary memory. The participants then assessed how much support they thought they could count on from friends and family if times grew hard. Once again the results showed that the simple act of recalling a nostalgic memory was enough to make people more certain of the support of their friends. Yearning for the past seems to increase our sense of social support, independent of cultural background.

Happy Endings

"To be able to look back on one's past life with satisfaction is to live twice," wrote first-century Roman poet Marcus Valerius Martial. And indeed, not only can nostalgia help people recover from sadness and isolation, but golden memories can inoculate against future bad moods. In a 2008 study psychologist Clay Routledge of North Dakota State University and the Southampton team confronted volunteers with the thought of their own death to see if nostalgia could allay this archetypal fear.

In a three-part experiment, the researchers asked half the volunteers to write a short essay about a particular circumstance that made them feel nostalgic. The other participants wrote about a commonplace event from their past. Next, participants were shuffled into two new groups. The first group was asked to answer two questions in writing: "What emotion triggers the thought of your

own death?" and "What, in your opinion, occurs in your body when you die, and what happens after you have died?" The second group was asked to write about failing an important test in the past.

Finally, participants were asked to work on a task that tests the extent to which the psyche is unconsciously preoccupied with the question of death. They had to take 28 word fragments (such as "coff") and suggest a complete word that incorporated the fragment. Six of these fragments could be either part of a word that has something to do with dying ("coffin") or part of a more neutral term ("coffee").

Participants who had earlier been pondering their own deaths were more apt to select morbid words. This tendency, though, was not evident among the nostalgics. Those who at the start of the study had reflected on beautiful memories completed the word fragments in a manner that was similar to the participants who in the second part of the experiment had looked back on their flunked exam.

As effective as nostalgia appears to be as a natural mood enhancer, for one large group the benefit can be more elusive: people with depression. A 2007 investigation led by psychologist Jutta Joormann of the University of Miami showed that in contrast to healthy people, patients who suffer from severe depression do not become happier when they think about happy moments from their school days. In fact, exactly the opposite occurs.

The reason appears to be that depressed people do not easily identify with the happier self of their past. A 2008 study led by one of us (Gebauer) at Cardiff University in Wales found that chronically sad people perceive very little similarity between the positive "I" of their memory and their negative self-perception in the present. Instead they believe that this positive "I" is located in a remote past and conclude, "In comparison to the person I was back then, I'm an absolute loser today." So depressed people can feel even worse after recalling a happy memory.

But not all happy thoughts are equal. Indeed, nostalgia has characteristics that make it different from other positive memories, and these distinctions point to ways in which nostalgia could help depressives. According to the studies by Wildschut and his colleagues, nostalgic recollections are more multifaceted, complex and vivid than mere positive memories. The redemption sequence they often contain could potentially hearten chronically unhappy people; after all, if something turned out well in the past, it could happen that way again.

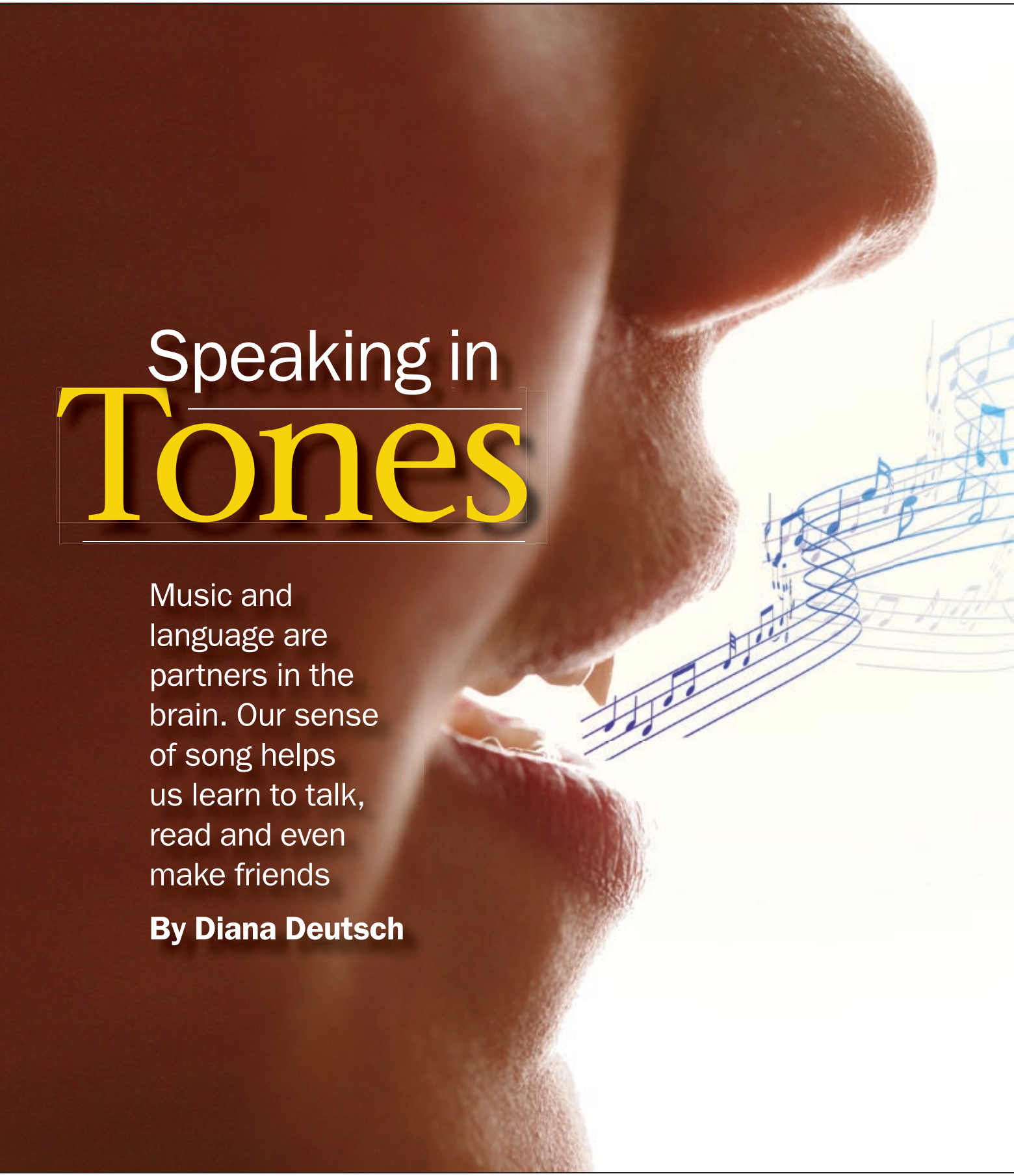
We are preparing a study to test whether this is the case. We intend to ask both depressed and healthy people to summon three images from the past: an image of themselves as they were five years ago, cast solely in terms of their positive attributes; an image from the same time that casts them solely in terms of their negative attributes; and a purely nostalgic episode, involving a sense of yearning for the past and a mastery or redemption sequence. We expect that only the nostalgic episode will help improve the self-image of people who are depressed, whereas the other two kinds of memories, including the positive one, may worsen it.

Like armor shielding the mind from dark thoughts, nostalgia protects against psychological onslaughts in the future.

For most of us, it seems, nostalgia not only fosters a sense of well-being but, like armor shielding the mind from dark thoughts, protects against psychological onslaughts in the future. Our research shows that nostalgic memories are especially detailed and vivid, in part because we tend to nurture them more assiduously than other memories. Indeed, the more we see how nostalgia provides balm for the wounded psyche, the farther the view of nostalgia as a pathological weakness recedes into the distant, and in this case less rosy, past. M

(Further Reading)

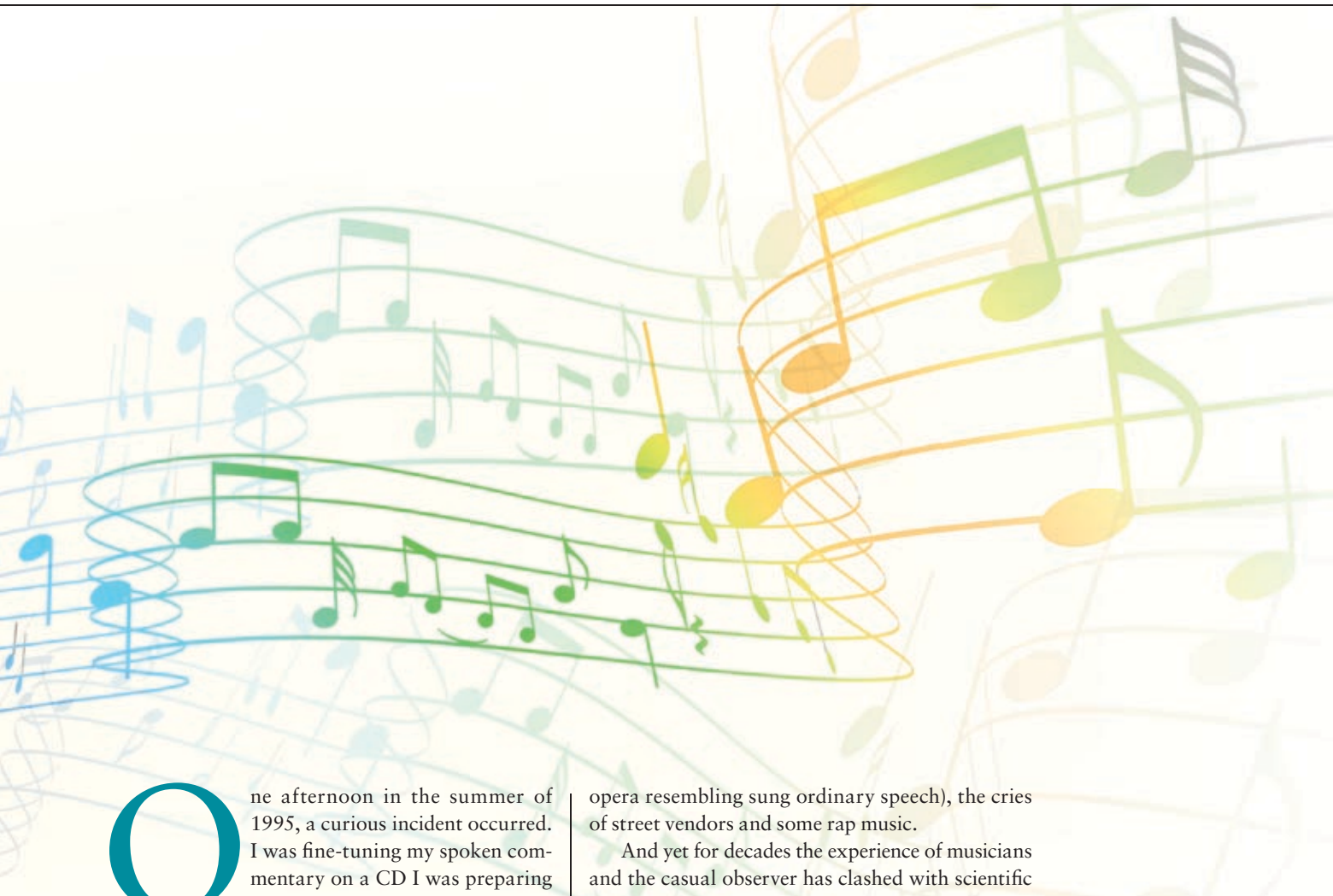
- **Nostalgia: Content, Triggers, Functions.** Tim Wildschut, Constantine Sedikides, Jamie Arndt and Clay Routledge in *Journal of Personality and Social Psychology,* Vol. 91, pages 975–993; 2006.
- **Counteracting Loneliness: On the Restorative Function of Nostalgia.** Xinyue Zhou, Constantine Sedikides, Tim Wildschut and Ding-Guo Gao in *Psychological Science,* Vol. 19, pages 1023–1029; 2008.
- **Inclusion-Exclusion of Positive and Negative Past Selves: Mood Congruence as Information.** J. E. Gebauer, P. Broemer, G. Haddock and U. von Hecker in *Journal of Personality and Social Psychology,* Vol. 95, pages 470–487; 2008.
- **Nostalgia: Past, Present, and Future.** Constantine Sedikides, Tim Wildschut, Jamie Arndt and Clay Routledge in *Current Directions in Psychological Science,* Vol. 17, pages 304–307; 2008.
- **Self-Enhancement and Self-Protection: What They Are and What They Do.** Mark D. Alicke and Constantine Sedikides in *European Review of Social Psychology,* Vol. 20, pages 1–48; 2009.



Speaking in Tones

Music and language are partners in the brain. Our sense of song helps us learn to talk, read and even make friends

By Diana Deutsch



PIOTR POWIETRZYNSKI *age Fotostock (mouth)*; MARCELA BARSSE *iStockphoto (sheet music)*

One afternoon in the summer of 1995, a curious incident occurred. I was fine-tuning my spoken commentary on a CD I was preparing about music and the brain. To detect glitches in the recording, I was looping phrases so that I could hear them over and over. At one point, when I was alone in the room, I put one of the phrases, "sometimes behave so strangely," on a loop, began working on something else and forgot about it. Suddenly it seemed to me that a strange woman was singing! After glancing around and finding nobody there, I realized that I was hearing my own voice repetitively producing this phrase—but now, instead of hearing speech, I perceived a melody spilling out of the loudspeaker. My speech had morphed into song by the simple process of repetition.

This striking perceptual transformation, which I later found occurs for most people, shows that the boundary between speech and song can be very fragile. Composers have taken account of the strong connections between music and speech, for example, incorporating spoken words and phrases into their compositions. In addition, numerous vocalizations seem to fall near the boundary between speech and song, including religious chants and incantations, oratory, opera recitative (a style of delivery in opera resembling sung ordinary speech), the cries of street vendors and some rap music.

And yet for decades the experience of musicians and the casual observer has clashed with scientific opinion, which has held that separate areas of the brain govern speech and music. Psychologists, linguists and neuroscientists have recently changed their tune, however, as sophisticated neuroimaging techniques have helped amass evidence that the brain areas governing music and language overlap. The latest data show that the two are in fact so intertwined that an awareness of music is critical to a baby's language development and even helps to cement the bond between infant and mother. As children grow older, musical training may foster their communication skills and even their reading abilities, some studies suggest. What is more, the neurological ties between music and language go both ways: a person's native tongue influences the way he or she perceives music. The same succession of notes may sound different depending on the language the listener learned growing up, and speakers of tonal languages such as Mandarin are much more likely than Westerners to have perfect pitch.

Word Symphonies

Musicians and philosophers have long argued that speech and melody are interconnected. Russian

Certain vocalizations fall close to the border between speech and song. These include opera recitative, the shouts of street vendors and the chanting of rap musicians.

composer Modest Mussorgsky believed that music and talk were in essence so similar that a composer could reproduce a conversation. He wrote to his friend Rimsky-Korsakov: "Whatever speech I hear, no matter who is speaking … my brain immediately sets to working out a musical exposition of this speech." Indeed, when you listen to some of his piano and orchestral works, you may suddenly find that you are "hearing" the Russian language.

Despite such informal evidence of the ties between speech and music, researchers—bolstered in part by patients whose brain damage affected their speech but spared their musical ability—began espousing the opposite view around the middle of the 20th century. The brain divides into two hemispheres, and these experts hypothesized that its functions were just as neatly organized, with language residing on the left side and music on the right. Their theory was that the neural signal for dialogue bypassed the usual pathways for sound processing and instead was analyzed in an independent "module" in the brain's left hemisphere. That module supposedly excluded nonverbal sounds such as music. Similarly, the theory went, music was processed in a right-hemisphere module that excluded speech sounds. This attractive dichotomy became so popular that it effectively shut out for decades any thought that language and music might be neurologically—and functionally—intertwined.

But then, by the late 1990s, a generation of young researchers who did not have a stake in the separation of speech and song began questioning the idea. They brought to light existing data indicating that some aspects of music engage the left hemisphere more than the right. In addition, pioneering new experiments, many of which were conducted with emerging technology such as functional magnetic resonance imaging, showed that music and speech are not as neurologically separate as researchers had supposed.

One line of investigation demonstrated that the perception and appreciation of music could impinge on brain regions classically regarded as language processors. In a 2002 study neuroscientist Stefan Koelsch, then at the Max Planck Institute for Human Cognitive and Brain Sciences in Leipzig, Germany, and his colleagues presented participants with sequences of chords while using functional MRI to monitor their brains. They found that this task prompted activity on both sides of the brain but most notably in two regions in the left hemisphere, Broca's and Wernicke's areas [*see illustration on opposite page*], that are vital for language processing and that many researchers had assumed were solely dedicated to this function. Other more recent studies have revealed that speaking activates many of the same brain regions as analogous tasks that require singing. These and dozens of findings by other experimenters have established that the neural networks dedicated to speech and song significantly overlap.

This overlap makes sense, because language and music have a lot in common. They are both governed by a grammar, in which basic elements are organized hierarchically into sequences according to established rules. In language, words combine to form phrases, which join to form larger phrases, which in

FAST FACTS

Singing in the Brain

1» The brain circuits that interpret music overlap with those that process speech.

2» The musical qualities of speech are critical in early language development and in cementing the bond between infant and mother.

3» A person's native language may affect the way he or she hears a set of musical notes.

AFP/GETTY IMAGES (*opera singers*); GETTY IMAGES (*vendor*); NEWSPORT/CORBIS (*rapper*)

Language and music are both governed by a grammar: **basic elements organized hierarchically into sequences.**

turn combine to make sentences. Similarly, in music, notes combine to form phrases, which connect to form larger phrases, and so on. Thus, to understand either language or music, listeners must infer the structure of the passages that they hear, using rules they have assimilated through experience.

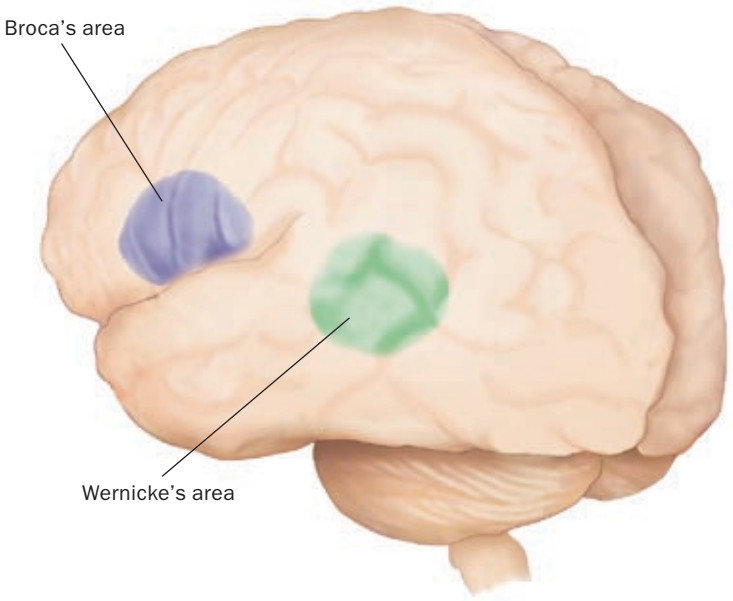
In addition, speech has a natural melody called prosody. Prosody encompasses overall pitch level and pitch range, pitch contour (the pattern of rises and falls in pitch), loudness variation, rhythm and tempo. Prosodic characteristics often reflect the speaker's emotional state. When people are happy or excited, they frequently speak more rapidly, at higher pitches and in wider pitch ranges; when people are sad, they tend to talk more slowly, in a lower voice and with less pitch variation. Prosody also helps us to understand the flow and meaning of speech. Boundaries between phrases are generally marked by pauses, and the endings of phrases tend to be distinguished by lower pitches and slower speech. Moreover, important words are often spoken at higher pitches. Interestingly, some pitch and timing characteristics of spoken language also occur in music, which indicates that overlapping neural circuitries may be involved.

Meaningful Melodies

At birth, babies are already familiar with the melody of their mother's speech. Audio recordings taken from inside the womb at the beginning of labor reveal that speech sounds produced by the mother can be loudly heard. The phrases reaching the baby have been filtered through the mother's tissues, however, so that the crisp, high frequencies—which carry much of the information important for identifying the meanings of words—are muted, whereas the musical characteristics of speech—its pitch contours, loudness variations, tempo and rhythmic patterning—are well preserved.

These spoken melodies seem to set the stage for mother-child bonding. In an ingenious experiment published in 1980, psychologists Anthony J. DeCasper of the University of North Carolina at Greensboro and William P. Fifer, now at Columbia University, recorded new mothers reading a story out loud. In this experimental setup, the newborn babies could turn on the recordings by sucking on a pacifier, a connection they learned over time, and they sucked more frequently when their actions produced their mothers' voices compared with those of other women. The researchers reasoned that the newborns preferred to listen to the voices with which they had become familiar before birth. Then, in 1996, psychologists Melanie J. Spence and Mark S. Freeman of the University of Texas at Dallas reported carrying out a similar experiment in which they used a low-pass filter to muffle recorded female voices so that they sounded as they would in the womb. The newborn babies preferred their mothers' filtered voices over those of other women, again indicating that they had become familiar with the melodies of their mothers' utterances in the womb.

In addition to forging a nascent connection between mother and child, early exposure to musical speech sounds may begin the process of learning to talk. In one 1993 study, for example, two-day-old babies preferred to listen to recordings of speech in their native language to those in a foreign tongue. Because such young babies could only have become familiar with such speech in the womb, the results suggest that the babies initially become comfort-



The appreciation of music requires many of the same brain regions that are involved in the processing of language. These multipurpose regions include Broca's (*purple*) and Wernicke's (*green*) areas.

MELISSA THOMAS

(The Author)

DIANA DEUTSCH is a professor of psychology at the University of California, San Diego, who studies the perception of music and language. She has recorded two CDs consisting of audio illusions that she has discovered: *Musical Illusions and Paradoxes* and *Phantom Words and Other Curiosities* (http://philomel.com). In these anomalies, the perception of a given set of sounds varies among people or changes over time, even when the sounds remain the same. For examples, see http://deutsch.ucsd.edu.

The exaggerated speech melodies—termed motherese—that parents use when speaking to their babies help the infants grasp the speaker's intentions.

Infants echo the inherent melodies of their native language when they cry, long before they can speak.

able with the musical qualities of their language.

Accordingly, music may be the first part of speech that babies learn to reproduce; infants echo the inherent melodies of their native language when they cry, long before they can utter actual words. In a study published in 2009 medical anthropologist Kathleen Wermke of the University of Würzburg in Germany and her colleagues recorded the wails of newborn babies—which first rise and then fall in pitch—who had been born into either French- or German-speaking families. The researchers found that the cries of the French babies consisted mostly of the rising portion, whereas the descending segment predominated in the German babies' cries. Rising pitches are particularly common in French speech, whereas falling pitches predominate in German. So the newborns in this study were incorporating into their cries some of the musical elements of the speech to which they had been exposed in the womb, showing that they had already learned to use some of the characteristics of their first language.

After birth, the melody of speech is also vital to communication between mother and infant. When parents speak to their babies, they use exaggerated speech patterns termed motherese that are characterized by high pitches, large pitch ranges, slow tempi, long pauses and short phrases. These melodious exaggerations help babies who cannot yet comprehend word meanings grasp their mothers' intentions. For example, mothers use falling pitch contours to soothe a distressed baby and rising pitch contours to attract the baby's attention. To express approval or praise, they utter steep rising and falling pitch contours, as in "Go-o-o-d girl!" When they express disapproval, as in "Don't do that!" they speak in a low, staccato voice.

In 1993 psychologist Anne Fernald of Stanford University reported exposing five-month-old infants from English-speaking families to approval and prohibition phrases spoken in German, Italian and nonsense English, as well as regular English motherese. Even though all this speech was gibberish to the babies, they responded with the appropriate emotion, smiling when they heard approvals and becoming subdued or crying when they heard prohibitions. Thus, the melody of the speech alone, apart from any content, conveys the message.

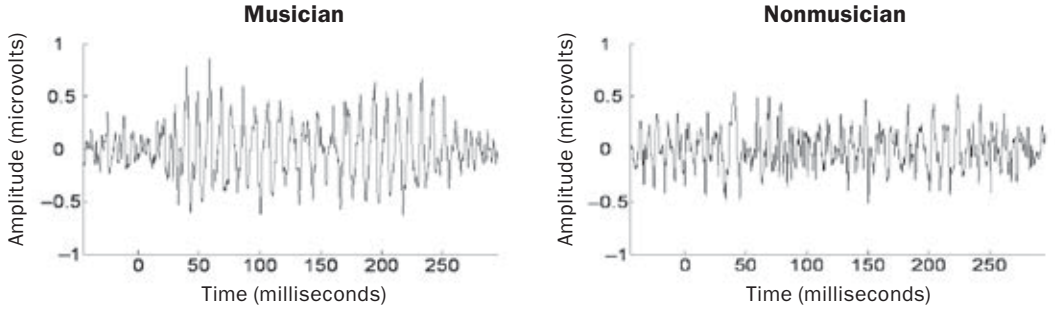
Although the ability to detect speech melodies is inborn, people can hone this skill by taking music lessons. In a study published in 2009 neuroscientists Mireille Besson of CNRS in France and Sylvain Moreno, now at the Rotman Research Institute in Toronto, and their colleagues recruited eight-year-old children who had been given no musical training and divided them into two groups. One group took music lessons for six months while the other enrolled in painting lessons. Before and after this training, the children listened to recorded sentences; in some of these, the last word was raised in pitch so that it sounded out of keeping with the rest of the sentence, and the children were asked to detect the altered sentences. At the start, the two groups did not differ in their ability to detect the pitch changes, but after the six months of instruction, the children who had taken music lessons outperformed the others. Musically trained children may thus be at an advantage in grasping the emotional content—and meaning—of speech.

Musical training may affect perception of prosody in part by tuning the auditory brain stem—a group of structures that receive signals from the ear and help to decode the sounds of both speech and

CORBIS

Tuning the Brain

In a 2007 study scientists monitored the brain waves of people who were listening to recordings of words spoken in Mandarin. The study subjects, all English speakers, did not understand the meaning of what they heard. But the ones who had a music background showed a much stronger electrical response in a region called the auditory brain stem (*left*) than did those who had no musical training (*right*). The work suggests that learning to sing or play an instrument can make people more attuned to the melody of speech.



music. In a 2007 investigation neuroscientists Patrick Wong and Nina Kraus, along with their colleagues at Northwestern University, exposed English speakers to Mandarin speech sounds and measured the electrical responses in the auditory brain stem using electrodes placed on the scalp. The responses to Mandarin were stronger among participants who had received musical training—and the earlier they had begun training and the longer they had continued training, the stronger the activity in these brain areas [*see illustration above*].

Additional research shows that music lessons can improve the ability to detect emotions conveyed in speech (presumably through a heightened awareness of prosody). In a study published in 2004 psychologist William F. Thompson and his colleagues at the University of Toronto gave a group of six-year-old children musical keyboard lessons for a year and then tested their ability to identify emotions expressed in spoken sentences, comparing their scores with those of children who did not receive musical training. They found that the kids who received music lessons were better at identifying whether sentences were spoken in a fearful or angry tone of voice—even when the sentences were spoken in an unfamiliar language.

Musical training might even accelerate the process of learning to read. Good readers tend to do better than poor readers on tests of musical ability (although there are many exceptions to this rule). In their 2009 study Moreno and his colleagues found that the eight-year-olds who had taken music lessons also showed better reading ability than the children who had instead learned to paint, suggesting that facility with music may spill over into skill at deciphering the written word. Researchers have even suggested that musical training (in combination with other therapies) might be useful in remedying dyslexia.

Talking in Tune

Not only can exposure to music enhance our language skills, but the speech we hear also influences our perception of music. For example, in a musical illusion called the tritone paradox, which I discovered in the 1980s, a listener hears two computer-generated tones that are half an octave (or tritone) apart, one after the other. Each tone is a clearly defined note such as C, C-sharp or D, but its octave is inherently ambiguous so that a note could be, say, middle C, an octave above or below middle C, or any other C. The listener then decides whether the pattern ascends or descends in pitch. (Because of the ambiguity in the octave placement of the notes, there is no correct answer, and perception varies by listen-

Taking music lessons can help children detect emotions conveyed in speech and may even accelerate the process of learning to read.

NINA KRAUS *Northwestern University (graph)*; AGE FOTOSTOCK *(music lesson)*

➥ For an audio slideshow featuring Deutsch's work on the musical aspects of language, visit **www.ScientificAmerican.com/Mind/music-and-speech**

er.) Interestingly, I found that such judgments depend on the language or dialect to which the listener has been exposed. For example, in a 1991 study I asked people who had been raised in California and those raised in the south of England to judge these tritones and found that when the Californians tended to hear the pattern as ascending, the southern English subjects tended to hear it as descending, and vice versa. In another study published in 2004 my colleagues and I found the same dichotomy between listeners from Vietnam and native English speakers born in California, suggesting that the language we learn early in life provides a *musical* template that influences our perception of pitch.

Such a template might also constrain the pitch range of our speaking voice. In a study published in 2009 my colleagues and I examined the pitch ranges of female speech in two Chinese villages and found that these clustered together for people in the same village but differed across villages, suggesting that even local differences in the voices we hear around us can affect the pitch of the speech we produce.

The language to which we are exposed can also greatly influence the chances of developing perfect pitch—the ability to name the pitch of a note without a reference note. This skill is very rare in our culture: only an estimated one in 10,000 Americans have it. In 1997 I noticed that when I uttered a Vietnamese word without paying attention to its pitch, a native listener would either misunderstand me or have no idea what I was trying to say. But when I got the pitch right, the problem disappeared. Vietnamese and Mandarin are tone languages in which words take on entirely different meanings depending on the tones with which they are spoken. In Vietnamese, the word "ba" spoken in the mid-flat tone means "father;" the same word spoken in the low-descending tone means "grandmother." In Mandarin, the word "ma" means "mother" in a tone that is high and flat but "horse" in a tone that is low and first descends and then ascends [*see table on opposite page*].

I then learned that not only were Vietnamese and Mandarin speakers very sensitive to the pitches that they hear, but they can produce words at a consistent absolute pitch. In a study published in 2004 my colleagues and I asked native speakers of Mandarin and Vietnamese to recite a list of words in their native language on two separate days. We found that their pitches were remarkably consistent: when compared across days, half of the participants showed pitch differences of less than half a semitone. (A semitone is half a tone—that is, the difference between F and F-sharp.)

In light of these findings, I wondered if tone language speakers acquire perfect pitch for the tones of their language in infancy along with other features of their native tongue. Perfect pitch for musical tones would then be much easier for tone language

The language we learn early in life provides a musical template that influences our perception of pitch.

HANS NELEMAN *Getty Images*

Perfect pitch is remarkably common in speakers of tone languages. Ninety-two percent of Mandarin speakers who began music lessons at or before age five had perfect pitch, compared to just 8 percent of English speakers with comparable musical training.

What's in a Word?

In a tone language such as Mandarin, a word's meaning depends on its pitch and pitch pattern. Below are examples of words that are phonetically identical but, depending on the pitches with which they are spoken, have four unrelated meanings. (Tone 1 is high and flat; tone 2 starts mid-high and rises; tone 3 starts low, falls and then rises; and tone 4 begins high and falls.) Each word is written with a distinct character.

Tone	Word	Chinese character	English meaning
1	mā	妈	mother
2	má	麻	hemp
3	mǎ	马	horse
4	mà	骂	reproach

Tone	Word	Chinese character	English meaning
1	wēn	温	warm
2	wén	闻	hear
3	wěn	稳	stable
4	wèn	问	ask

Tone	Word	Chinese character	English meaning
1	yāo	腰	waist
2	yáo	摇	shake
3	yǎo	咬	bite
4	yào	药	drug

Tone	Word	Chinese character	English meaning
1	wēi	微	tiny
2	wéi	围	surround
3	wěi	尾	tail
4	wèi	喂	feed

speakers to develop than it would be for speakers of a nontone language, such as English. In an experiment published in 2006 my colleagues and I gave a test for perfect pitch to two large groups of music conservatory students—Mandarin speakers at the Central Conservatory of Music in Beijing and speakers of English or of another nontone language at Eastman School of Music in Rochester, N.Y.—and found that the prevalence of perfect pitch was indeed far higher among the Mandarin speakers. These findings were consistent with my hypothesis, but because the Central Conservatory students were all Chinese, the results could mean that genes that spur the development of perfect pitch are just more prevalent among Chinese people.

To decide which explanation was correct, my colleagues and I gave a test for perfect pitch to University of Southern California music conservatory students, including English speakers and three groups of East Asian students divided by how well they spoke their native tone language. Among the English speakers, the prevalence of perfect pitch was just 8 percent among those who had begun musical training at or before age five and 1 percent among those who had begun training between ages six and nine. The statistics were similar among the East Asian students who were not at all fluent in their native tone language. In contrast, the students who were very fluent tone language speakers performed extraordinarily well on our test: 92 percent of those who had begun musical training at or before age five had perfect pitch as did 67 percent of those who started music lessons between ages six and nine. The students who spoke a tone language moderately well fell between the two extremes. These findings, which we published in 2009, strongly indicate that the high prevalence of perfect pitch among the tone language speakers is not genetic but related to exposure to their language.

Thus, the language we learn in infancy, and continue to speak, can have a profound effect on the way in which we encode the sounds of music. Indeed, in many respects, music and speech seem to be mirror images, with both playing integral roles in the development of the other—in the way we, as people, bond and communicate, in how we perceive the sounds around us, in our understanding of language and in the workings of our minds. M

(Further Reading)

- **The Psychology of Music.** Second edition. Edited by Diana Deutsch. Elsevier, 1999.
- **The Enigma of Absolute Pitch.** Diana Deutsch in *Acoustics Today,* Vol. 2, pages 11–19; 2006.
- **Musicophilia: Tales of Music and the Brain.** Oliver Sacks. Knopf, 2007.
- **Newborns' Cry Melody Is Shaped by Their Native Language.** Birgit Mampe et al. in *Current Biology,* Vol. 19, pages 1994–1997; 2009.
- **Perfect Pitch: Language Wins Out over Genetics.** Diana Deutsch et al.: **www.acoustics.org/press/157th/deutsch.html**
- **The Speech-to-Song Illusion.** Diana Deutsch et al.: **www.acoustics.org/press/156th/deutsch.html**

When PASSION is the Enemy

People with borderline personality disorder endure emotional extremes that can rip apart their lives

By Molly Knight Raskin

Four years ago Amanda Wang, then 27 years old, was at a rehearsal dinner for a close friend. At the start of the evening, she felt content, eager to enjoy the wedding festivities. But shortly after she sat down to dinner, she was struck by "a tidal wave" of negative emotions. Her mind began to race with disturbing thoughts about her own marriage, which was unstable, and feelings of self-loathing. Suddenly, Wang says, it was as if someone had draped a heavy cloth over her, suffocating her and cutting her off from the conversation. Overcome by anxiety and dread, she excused herself from the dinner table and escaped to the bathroom. Desperate to dull her feelings, she removed her belt, tied it around her neck and pulled it tight to stop herself from breathing. She performed this act several times, until the pain offered her some relief from her emotions. After about 10 minutes, she returned to the table, feeling much better.

At the time, Wang felt she was the only person in the world who battled such extreme mood swings—being content one moment and nearly suicidal the next—and who harmed herself to cope with them. "Self-harm was one of the things that I did to myself to stop feeling crazy, to stop all the arguments in my head, the edginess and anxiety," she says.

But the edginess kept coming back, and just three months later, struggling with suicidal urges, she checked herself into the Payne Whitney Clinic of New York–Presbyterian/Weill Cornell. There an astute social worker studied notes penned by doctors and read interviews with Wang's friends and family—and delivered the diagnosis that Wang believes saved her life: borderline personality disorder (BPD). Wang and other BPD patients suffer from pervasive instability in mood, relationships and behavior. Partly as a way to cope with their internal chaos, people with BPD may impulsively quit their job, abruptly break off relationships or, like Wang, flirt with suicide.

GETTY IMAGES

These patients were so **exquisitely sensitive** in their relationships that they often **abruptly terminated therapy** or threatened to sue their therapists for perceived slights.

Because those afflicted display a disparate and variable set of symptoms, even trained mental health professionals can miss the diagnosis or attribute the behaviors to some other cause. What makes diagnosis even trickier is that BPD patients often also suffer from other psychiatric problems, such as depression, bipolar disorder, substance abuse and eating disorders.

Despite such complexity, professionals have identified up to 14 million Americans as having BPD, more than are afflicted with either bipolar disorder or schizophrenia. Its sufferers are among the most likely to injure themselves and to commit suicide; about 10 percent of patients take their own lives. Individuals with BPD also flock to doctors more readily than people with other psychiatric illnesses, occupying fully one fifth of the beds in psychiatric wards, thereby constituting a major public health problem.

In the past scientists and many clinicians viewed the more audacious symptoms of BPD—such as angry outbursts or experiments with self-harm—as willful efforts to manipulate others or attract attention. But in recent years biologists have been looking deeper at the psychological and neurological causes of BPD and have sketched a radically different picture of the ailment. BPD patients do not choose to act the way they do; they are buffeted by a combination of unconscious processes—an unusual tendency to pick up on the subtle facial expressions of others, coupled with hyperactive emotional responses. In addition, a brain region that helps to guide people amicably through social scenarios seems to malfunction in BPD sufferers, an impairment that may add to their insecurity in relationships.

People with borderline personality disorder may covertly cut themselves to ease their emotional agony in social situations. About 10 percent commit suicide.

PETER DAZELEY *Getty Images*

FAST FACTS

Flooded by Feeling

1» **Borderline personality disorder (BPD), a disorder characterized by pervasive instability in mood, relationships and behavior, is more common among Americans than either bipolar disorder or schizophrenia.**

2» **BPD patients are not deliberate attention seekers. Instead recent studies reveal that their behavior stems from an unusual sensitivity to subtle facial expressions and extreme difficulty controlling their emotions.**

3» **Psychotherapy for BPD is now enabling patients to overcome an illness that has long been viewed as a life sentence.**

These findings establish BPD's credentials as a brain disease. The work also has inspired more effective therapies, based on perceptual and emotional underpinnings of the disorder. Psychotherapy for BPD is now enabling patients to overcome an illness that has long been viewed as a life sentence. "This is a disorder that everyone, for a long time, said was untreatable," says psychiatrist John Gunderson of Harvard Medical School and McLean Hospital. "Today our research shows that when treated properly, BPD is actually a good-prognosis diagnosis."

Branded Borderline

In the 1930s American psychoanalyst Adolf Stern first coined the term "borderline" to describe patients who fell short of complete psychosis (expe-

Identifying Borderline Behavior

People with borderline personality disorder (BPD) may not receive a proper diagnosis for several years after seeking help. The disorder is difficult to recognize, in part because it takes on many guises. Someone who has any five of the following nine traits and behaviors may be at risk. (Keep in mind that only a trained professional can make a true diagnosis.)

1. Displaying frantic attempts to avoid real or imagined abandonment. Some patients might stalk a friend or a loved one or even hurt themselves to attract the attention of someone they care about.
2. Exhibiting a pattern of highly unstable relationships. People with BPD may suddenly shift from idealizing and loving someone to feeling intensely angry with that person.
3. Showing signs of an unstable self-image or sense of self, which can lead to desperate attempts to win the approval of others.
4. Acting impulsively in at least two potentially self-destructive ways, such as excessive spending, risky sex, reckless driving, binge eating or substance abuse.
5. Engaging in suicidal behavior or self-mutilation.
6. Experiencing intense mood shifts that often last only a few hours but are very hard to control.
7. Feeling empty much or most of the time.
8. Displaying inappropriate, intense anger or having difficulty controlling anger.
9. Thinking paranoid thoughts, if only briefly, particularly when exposed to severe stress.

NOTE: The above symptoms have been adapted from the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders *(American Psychiatric Association, 2000).*

riencing a total break with reality) but were emotionally fragile and irrationally sensitive in social situations. In the two decades that followed, clinicians kept encountering patients with similar difficulties, clustering them under titles such as "borderline syndrome" and "borderline personality organization." Despite its repeated use, the "borderline" label remained vague, considered by many to be a wastebasket diagnosis for people with severe symptoms who did not fit any clear diagnostic category.

As a young resident in the 1960s, Gunderson was nonetheless drawn to this somewhat eclectic group of patients, seeking to better define what ailed them. He was partly driven by the challenge of treating a patient population that many of his colleagues deemed hopeless and irritating. These patients were so exquisitely sensitive in their relationships that they often abruptly terminated therapy, exploded with anger at their clinicians, and even sued them (or threatened to) for perceived slights, abandonment or betrayal. At the same time, they could often be charming, bright and interesting. This Jekyll and Hyde nature fascinated Gunderson, whose roster of BPD patients kept growing. In 1975 he and psychologist Margaret Singer of the University of California, Berkeley, published a seminal paper outlining the nine defining symptoms of BPD [*see box above*]. In 1980 BPD became a bona fide psychiatric diagnosis, gaining entry into the third edition of the *Diagnostic and Statistical Manual of Mental Disorders* (*DSM-III*).

BPD patients commonly suffer from three core difficulties: emotional instability, impulsive behavior and disturbed interpersonal relationships. The emotional storms of people with BPD are not only intense, they are frequent. The cause of these ups and downs is not always apparent to others or easy for people with the disorder to explain. Sometimes a perceived slight—something as minor as a raised eyebrow—can trigger a hemorrhaging of emotion—fear and

(The Author)

MOLLY KNIGHT RASKIN is a freelance writer and producer whose work has appeared in numerous publications, including the *Washington Post* and the *Baltimore Sun*. A former reporter for *The NewsHour with Jim Lehrer* and WNET, she was a 2007 Rosalynn Carter Fellow for Mental Health Journalism.

BARRY YEE *Getty Images*

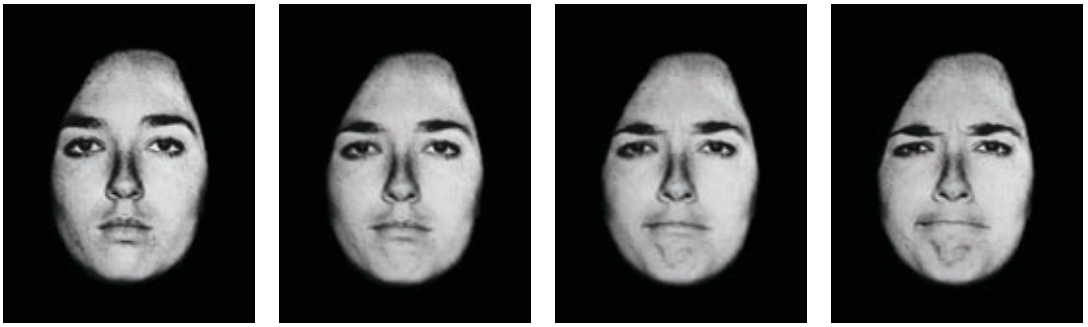
A subtle slight—something as minor as a raised eyebrow—can unleash a hemorrhaging of anger from borderline personality patients, leading them to act impulsively.

loneliness, perhaps, or anger and anxiety. The person might be aware that they are overreacting, but the emotions are too forceful for them to control.

Psychiatrist Frank Yeomans of Weill Cornell Medical College says he has been a few minutes late to an appointment only to have a patient storm out of his office, accusing him of hating and neglecting him or her. Once a male patient shared a touching story with Yeomans about his upbringing in an impoverished home. Yeomans recalls being moved to tears, but the patient responded to his sympathy with, "You're mocking me." To calm themselves, such patients often act impulsively, making rash decisions and indulging in behaviors such as substance abuse, binge eating, compulsive shopping or, more disturbingly, self-injury. Deliberate self-harm seems to relieve emotional agony in part by the distraction of physical pain and perhaps through the release of natural painkilling opiates.

BPD shares some features with bipolar disorder, for which it is frequently mistaken, but unlike bipolar disorder, BPD does not lead to lengthy cycles of highs and lows. Instead it causes more rapid mood swings. In less than 24 hours, people with BPD can experience euphoria, suicidal depression and everything in between. BPD is also characterized by a disturbing, but fascinating, dual nature: when people with the disorder are not experiencing flagrant symptoms, they often appear highly functional. "You could meet a patient with BPD in a social setting and not have an inkling that the patient had a major psychiatric disorder," says psychiatrist Glen O. Gabbard of the Baylor College of Medicine. "The very next day the same patient could appear in an emergency room in a suicidal crisis and require hospitalization."

For most of the 20th century, the prevailing wisdom held that personality disorders were the result of life experience. For BPD, the offending experience was thought to be early childhood trauma. But although people with BPD have often endured traumatic events—40 to 71 percent of inpatients report childhood sexual abuse—childhood trauma can have diverse effects on the psyche. Studying BPD



A hypersensitivity to subtle facial expressions is an important feature of borderline personality disorder. Patients recognized anger when it appeared gradually on a computer-generated face much earlier than did mentally healthy people.

JUDITH WAGNER *Corbis (fighting)*; FROM "HEIGHTENED SENSITIVITY TO FACIAL EXPRESSIONS OF EMOTION IN BORDERLINE PERSONALITY DISORDER," BY THOMAS R. LYNCH ET AL., IN *EMOTION*, VOL. 6, NO. 4; 2006. REPRINTED WITH PERMISSION OF THE AMERICAN PSYCHOLOGICAL ASSOCIATION *(faces)*

An afflicted individual might see **a happy expression** as a sign of love and react with **inappropriate passion**, leading to a whirlwind, stormy romance.

through the lens of abuse did not help psychologists get a handle on the disorder. By the 1990s researchers were seeking to capture the core psychological abnormalities of patients by investigating them directly and by peering inside their brains.

Emotion Overload

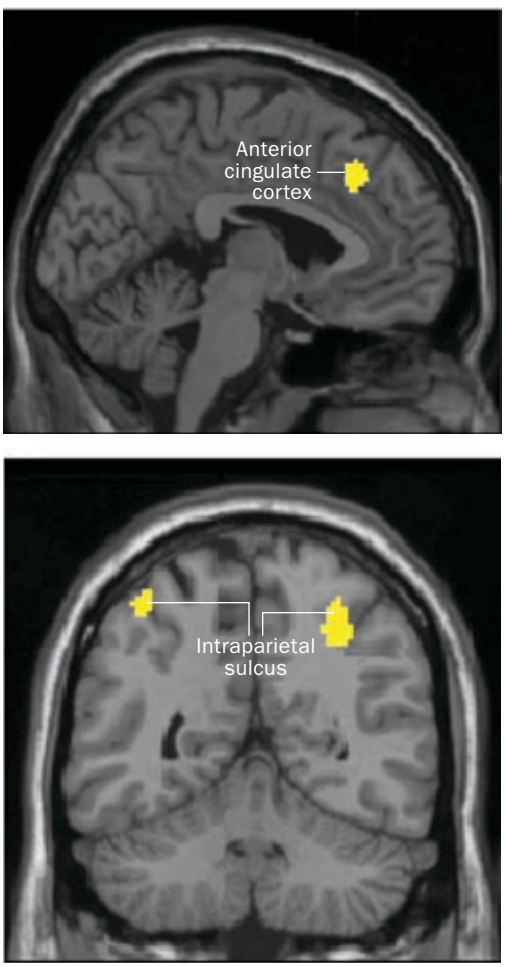
Specifically, scientists wanted to better understand the three hallmarks of BPD: emotional instability, impulsive aggression and interpersonal chaos. Why do people with BPD have so many more emotional flare-ups than healthy people do? And when they feel upset, why do they act out impulsively?

In 2006 psychologist Thomas R. Lynch, then at Duke University, and his colleagues found a clue in the reading of facial expressions. The researchers asked 20 adults with BPD and 20 mentally healthy people to watch a computer-generated face change from neutral to emotional. They told subjects to stop the changing image the moment they had identified the emotion. On average, the people with BPD correctly recognized both the unpleasant expressions and the happy faces at a much earlier stage than the other participants did. The results suggest that BPD patients are hyperaware of even subtly emotive faces—problematic in people who are intensely reactive to other people's moods. So, for example, a hint of boredom or annoyance on a person's face that most people would not notice might produce anger or fears of abandonment in a person with BPD. Conversely, someone with BPD might see a happy expression as a sign of love and react with inappropriate passion, leading to the whirlwind, stormy romances that rock the lives of people with BPD.

A recent brain-imaging study suggests why these patients are so socially sensitive and moody. In 2009 psychiatrist Harold W. Koenigsberg and his colleagues at the Mount Sinai School of Medicine used functional magnetic resonance imaging to record activity in the brains of 19 BPD patients and 17 mentally healthy individuals as the subjects examined photographs of people crying, smiling, acting violently and making sexual gestures. The researchers found that the unpleasant images (a man grabbing a woman's neck, say, or a woman crying) elicited much more activity in several regions of the brains of BPD patients compared with those of healthy vol-

Losing Control

In a recent study, scientists performed brain scans on people as they tried to distance themselves from emotionally charged pictures. Some of the study subjects had borderline personality disorder and others did not. The brain scans of the healthy people revealed much greater activity in the dorsal anterior cingulate cortex (*top*), which regulates emotion, and in the intraparietal sulcus (*bottom*), which directs visual attention. These results suggest that people with borderline personality disorder have unusually weak neurological brakes on their feelings and trouble turning their attention away from disturbing scenes.



HAROLD W. KOENIGSBERG *Mount Sinai School of Medicine*

Self-soothing techniques such as taking a walk or listening to music are an important part of a widely used therapy for borderline personality disorder.

KREG HOLT *Getty Images*

unteers. These areas included those involved in basic visual processing as well as the amygdala, which governs emotional reactivity and memory, and the superior temporal gyrus, which is involved in the faster, "reflexive" processing of social situations. That pattern of activation suggests that BPD patients may react not only more strongly but also more rapidly to disagreeable images and scenarios, perhaps providing less time to reflect on them rationally or divert attention elsewhere.

In a second study, Koenigsberg's team asked BPD patients and healthy people to attempt to distance themselves as they viewed another series of emotionally charged pictures. In this case, the researchers saw virtually no activity in regions of BPD patients' brains, such as the anterior cingulate cortex, that regulate emotion. Regions that help to direct visual attention such as the intraparietal sulcus were also underactive [*see box on preceding page*]. The study suggests that people with BPD have weaker neurological brakes on their emotional reactions and a hampered ability to distract themselves from emotional triggers.

Moreover, a 2008 study led by neuroscientist Brooks R. King-Casas of Baylor showed that people with BPD lack the brain activity that, in most people, interprets social gestures, such as those that signal trust. The researchers tested the ability of BPD patients to interpret the actions of a partner (in this case, the amount of money he or she invested) in a betting game as signs of trust or its absence—something those with the illness had trouble doing. The scientists found that a brain area called the anterior insula, which responded to the investment level in the healthy participants, was unresponsive to this amount in the BPD patients. The insula ordinarily monitors uncomfortable interactions with others, such as those stemming from the violation of trust and other social norms. But the BPD patients seem to lack this gauge in their brain, leading to their difficulty perceiving a breakdown of trust from others' actions. As a result, patients may not feel they can trust others [see "Perturbed Personalities," by Andreas Meyer-Lindenberg; Scientific American Mind, April/May/June 2009]. Thus, although people with BPD may be hypersensitive to subtle facial expressions, they are impaired when it comes to perceiving true signs of social collaboration—or the lack of it. That is, people with BPD may be sensitive to less reliable social cues.

Exercising Restraint

These findings and similar ones have built a case for therapies that make patients aware that they see the world through an emotional microscope and that widen and temper their perspective on life. Although several different psychotherapeutic techniques can help patients tame their emotional reactions to social cues, one of the most widely used—and most successful in treating acute symptoms of BPD—is dialectical behavior therapy (DBT). Developed by psychologist Marsha M. Linehan of the University of Washington, DBT is an innovative form of cognitive-behavior therapy (CBT) designed specifically to treat BPD. It incorporates the central tenets of CBT, in which counselors teach patients to detect and combat distorted thought patterns (the cognitive part) and to counteract problematic behaviors and associated emotions. In addition, DBT incorporates elements of Buddhist meditative practice to help patients maintain a sense of calm.

Therapists first coax patients to acknowledge that

they have a problem controlling their emotions. Then they suggest ways of preventing these feelings from becoming overwhelming and triggering inappropriate or impulsive actions. One core strategy is mindfulness, which is the capacity to live in the moment without passing judgment. Therapists teach patients to focus on the physical environment they currently inhabit—say, the colors in the room, the trickling of a brook or even their own breathing—to move their mind away from their tumultuous inner thoughts.

Another key component of dialectical behavioral therapy is the use of self-soothing techniques to manage mood swings. These methods include practicing deep breathing, taking walks, listening to music and having a nice meal. Therapists also instruct patients about how to build healthy relationships by telling them, for example, to resist the urge to attach themselves too quickly to someone: BPD patients have a reputation for coupling up with each other at an alarming rate, falling in love, say, after just a few group therapy sessions—and then enduring stormy breakups of these impulsive pairings. Other relationship skills BPD patients need are learning to appreciate another person's point of view and to adopt a friendly manner when dealing with others.

To counteract their tendency to overreact to their emotions, patients practice doing the exact opposite of what they are inclined to do. If, for example, they feel intense anger and the urge to blow up at someone, they might instead remove themselves from the situation. Or if they are so depressed they want to stay in bed all day, they get up and take a walk. Therapists also remind patients to get enough sleep and eat regular meals, both of which can improve emotional control. (Unlike most therapists, DBT practitioners encourage their patients to phone them between sessions, a tactic designed to make vulnerable patients feel validated and supported.)

At least one study suggests that these strategies are effective. In 2006 Linehan and her colleagues showed that DBT halved suicide attempts among 52 BPD patients, compared with nonbehavioral therapies tested on another group of 49 patients. DBT also reduced the use of emergency room and inpatient services by these individuals more than other therapies did.

Still other forms of psychotherapy may help patients as well. In fact, results from the two major long-term studies to date of BPD indicate that regular treatment has a surprisingly positive effect, especially on the most serious symptoms, namely, self-harm and suicidal urges. In one of these investigations, psychiatrist Mary Zanarini of Harvard's McLean Hospital and her colleagues reported in 2006 that after 10 years of therapy both in and outside the hospital, 88 percent of the 242 patients no longer met the criteria for BPD. In addition, recurrences in these patients were rare, suggesting that patients can learn how to successfully manage their symptoms.

Wang, now age 31 and living on Long Island, N.Y., credits her survival to the three years of DBT she received after her diagnosis. "My turmoil used to be all jumbled into this big ball of despair," she says. "I've learned that emotions run a certain course—and within this course we have choices to make. Now my emotion no longer has the control it once had, and for the most part I can manage it."

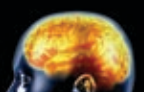
Although Wang still occasionally struggles with thoughts of self-harm and suicide, her improved ability to manage her emotions has stabilized her marriage as well as her relationships with colleagues in her job as a graphic designer and her own sense of herself. "I used to think I was crazy, and feeling crazy is very lonely," she says. "When I found out I had BPD, everything made sense. I understood that it was a disorder and that I was part of a community of people struggling with it. I was no longer alone." M

"I've learned that **emotions run a certain course**—and within that course we have choices to make," one patient says. "**Now my emotion** no longer has the control it once had."

(Further Reading)

- **Stop Walking on Eggshells: Taking Your Life Back When Someone You Care about Has Borderline Personality Disorder.** Paul T. Mason and Randi Kreger. New Harbinger Publications, 1998.
- **Borderline Personality Disorder Demystified: An Essential Guide for Understanding and Living with BPD.** R. O. Friedel et al. Da Capo Press, 2004.
- **Borderline Personality Disorder: Ontogeny of a Diagnosis.** John G. Gunderson in *American Journal of Psychiatry,* Vol. 166, No. 5, pages 530–539; May 2009.
- **Treatment in Psychiatry: Insight, Transference Interpretation, and Therapeutic Change in the Dynamic Psychotherapy of Borderline Personality Disorder.** Glen O. Gabbard and Mardi J. Horowitz in *American Journal of Psychiatry,* Vol. 166, No. 5, pages 517–521; May 2009.
- National Education Alliance for Borderline Personality Disorder: **www.borderlinepersonalitydisorder.com**
- RethinkBPD blog: **http://blog.rethinkbpd.com**

MIND MATTERS



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.

The Mechanics of Mind Reading

Recent advances in brain scanning allow unprecedented access to our thoughts and mental states

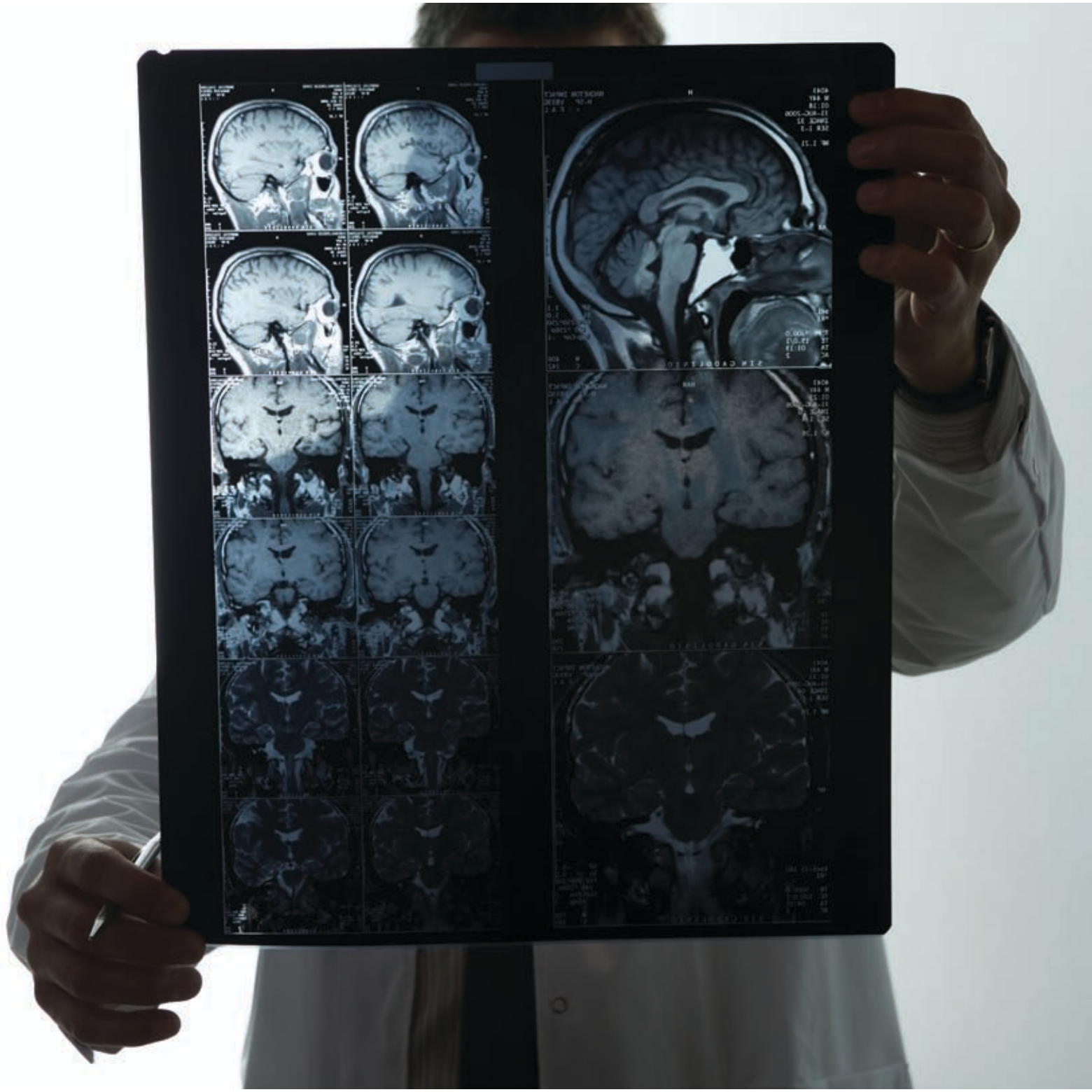
By Daniel Bor

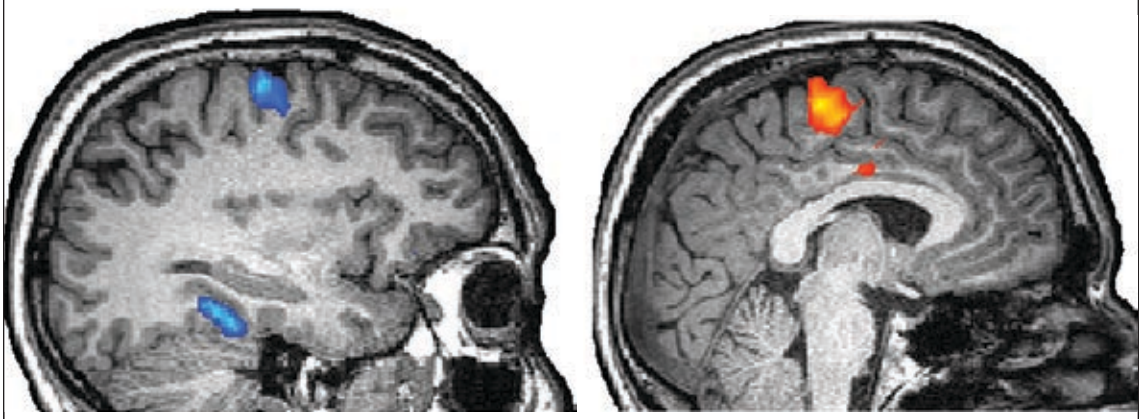
As a favor to friends in my academic department, I have frequently been a guinea pig in the functional magnetic resonance imaging (fMRI) scanner. In most of these cases, I fight valiantly against slumber as the stimuli flash on the small screen in front of me and the hypnotic, high-pitched beeps of the scanner reverberate all around. This time, though, it was different. Martin Monti, a fellow neuroscientist at the MRC Cognition and Brain Sciences Unit in Cambridge, England, was going to read my mind. As the bed I lay on slid robotically into the giant doughnut-shaped scanner, I had a strange sensation that I was about to be seen naked—mentally, at least.

The task was simple: Monti would ask me questions—did I have any siblings, did I think England was going to win the soccer match that night, and so on. If I wanted to answer "yes," then I would imagine myself playing tennis, activating a known set of motor regions in my brain by doing so. If I wanted to answer "no," then I was to imagine navigating around the rooms of my home, activating an entirely different set of areas involved in scene perception. Given that each scan—and thus each of my yes or no answers—took five minutes, the conversation was not the most riveting I had ever had, but when Monti accurately guessed my response every time, it was nonetheless thrilling and unnerving in equal measure.

Last year Monti and others used this technique on a patient diagnosed with a permanent vegetative state, who showed few outward signs of awareness. The researchers demonstrated that the patient was still conscious and could even communicate, as they

LATIN STOCK COLLECTION/CORBIS





Think of tennis to say "yes" (*orange*); visualize your home's layout to say "no" (*blue*). This technique allowed a brain-damaged patient to communicate by thought alone.

reported in the *New England Journal of Medicine* on February 18, 2010. The patient responded to questions with "yes" and "no" the same way I did, by thought alone [*see illustration above*]. No other means currently exist that could have shown that a fully aware, communicative mind was trapped in the patient's unresponsive body. [For a preview of this technique as it was being developed, see "Freeing a Locked-In Mind," by Karen Schrock; Scientific American Mind, April/May 2007.]

Such a feat of scientific telepathy was unheard of a decade ago. But now "mind reading" in various guises is beginning to dominate the field of neuroscience. What caused this revolution? Over the past five years many scientists have changed the way they analyze the data they gather from brain scans. Using a new information-crunching technique, they have deciphered brain activity to reveal not only the content of conscious thought but also information from participants' unconscious minds—even recreating the images in movies they are watching. The new technique has led to insights into the intricate workings of memory and the complex process of decision making. And the method is still in its infancy—the most exciting breakthroughs are no doubt still to come.

FAST FACTS

Thoughts Made Visible

1» **A new method of data interpretation called multivariate pattern analysis has revealed that telltale patterns of brain activity correspond to specific mental states.**

2» **Based on brain activity alone, researchers can predict which picture a volunteer is thinking of or what activity they are imagining doing—but only out of a limited list of possibilities.**

3» **True mind reading—the ability to decode spontaneous thoughts—will require major technological advances, but the latest research is already yielding key insights into how the brain remembers and makes decisions.**

Seeing the Forest and the Trees

The quest to get inside other people's heads is far from new. Polygraph machines represent a century's worth of persistent attempts to use technology to decode thoughts. But lie detectors work indirectly—they identify only the stress response that may or may not be a sign of dishonesty. To truly read thoughts, scientists need to directly decode brain activity. Brain-computer interfaces are progressing rapidly on this front, using electroencephalography (EEG) or electrodes implanted in the brain to detect neural signals and translate them into commands to move robotic arms or cursors on a computer screen. Researchers are using such technology today to train patients with amyotrophic lateral sclerosis, or Lou Gehrig's disease, whose ability to move is slowly failing, to control a communication interface by thought alone. [For more on brain-computer interfacing, see "Chips in Your Head," by Frank W. Ohl and Henning Scheich; Scientific American Mind, April/May 2007.]

But this type of signal decoding, though hugely important in medicine, has limited mind-reading potential; it requires that users practice extensively to direct their thoughts in such a way that a computer can translate their brain signals into commands for motion or speech. Decoding a range of thought processes without resorting to heavy training regimes requires a very different approach.

Enter fMRI. Developed in the 1990s, this imaging technology offered a radical new opportunity to peer inside the mind as it worked, by detecting blood flow to active brain areas. But fMRI data sets can be vast. Each image of activity might require 100,000 three-dimensional pixels, called voxels,

FROM "WILLFUL MODULATION OF BRAIN ACTIVITY IN DISORDERS OF CONSCIOUSNESS," BY MARTIN M. MONTI ET AL., IN *NEW ENGLAND JOURNAL OF MEDICINE*, VOL. 362, NO. 7; FEBRUARY 18, 2010

Strong signals in the brain predicted volunteers' choices up to 10 seconds before they consciously decided to act. Does this result mean we have no free will?

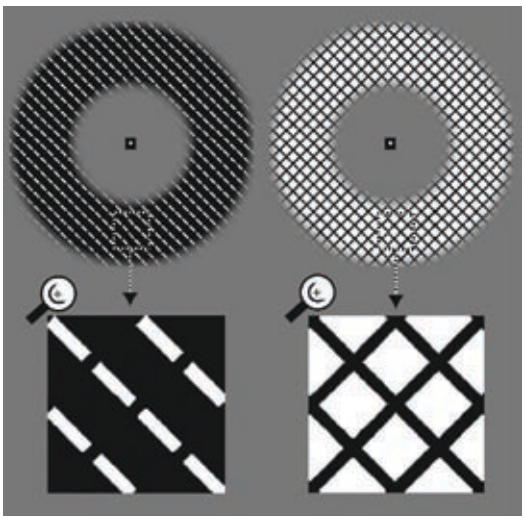
with a new image being taken every two seconds, for up to an hour. Multiply that by around 20 subjects in a study, and you end up with perhaps four billion voxels to examine. The traditional way of solving this problem is to focus on just one of those 100,000 voxels in each image, in one location in all the subjects, and to see whether that voxel rises or falls in activity over time, in accord with the mental fluctuations under study.

But analyzing brain scans in this way involves throwing away vast amounts of useful data by ignoring how these voxels might be working together, in a pattern of activity, to represent information. The old method is comparable to looking at a fuzzy photograph and concluding that only the bright regions are important. The new method would consider all the textures and contrasts of the fuzzy photograph, gauging how they relate to one another to create shapes and figures—and ultimately recognize a picturesque landscape or a smiling face.

This new, far more sensitive method, known as multivariate pattern analysis (MVPA), is effectively a form of artificial intelligence. The program creates algorithms that link mental events with specific patterns of brain activity—for instance, when told a person is thinking about tennis, it detects a corresponding signal in the pattern of activity among motor area voxels—and then, based on those assessments, it makes predictions about how new brain data relate to a person's mental state. Each time the program spots an identifiable pattern of brain signals, it makes a prediction about what the person is thinking about—whether it's playing tennis or, if the telltale brain activity takes a different form, something else entirely. These predictions potentially allow neuroscientists to read minds.

Locating Consciousness

The main early successes of MVPA came in the tricky attempt to study how brain activity generates consciousness. For example, how do people make visual sense of the world around them? In 2005 neuroscientist Geraint Rees and his colleagues at University College London investigated a well-known effect known as binocular rivalry. When different images are presented to each eye, people consciously perceive only one at a time, even though



Brain scans exposed volunteers' subconscious minds in a study using these patterned disks. People gazed at a screen showing the white disk (*right*) interrupted by brief flashes of the black disk (*left*). Volunteers did not see the black disk long enough to say which way its white lines pointed, but their brain activity revealed that the information was registering subconsciously.

their eyes are viewing both images. Awareness tends to alternate between the two images every 15 seconds or so. Using MVPA, the Rees team pinpointed what is happening in the brain as the images flip back and forth. They learned that activity in the primary visual cortex, the first cortical area that responds when we look at something, consists of raw input that has little to do with the image we consciously see. Other, more complex, visual regions that become active later in the chain of events turn out to be the areas that create the image that people report seeing in any given moment. Standard brain-imaging analysis methods lacked the power to detect such results.

More intriguing, Rees and his colleague John-Dylan Haynes, now at the Bernstein Center for Computational Neuroscience in Berlin, used MVPA in 2005 to read subjects' unconscious minds. They showed volunteers pictures of a black disk marked with dashed white lines that were oriented in one of two directions. The disk was masked most of the time by a second disk that had crisscrossing lines in

(The Author)

DANIEL BOR is a cognitive neuroscientist who was formerly based at the University of Cambridge and the MRC Cognition and Brain Sciences Unit in Cambridge, England, and is now at the Sackler Center for Consciousness Studies at the University of Sussex. His first book, *Ravenous for Wisdom: The Consciousness Revolution,* will be published by Basic Books in 2011.

FROM "PREDICTING THE ORIENTATION OF INVISIBLE STIMULI FROM ACTIVITY IN HUMAN PRIMARY VISUAL CORTEX," BY JOHN-DYLAN HAYNES AND GERAINT REES, IN *NATURE NEUROSCIENCE*, VOL. 8, NO. 5; MAY 2005

both directions [*see illustration on preceding page*]. When the mask disappeared, it revealed the target disk for only 17 milliseconds at a time—too short a span for the volunteers to consciously register the direction of the dashed lines. And, as expected, before the volunteer consciously decided to act. This result has deep ramifications. Does it mean that we have no free will? Or does free will kick in only for more complex decisions? More research will be needed to answer these questions—but it is

A new pattern-recognition program can guess which of 1,000 pictures a person just viewed—a dramatic leap from the two or three options other algorithms can parse.

their guesses at the orientation of the lines on the target disk had only chance-level accuracy (50 percent). Using MVPA to study the primary visual cortex, however, the scientists were able to learn which line orientation a subject was seeing—even though the subject himself did not know! As in the previous study, the results suggest the primary visual cortex is a kind of brain-only version of what the eyes see; that information is later processed by other visual brain regions in more conscious ways.

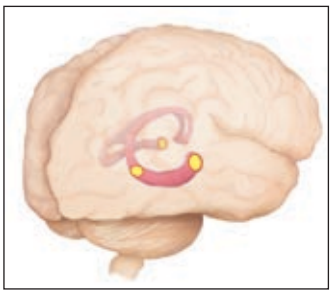
It wasn't long before these powerful MVPA methods branched out into territory far removed from consciousness perception. Although ethically contentious progress is being made using MVPA to predict when a person is lying [see "Portrait of a Lie," by Matthias Gamer; SCIENTIFIC AMERICAN MIND, February/March 2009], considerably more profound results are appearing in another field: decision making.

In 2008 Haynes asked volunteers to carry out a simple task—to choose whether to press the left or right button on a remote control while in the fMRI scanner. When Haynes set his MVPA algorithm to learn which patterns corresponded with this decision, he was astounded to find strong signals in the prefrontal and parietal cortices (areas involved in processing novel or complex goals) up to 10 seconds

exciting that MVPA has moved such concerns, once strictly the domain of philosophy, into the province of scientific study.

I Know What You're Seeing

One drawback of many fMRI studies is that the stimuli are so artificial—say, dashed white lines on a black disk—that their generalization to the real world is limited. But now, because of the flexibility and power of MVPA methods, it is feasible to show photographs or videos in the scanner and analyze the resulting brain activity. Such methods have enabled scientists to refine their understanding of the basic workings of memory. For instance, neuroscientist Eleanor Maguire, also at University College London, and her co-workers recently used MVPA to identify patterns in the part of the brain that stores memories, the hippocampus. As reported in *Current Biology* on March 23, the researchers showed volunteers three seven-second movie clips depicting women doing everyday activities (for instance, drinking from a coffee cup, then throwing it away). The volunteers then recalled each of the clips while the researchers scanned their brains. Using MVPA, the researchers were able to predict which clip each volunteer was recalling at any given time. They also discovered that particular areas



When people remember an event or a short film, such as the above clip of a woman throwing out a coffee cup, they activate their so-called episodic memory to replay the scenes in their mind. Using a powerful data-crunching technique, researchers can now determine which of three similar clips volunteers are recalling at any given time. The same analysis technique has enhanced our understanding of the brain's memory storage area, the hippocampus (*pink*), by revealing substructures (*yellow*) especially important for episodic memory.

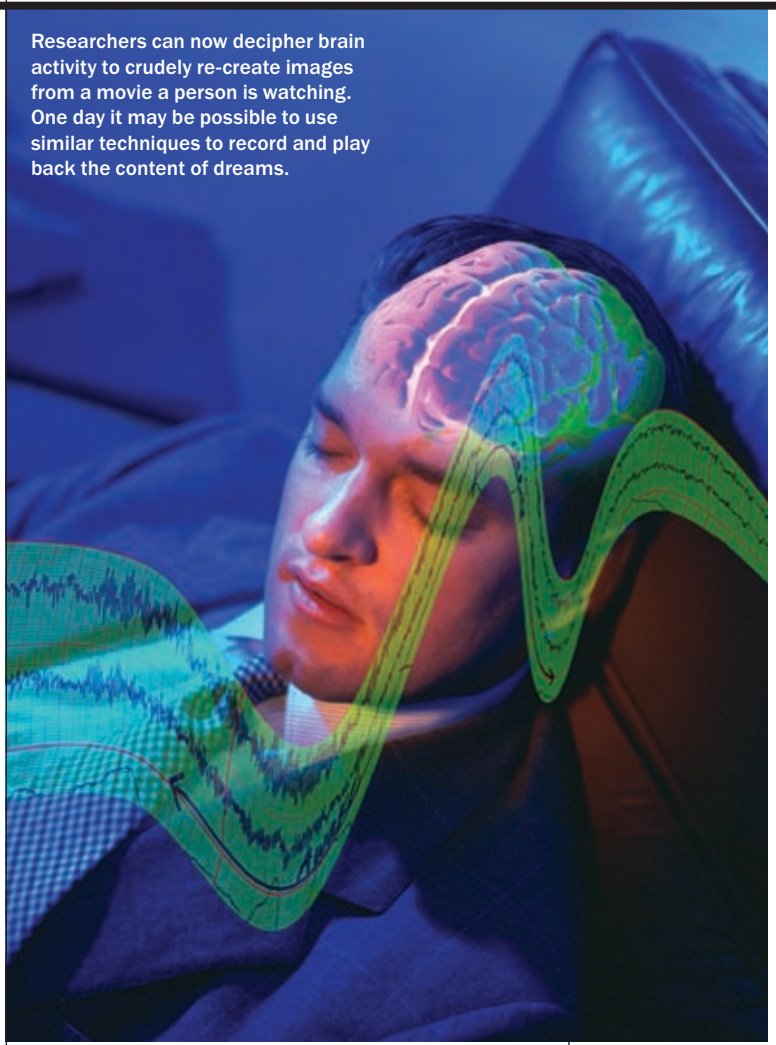
FROM "DECODING INDIVIDUAL EPISODIC MEMORY TRACES IN THE HUMAN HIPPOCAMPUS," BY MARTIN J. CHADWICK ET AL., IN *CURRENT BIOLOGY*, VOL. 20, NO. 6; MARCH 11, 2010 (*movie stills*); MELISSA THOMAS (*illustration*)

within the hippocampus, including the right and left anterior and the right posterior portions, are especially important for storing these so-called episodic memories [*see illustration on opposite page*].

Impressive though the results have been, the studies to date are relatively crude, capable of identifying one of a handful of mental states (tennis game or home layout?). This is a far cry from genuine mind reading, where looking at neural activity would reveal a person's thoughts without referring to a preset shortlist of possibilities. One lab, though, seems to be edging closer. Neuroscientist Jack Gallant of the University of California, Berkeley, published results in 2008 showing that his pattern-recognition programs can guess which of 1,000 pictures the person just viewed—a dramatic leap from the two or three options other algorithms have learned to parse. And at the Society for Neuroscience conference last fall, he presented data that went much further—actually reconstructing, from the activity in the visual cortex, what volunteers were seeing when they watched a series of movie trailers. For instance, at the very moment that a man in a white shirt appeared on screen, the program would spit out an outline of a white torso. These data have not yet been published in a peer-reviewed journal, and the reconstruction is at a preliminary stage, so the results should be viewed cautiously. Nevertheless, such provisional progress suggests tantalizing possibilities, such as the ability to "read off" a crime witness's memories or record and play back the visual imagery in dreams.

Some scientists remain skeptical about the promise of MVPA. The studies that demonstrate that the technique makes accurate predictions are statistically significant, but that often means that the computer's guess is a hair's breadth above chance. Many studies that rely on MVPA to pick between two alternatives score around 60 percent accuracy, for instance, when a blind guess would give 50 percent—a useful improvement, but hardly telepathy. The yes-or-no experiment I took part in is far more robust, partly because it gathers a large amount of data before assessing the guesses. Yet if I were mischievously to imagine playing baseball instead of tennis or navigating around my childhood home instead of my current one, neither the prediction program, nor the experimenter, would have a clue that I was breaking the rules.

In the end, what the fMRI scanner shows is a noisy, indirect measure of neural activity—blood flow is thought to correlate to activity, but it may not be a perfect proxy. The imperfect nature of the data creates inherent limits to what the technology can achieve. And even if fMRI provided a direct measure, it would still be an approximate one: a single voxel represents the collective activity of many tens of thousands of neurons. Still, technological advances in MRI physics may be on the horizon, enabling more reliable, higher-resolution measurements and nudging true mind reading out of the realm of science fiction. **M**



Researchers can now decipher brain activity to crudely re-create images from a movie a person is watching. One day it may be possible to use similar techniques to record and play back the content of dreams.

MICHEL TCHEREVKOFF *Getty Images*

(Further Reading)

- **Decoding Mental States from Brain Activity in Humans.** John-Dylan Haynes and Geraint Rees in *Nature Reviews Neuroscience,* Vol. 7, No. 7, pages 523–534; July 2006.
- **Identifying Natural Images from Human Brain Activity.** Kendrick N. Kay, Thomas Naselaris, Ryan J. Prenger and Jack L. Gallant in *Nature,* Vol. 452, pages 352–356; March 20, 2008.
- **Unconscious Determinants of Free Decisions in the Human Brain.** Chun Siong Soon, Marcel Brass, Hans-Jochen Heinze and John-Dylan Haynes in *Nature Neuroscience,* Vol. 11, No. 5, pages 543–545; May 2008.
- **Willful Modulation of Brain Activity in Disorders of Consciousness.** Martin M. Monti, Audrey Vanhaudenhuyse, Martin R. Coleman, Melanie Boly, John D. Pickard, Luaba Tshibanda, Adrian M. Owen and Steven Laureys in *New England Journal of Medicine,* Vol. 362, No. 7, pages 579–589; February 18, 2010.

Mrs. K. questions who she really is.

Her family, her career, her entire life seem pointless. She feels anxious and broods. She sometimes screams at her children for no reason and then feels guilty. She has toyed with the idea of suicide. In contrast, Mr. M. believes that he possesses extraordinary gifts. He spends long nights writing down grandiose plans to save the world and sends his manuscripts to numerous publishers. Despite heaps of debt, he buys an expensive sports car, anticipating success. He has never felt more confident. These patients suffer from different mental illnesses—Mrs. K. is depressed, and Mr. M. is manic—but they both hold highly distorted views of themselves.

It is more than just sage advice to "know thyself," as Heraclitus advocated in the fifth century B.C. A realistic self-image is a hallmark of a healthy mind. Ancient Greek philosophers speculated that the psyche determines behavior. Since then, numerous studies have shown that people

Me, Myself and I

Although people change throughout their lives, most hold a steady view of who they are. How does the brain maintain a sense of self? **By Uwe Herwig**

with a faulty self-image tend to have high levels of anxiety, defensiveness, self-doubt and narcissism. Relationships, careers and happiness suffer when reality doesn't match who we think we are.

How does a person's self-image come unglued? Neuroscientists have long searched for the origins of self in the brain. Thanks to advances in imaging technologies, they have made progress in recent years, but the "I" remains hard to pin down. For one thing, it is the product of a distributed array of brain structures. More confounding, the "I" is a moving target: many factors—from a person's upbringing to major life events—continually shape the self. This shifting sense of self does not only derive from the narratives we construct to make sense of our lives. It is also biological: experiences generate new brain cells and neural pathways.

Yet despite all this wiring and rewiring, the mind typically manages to maintain a consistent self-portrait. Subjectively, we perceive the "I" as an unchanging framework—a steady reference point for ordering our thoughts, emotions and experiences. Moreover, the "I" provides clear boundaries—we make sharp distinctions between internal and external events. We regard thoughts, feelings and memories as our own; they belong to us. And even when we empathize with others, we know very well whose mental states belong to whom. How does the healthy brain maintain this unwavering, well-defined self? And to what end? Why aren't we simply biologi-

AARON GOODMAN

Self-awareness begins shortly after birth. When babies are between three and five months old, they begin to figure out that they can control the movements of their own limbs. By 18 months, toddlers can recognize themselves in a mirror.

cal automatons—unaware of ourselves or of how we relate to our surroundings? It is perhaps one of the central questions of what it means to be human.

The Layers of Self-Awareness

We begin to establish a sense of self shortly after birth. From three to five months old, babies start to gain control over their movements; they recognize themselves in the mirror at about 18 months; they grasp concepts such as "I" and "mine" at about age two; and they readily describe their own feelings at about three years old. Once children reach elementary school, they make friends and begin to draw comparisons, which further inform their self-image. Teens and young adults continue to expand their personal identities as they practice progressively nuanced social skills.

FAST FACTS

All about Me

1» We perceive the "I" as stable, but the self is actually a construct that the brain works constantly to maintain.

2» Self-knowledge involves both simple mental processes, such as knowing where one's body is in space, and complex ones, such as fabricating a life story out of past events.

3» A critical aspect of self-awareness is the ability to recognize and temper one's emotions.

Neural connections form in step with these developmental stages. A newborn's brain exhibits relatively few of the trillions of synaptic linkages it will ultimately possess. By a child's sixth year, however, his or her brain has experienced an explosive growth in its connections. Over time, experience consolidates and prunes these associations: unused links disappear, while significant or frequent experiences reinforce other channels. As this fine-tuning takes place, we become increasingly well acquainted with ourselves—from our basic biological urges to deep-seated desires and dreams.

The sense of self has multiple components. To begin with, there is the ability to recognize one's own face and body and to know what those body parts are doing at any given moment. There is also the sense of ownership—you perceive your body as belonging to you—and the sense of agency: you feel responsible for your own movements and actions. And at the highest level, there is the awareness of one's own emotions and the ability to link disparate life experiences to a stable self-image.

Brain malfunctions can disrupt any of these processes. We have seen how depression and mania can derail a stable self-image, but other aspects of self are equally vulnerable. There are people, for example, who function pretty much normally except that they do not recognize themselves in a mirror. Others have trouble tracking the movements of their bodies. Some may even disown one of their limbs [see "Amputee Envy," by Sabine Mueller; Scientific American Mind, December 2007/January 2008].

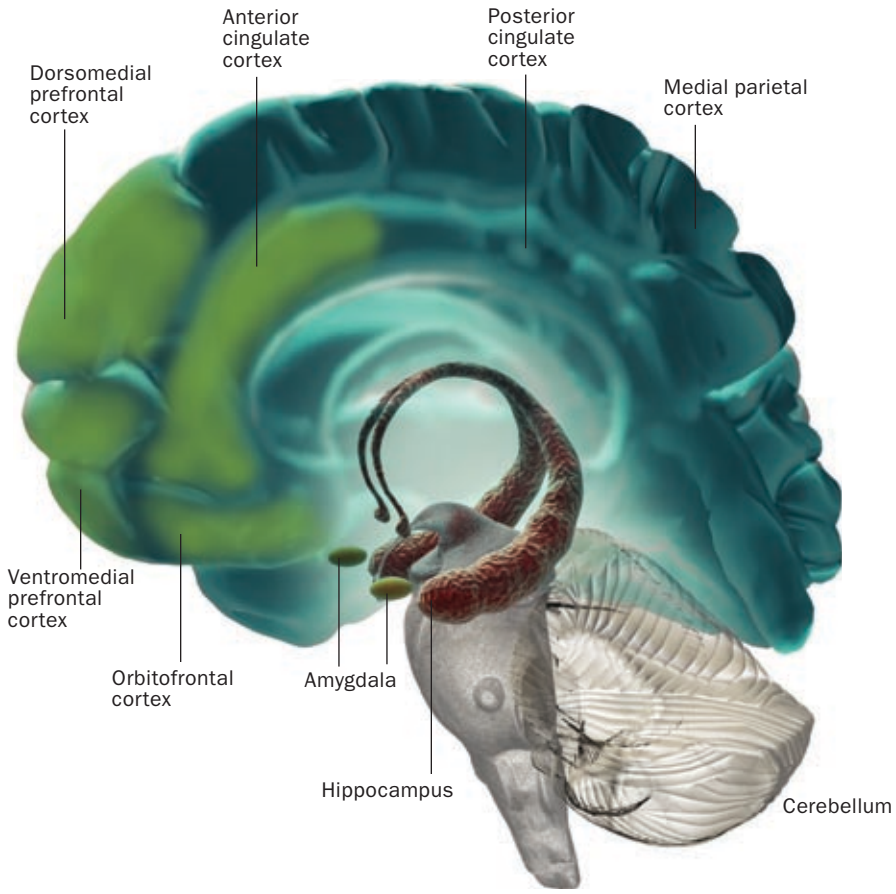
In the mid-1990s neurologist Antonio R. Damasio, then at the University of Iowa, distilled the self's multiple layers into a three-part hierarchy. The lowest level, which Damasio calls the proto-self, corresponds to a simple, neural representation of the body. This proto-self oversees basic physical functions such as metabolism, body temperature and circadian rhythms. We are not conscious of the proto-self unless problems arise, eliciting attention from the core self (the intermediate level), which generates our immediate cognizance of the here and now. At this level of awareness, signals from the body give rise to nonverbal impulses—feelings of hunger, sadness or cold. The autobiographical self, Damasio's top layer, enables us to evaluate our impulses rationally—referencing earlier experiences and current goals—and to guide our behavior in a targeted way.

These three layers of self emanate from increasingly sophisticated processing centers in the brain. The proto-self is associated with the brain stem and the hypothalamus, structures found at the base of the brain near the spinal cord. The core self enlists

BLUEDUCK/GETTY IMAGES

Thinking before You React

What is self-awareness good for? It helps people recognize and manage fear, anger and other potentially destructive emotions. Studies show that when people distance themselves from upsetting feelings, the rational parts of their brains (*light green*) tamp down emotional ones such as the amygdala—and they feel better.



areas in the interbrain, or diencephalon, which serve as a relay for visceral activities, and the amygdala, which is primarily involved in processing emotions. It also activates the cingulate cortex and the insula, which are connected to emotions, and the medial and dorsolateral prefrontal cortex, which act as an internal governor, forming plans of action and issuing commands. The autobiographical self, meanwhile, relies on linguistic abilities that only humans possess. Accordingly, it employs speech and memory centers in the hippocampus and Broca's area, as well as parts of the prefrontal cortex. Many of the areas related to the self are found along the brain's midline, where its two hemispheres meet.

The Tickle Conundrum

To explore the self in the laboratory, scientists often use a two-part model instead of Damasio's triumvirate. On a practical level, it makes sense to divide the "I" into its physical and cognitive components. The physical self is where we feel our own body, thanks to sensory feedback from the skin, joints and abdominal cavity. This input generates interoception—our awareness of pain, temperature, itching and hunger, among other internal sensations. The cognitive self is where we recognize and reference ourselves in the world.

Interoceptive awareness appears to depend heavily on the anterior insula, a brain structure that is buried deep within the cerebral cortex. In 2004 Hugo D. Critchley and his co-workers at University College London conducted an experiment in which they asked people to estimate their own heart rates as they lay in a magnetic resonance imaging ma-

(The Author)

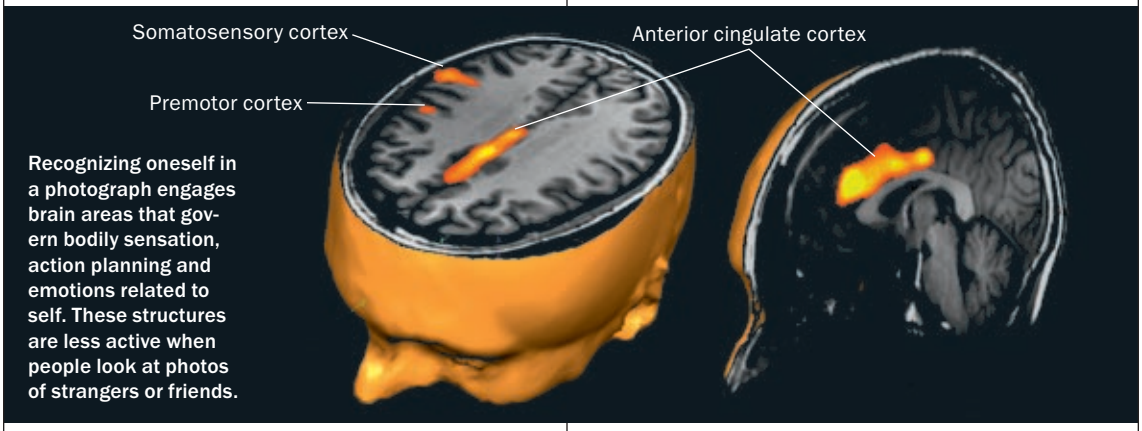
UWE HERWIG leads the emotion-regulation working group at the Psychiatric University Hospital Zurich. He teaches at the universities of Zurich in Switzerland and Ulm in Germany.

GEHIRN & GEIST/MEGANIM

Many creatures, not just humans, have a basic level of self-awareness. They need it to survive.

chine. The study subjects listened to their heartbeats through a headset—either in real time or delayed by half a second—and then had to decide which version was their actual pulse.

The results showed that greater activity in the anterior insula corresponded to greater accuracy on the task. In other words, subjects who were more in tune with their own heartbeat made greater use of their insula. Furthermore, people who were particularly sensitive to physical sensations—for instance, they were more apt to notice a dry mouth or abdominal pressure—tended to have more insular gray matter than is normal. Other research has implicated heightened interoceptive awareness in panic and anxiety disorders. In such conditions, behavioral dysfunction may relate to faulty readings of the self.



Recognizing oneself in a photograph engages brain areas that govern bodily sensation, action planning and emotions related to self. These structures are less active when people look at photos of strangers or friends.

The cognitive self, in contrast, seems to reside in the medial prefrontal cortex—located behind the eyes on the inner surface of each hemisphere. In 2006 Joseph Moran, now a postdoctoral fellow at the Massachusetts Institute of Technology, and his colleagues asked healthy test subjects to judge how well a string of adjectives applied either to themselves or to people they knew. Only when the participants related the traits to themselves did functional MRI scans of their brains show increased activity in the medial prefrontal cortex. Interestingly, this increase occurred regardless of whether the adjective described a positive or a negative attribute.

The brain also contains specialized circuits for distinguishing between self-generated and external stimuli—which explains at least in part why we cannot tickle ourselves. To discover which brain regions normally make this self/nonself distinction, Knut Schnell of the University of Bonn in Germany and his colleagues asked 15 men to play a simple racing video game. Periodically, the computer would take over the steering function, and the men had to monitor, as they played, whether they or the computer was controlling the car.

Functional MRI scans revealed that as the participants observed their own actions, they activated a network in the prefrontal cortical region and in the inferior parietal lobe. The prefrontal cortex, in its role as the brain's command center, plans our actions and sends instructions to whatever parts of the body are required. At the same time, it sends a copy of its instructions to parts of the parietal lobe, which monitor our movements and anticipate the corresponding sensations. The brain takes special notice if our experience does not match the parietal lobe's predictions—say, the car turns left when we turn the wheel to the right. In this way, we filter out self-generated stimuli and perceive external input—sensations we have not predicted—more urgently.

Related brain structures are responsible for self-referential thinking, according to studies by Tilo Kircher of the University Psychiatric Clinic in Marburg, Germany, and Steven M. Platek of Georgia Gwinnett College in Lawrenceville, Ga. Activity in the cingulate cortex, as well as the premotor, insular and somatosensory cortices, increased when test subjects looked at photographs of themselves. But when the participants looked at photographs of other people (some of whom they knew, others whom they did not), these brain areas either did not light up or lit up only faintly on the MRI scanner. Moreover, cingulate and insular areas fire even when someone merely expects to see his or her own face, as Annette B. Brühl of the Psychiatric Univer-

COURTESY OF UWE HERWIG

sity Hospital Zurich reported in 2008 at the annual meeting of the German Psychiatry and Psychotherapy Association in Berlin.

The Emotion Connection

Why does the brain contain mechanisms for picturing ourselves—where we are, what we are doing, who we are and how we feel? The simple answer is that many creatures, not just humans, have a basic level of self-awareness; they need it to survive. An animal that can't tell what is itself and what is the world is virtually helpless. It can't react or coordinate its movements. It can't make the critical inferences about cause and effect ("When *x* happened, I felt *y*") that enable it to find food and avoid harm.

But for animals, like humans, that inhabit a complex social universe, the autobiographical self offers another advantage: the opportunity to regulate feelings. We live in a sea of emotionally significant stimuli, from the neighbor's snapping dog to an unexpected hug, and it is vital to our mental and physical health that we respond appropriately—which may involve replacing a knee-jerk emotion with a more reasoned view. Once we bring charged emotions into the realm of awareness, we can neutralize their stressful physiological effects, such as an elevated heart rate, increased blood pressure, sweating and trembling.

In 2007, building on previous work by Kevin N. Ochsner of Columbia University and James J. Gross of Stanford University, my colleagues and I explored the neural basis of a technique known as cognitive reappraisal that depends, by definition, on self-awareness. Using this method, people learn to reflect on a situation and reframe it in a positive way.

Our team from the Psychiatric University Hospital Zurich, the University of Zurich in Switzerland and the University of Ulm in Germany conducted a two-part study. In the first part, we told 18 healthy test subjects that we would present them with either unpleasant or emotionally ambiguous pictures—possibly happy, possibly not—as they lay in an MRI scanner. We asked them, as they anticipated the pictures, to reassure themselves that they were perfectly safe no matter what the images showed.

In the second part, we told another 16 subjects to anticipate these images but did not instruct them to manage their expectations in any way. The people from the first group who successfully used cognitive reappraisal to stay calm showed increased activity in the prefrontal cortex and weaker activity in the amygdala—they had apparently prompted the brain to use its decision-making powers to buffer emotional responses. And the strategy worked even when people did not know what was coming.

GETTY IMAGES

Studies show that when people are in touch with their feelings, they are better able to manage everyday stresses. In fact, the awareness of self may have evolved, in part, to help us navigate the emotionally charged interactions that are a necessary part of being human.

Meditation techniques that enhance mindfulness—purposeful, attentive and nonjudgmental awareness of the moment—seem to prime the same circuitry. In a recent study we asked subjects either to be aware of their current emotions or to think about themselves. The pure focus on an individual's emotional state reduced activity in the amygdala, creating a calming effect.

As imaging technology continues to develop, it is possible that brain-scanning devices might someday provide real-time feedback to people as they meditate, enabling them to train their brain to be more mindful. And in the near future scientists may be able to study whether this kind of feedback might be used to help people master emotional self-regulation. People such as Mrs. K. and Mr. M. would likely derive benefit. Research makes it clear that our self-image is a product of our brain. By honing our powers of self-reflection, we can actively work to keep our self-image in step with reality. M

(Further Reading)

- **The Feeling of What Happens: Body and Emotion in the Making of Consciousness.** Antonio Damasio. Harvest Books, 2000.
- **Neural Systems Supporting Interoceptive Awareness.** H. D. Critchley, S. Wiens, P. Rotshtein, A. Öhman and R. J. Dolan in *Nature Neuroscience,* Vol. 7, No. 2, pages 189–195; February 2004.
- **The Cognitive Control of Emotion.** K. N. Ochsner and J. J. Gross in *Trends in Cognitive Sciences,* Vol. 9, No. 5, pages 242–249; May 2005.
- **Overlapping and Non-overlapping Brain Regions for Theory of Mind and Self Reflection in Individual Subjects.** R. Saxe, J. M. Moran, J. Scholz and J. Gabrieli in *Social Cognitive and Affective Neuroscience,* Vol. 1, No. 3, pages 229–234; December 2006.
- **Modulation of Anticipatory Emotion and Perception Processing by Cognitive Control.** U. Herwig, T. Baumgartner, T. Kaffenberger, A. Brühl, M. Kottlow, U. Schreiter-Gasser, B. Abler, L. Jäncke and M. Rufer in *NeuroImage,* Vol. 37, No. 2, pages 652–662; August 15, 2007.
- **Self-Related Awareness and Emotion Regulation.** U. Herwig, T. Kaffenberger, L. Jäncke and A. B. Brühl in *Neuroimage,* Vol. 50, No. 2, pages 734–741; April 2010.

Sex in Bits and Bytes

How destructive is Internet porn?

BY HAL ARKOWITZ AND SCOTT O. LILIENFELD

IS IT POSSIBLE to have sex with a computer? Well, not exactly, but people can use their computers to engage in a variety of online sexual activities, including hooking up with partners (both virtually and in the flesh) and finding fodder for kinky obsessions.

Online porn is accessible, affordable and often anonymous, and viewing it has become a popular pastime. A survey of college students in 2008 by psychologist Chiara Sabina of Penn State Harrisburg and her colleagues found that more than 90 percent of the men and 60 percent of the women had watched Internet pornography before age 18. In a separate study the rate of use was less than half as frequent among those between the ages of 40 and 49, suggesting that Internet porn consumption may decline with age—although that statistic could reflect generational differences in computer use. Studies have revealed a gender difference in online sexual activities: men are more likely to watch pornography, whereas women are more apt to participate in sexual chat rooms, suggesting that they prefer sexual stimulation in the context of interaction.

Most people who watch porn seem to be occasional dabblers, but a small percentage of users indulge excessively in online sexual content. In 1998 Alvin Cooper, then at the Marital and Sexuality Center in San Jose, Calif., and his associates conducted an online study of more than 9,000 people who used the Internet for sexual purposes. Slightly fewer than half the respondents—most of them men who were married or in a committed relationship—indulged for an hour or less a week. Forty-five percent reported engaging in online sexual activity between one and 10 hours a week. Eight percent used the Internet for such purposes for 11 or more hours weekly, and a small but distinctive 0.5 percent reported more than 70 hours a week.

Emerging evidence suggests that such heavy use may be associated with harmful effects on the psyche and on relationships. Some experts even contend that Internet porn can be addictive, but the use of the term in this context is controversial.

The Price of Consumption

Although occasional use of pornography sites and other online sexual activities does not appear to be associated with serious problems—at least according to reports from users—even relatively light use may have a negative effect on one's partner or spouse. What is more, heavy consumption of porn, including the Internet variety, may contribute to relationship strains and sexually aggressive attitudes and behaviors toward women.

Numerous studies have found associations between the amount of exposure to pornography and sexually belligerent attitudes such as endorsing coercive sex and sexually aggressive behaviors—say, forcibly holding a woman down. These associations are strongest for men who watch violent pornography and for those who already tend to be sexually aggressive.

Other findings have tied frequent porn use to attitudes such as assigning blame to victims of sexual assault, justifying the actions of sexual perpetrators and discounting the violence of rape. Enthusiasm for porn often accompanies callousness toward women, dissatisfaction with a partner's sexual performance and appearance, and doubts about the value of marriage. Such attitudes are

COURTESY OF HAL ARKOWITZ (*Arkowitz*); COURTESY OF SCOTT O. LILIENFELD (*Lilienfeld*); GETTY IMAGES (*keyboard*)

Thirty-two percent of female partners of porn users said their man's habit adversely **affected their lovemaking.**

clearly detrimental to relationships with women and could conceivably be linked to crimes against them.

But should we conclude that watching pornography causes these misogynistic beliefs and actions, as many social commentators assume? Most of the studies merely show a statistical association between pornography use and such traits. They do not reveal whether watching pornography begets them. For example, although heavy porn use may indeed cause callousness toward women, an existing callousness toward women may instead lead to pornography use. Alternatively, a third factor, such as personal problems of the user, may lead to both pornography use and callousness toward women.

Research has tied heavy porn consumption to misogynistic attitudes such as assigning blame to sexual assault victims. But these associations could simply mean that men with such beliefs are attracted to porn.

Researchers have also asked the female partners of men who are heavy consumers of pornography how they feel about their partner's habits. Psychologist Ana Bridges of the University of Arkansas and her colleagues found that although most of the women received low overall scores on a measure of distress about their partner's porn use, most of them also endorsed some statements indicative of anguish. For example, 42 percent agreed that their partner's porn consumption made them feel insecure, 39 percent that the partner's porn use had a negative effect on their relationship and 32 percent that it adversely affected their lovemaking, hinting that the habit may have downsides.

Addicted to Porn?

Even if porn proves detrimental to its users and, in some cases, their partners, it may or may not be addictive. Scientists debate whether addiction is an appropriate term for behaviors such as excessive gambling, shopping, Internet use, sexual activity and viewing of Internet pornography. Those in favor of recognizing so-called behavioral addictions argue that some immoderate actions share core characteristics with alcohol and drug addiction. These include extreme indulgence and continued use despite a negative effect on the user.

Skeptics counter, however, that although people may partake excessively in certain activities and sometimes suffer detrimental life consequences, they rarely develop tolerance or obvious withdrawal symptoms—two hallmarks of addiction. Some critics further maintain that the label of "addict" adds unnecessary stigma to the problem. Others contend that this description lets people "off the hook" for socially problematic behaviors that are at least partly under their control.

Although researchers have just begun to explore the possible downsides of pornography use in general and Internet pornography in particular, the results of many studies of exposure to pornography suggest that excessive viewing of such material could sometimes be harmful. As a result, psychotherapists need to be alert to such behavior in their clients, especially when it impinges on their romantic relationships. A better understanding of how watching Internet pornography affects the men and women drawn to it may ultimately lead to meaningful treatments for those with a pornography habit that has hurt them and their loved ones. 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)

- **Pornography and Sexual Aggression: Are There Reliable Effects and Can We Understand Them?** N. M. Malamuth, T. Addison and M. Koss in *Annual Review of Sex Research,* Vol. 11, pages 26–91; 2000.
- **Internet Sex Addiction: Risk Factors, Stages of Development, and Treatment.** Kimberly S. Young in *American Behavioral Scientist,* Vol. 52, No. 1, pages 21–37; 2008.
- **The Internet's Impact on Sexuality: A Critical Review of 15 Years of Research.** Nicola M. Döring in *Computers in Human Behavior,* Vol. 25, No. 5, pages 1089–1101; 2009.

NICHOLAS RIGG *Getty Images*

The Willpower Paradox

Setting your mind on a goal may be counterproductive. Instead think of the future as an open question

BY WRAY HERBERT

WILLINGNESS is a core concept of addiction recovery programs—and a paradoxical one. Twelve-step programs emphasize that addicts cannot will themselves into healthy sobriety—indeed, that ego and self-reliance are often a root cause of their problem. Yet recovering addicts must be willing. That is, they must be open to the possibility that the group and its principles are powerful enough to trump a compulsive disease.

It's a tricky concept for many and must be taken on faith. But now there may be science to back it up. Psychologist Ibrahim Senay of the University of Illinois at Urbana-Champaign figured out an intriguing way to create a laboratory version of both willfulness and willingness—and to explore possible connections to intention, motivation and goal-directed actions. In short, he identified some key traits needed not only for long-term abstinence but for any personal objective, from losing weight to learning to play guitar.

"Will I?" Study subjects who wrote this question over and over again performed better on a subsequent task than those who wrote "I will."

MATT MENDELSON (*Herbert*); IMAGES.COM/CORBIS (*question mark*)

Ask, Don't Tell

Senay did this by exploring self-talk. Self-talk is just what it sounds like—that voice in your head that articulates what you are thinking, spelling out your options and intentions and hopes and fears, and so forth. It is the ongoing conversation you have with yourself. Senay thought that the form and texture of self-talk—right down to the sentence structure—might be important in shaping plans and actions. What's more, self-talk might be a tool for exerting the will—or being willing.

Here is how Senay tested this notion. He had a group of volunteers work on a series of anagrams—changing the word "sauce" to "cause," for example, or "when" to "hewn." But before starting this task, half the volunteers were told to contemplate whether they would work

> Half the subjects wanted to take responsibility for their health; the others feared **feeling guilty or ashamed** if they did not.

on anagrams, while the others simply thought about the fact that they would be doing anagrams in a few minutes. The difference is subtle, but the former were basically putting their mind into wondering mode, while the latter were asserting themselves and their will. It is the difference between "Will I do this?" and "I will do this."

The results were provocative. People with wondering minds completed significantly more anagrams than did those with willful minds. In other words, the people who kept their minds open were more goal-directed and more motivated than those who declared their objective to themselves.

These findings are counterintuitive. Think about it. Why would asserting one's intentions undermine rather than advance a stated goal? Perhaps, Senay hypothesized, it is because questions by their nature speak to possibility and freedom of choice. Meditating on them might enhance feelings of autonomy and intrinsic motivation, creating a mindset that promotes success.

Sticking to an exercise routine may be easier if you cultivate open-mindedness about the future, which leads to positive motivation.

LORI ADAMSKI PEEK *Getty Images*

Keeping an Open Mind

Senay designed another experiment to look at the question differently. In this study, he recruited volunteers on the pretense that they were needed for a handwriting study. Some wrote the words "I will" over and over; others wrote "Will I?"

After priming the volunteers with this fake handwriting task, Senay had them work on the anagrams. And just as before, the determined volunteers performed worse than the open-minded ones.

Next, Senay ran still another version of this experiment, one more obviously related to healthy living. Instead of anagrams, he changed the goal to exercise; that is, he measured the volunteers' intentions to start and stick to a fitness regimen. And in this real-world scenario, he got the same basic result: those primed with the interrogative phrase "Will I?" expressed a much greater commitment to exercise regularly than did those primed with the declarative phrase "I will."

What's more, when the volunteers were questioned about why they felt they would be newly motivated to get to the gym more often, those primed with the question said things like: "Because I want to take more responsibility for my own health." Those primed with "I will" offered strikingly different explanations, such as: "Because I would feel guilty or ashamed of myself if I did not."

This last finding is crucial. It indicates that those with questioning minds were more intrinsically motivated to change. They were looking for a positive inspiration from within, rather than attempting to hold themselves to a rigid standard. Those asserting will lacked this internal inspiration, which explains in part their weak commitment to future change. Put in terms of addiction recovery and self-improvement in general, those who were asserting their willpower were in effect closing their minds and narrowing their view of their future. Those who were questioning and wondering were open-minded—and therefore willing to see new possibilities for the days ahead. M

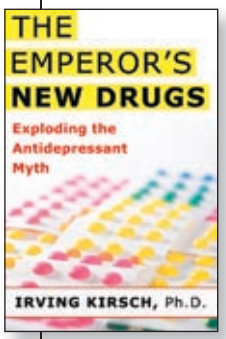
» For more insights into the quirks of human nature, visit the "We're Only Human . . ." blog and podcasts at www.psychologicalscience.org/onlyhuman

WRAY HERBERT is senior director for science communication at the Association for Psychological Science.

(Further Reading)

◆ **Motivating Goal-Directed Behavior through Introspective Self-Talk: The Role of the Interrogative Form of Simple Future Tense.** Ibrahim Senay, Dolores Albarracín and Kenji Noguchi in *Psychological Science,* Vol. 21, No. 4, pages 499–504; April 2010.

books



GOT MEDS?

The Emperor's New Drugs: Exploding the Antidepressant Myth

by Irving Kirsch. Basic Books, 2010 ($23.95)

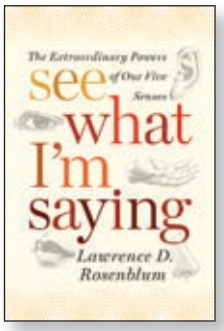
Prozac, Zoloft, Paxil, Effexor, Celexa. These popular antidepressants are effective—but their function arises mainly from the placebo effect. Psychologist Irving Kirsch arrived at this conclusion a few years ago after he and his colleagues took a thorough look at all the data from experiments with antidepressants.

In *The Emperor's New Drugs,* Kirsch reports that sugar pills are about as effective as antidepressants and that for many years drug companies withheld this information. Moreover, these placebos don't have to be sugar pills; even a synthetic thyroid hormone, disguised as an antidepressant, helped to alleviate depression in subjects with no thyroid problems.

Kirsch reveals some unsavory pharmaceutical company practices. He reports that drug companies frequently manipulate scientific data—by cherry-picking positive results, withholding negative findings from publication, and "salami slicing" (publishing positive data multiple times). For instance, in the 1990s GlaxoSmithKline conducted several trials on the effectiveness of the antidepressant Paxil, which showed the drug was no more effective than a placebo. The trials also revealed some dangerous side effects, including a possible increased risk of suicide. GSK, however, decided not to release most of the negative data to the public. When this negligent behavior was later uncovered, the company was sued by the New York attorney general for engaging in "repeated and persistent fraud." The company was forced to make all the data public.

In light of the fact that tens of millions of Americans—including many children—are taking antidepressants, it's hard not to find Kirsch's account disturbing. Moreover, it makes one wonder about the testing and approval processes for other medications. "For society as a whole, knowledge of what the data on antidepressants really say should be a clarion call," Kirsch says. We can only hope that the call will be heard. —*Nicole Branan*

See What I'm Saying: The Extraordinary Powers of Our Five Senses



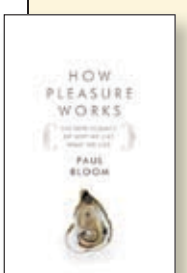
by Lawrence D. Rosenblum. W. W. Norton, 2010 ($26.95)

Here's some advice for your next job interview: mimic your interviewer's gestures and mannerisms. It may sound odd, but research suggests that people think highly of individuals who mimic them, even though they do not consciously notice the copycatting. Actually, you know what? Forget that I mentioned it—you're probably going to do it anyway. As it turns out, we typically mimic people when we really want them to like us.

This tendency to mimic—and to like being mimicked—stems from the fact that our senses and emotions are intimately and inextricably linked, argues Lawrence D. Rosenblum, a psychologist at the University of California, Riverside. In his new book Rosenblum provides hundreds of fascinating examples of the ways in which our sensory entanglements influence our daily

» Inside Our Emotions

From kinky pleasures to artistic expression to love, two new offerings explore the way the brain processes feelings.



Evolved Tastes

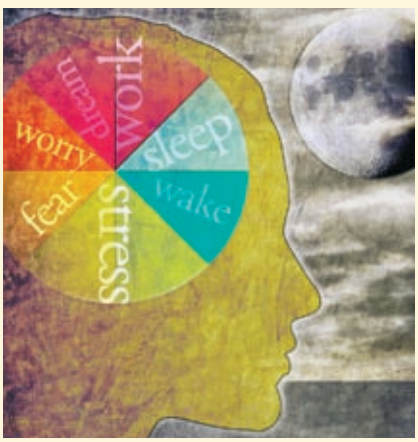
How Pleasure Works: The New Science of Why We Like What We Like

by Paul Bloom. W. W. Norton, 2010 ($27.95)

What sets humans apart from other animals? Psychologist Paul Bloom thinks it's the fact that we like Tabasco sauce. Actually, not just Tabasco but any food that is, at least at first, "aversive." In *How Pleasure Works,* Bloom tries to get to the bottom of why humans enjoy such weird pleasures as uncomfortably spicy food and owning an unwashed sweater once worn by George Clooney. The book is a compilation of examples of normal, odd and pathological human behaviors that range from the mundane (consuming bottled water) to the utterly horrifying (murdering and eating other human beings).

Bloom's central argument is that many human pleasures are accidents. These accidents are caused by essentialism, our ability to identify the essence of something pleasurable. For example, a pair of shoes once worn by a baby is more than just laces and leather—it is an object that contains memories of first steps and trips to the playground. Essentialism, he says, "pushes our desires in directions that have nothing to do with survival and reproduction." It lets us care more about what we think something is than what it actually is, Bloom argues. "For a painting, it matters who the artist was," and "for a steak, we care about what sort of animal it came from."

Bloom develops this theory more thoroughly for some categories of human pleasures than for others. We learn, for example, that despite describing sex as



IMAGES.COM/CORBIS

life's most pleasurable activity, the average American adult spends as much time having it as he or she does filling out tax forms. And one of Bloom's studies showed that although our enjoyment of art is an accident, even three-year-old children understand that art is no mistake—it matters whether a blob of paint was spilled on a canvas or put there intentionally.

How Pleasure Works may be "a chron-

lives and make us, well, *us*. Not only do our senses influence our emotions and perceptions—they also influence one another and can't really be thought of as separate entities at all.

Ever walked through the office reading a memo? You avoided colliding with the wall in part because you could hear where you were going. What happens if you eat with your eyes shut? Your meal will seem bland, because what we taste is so closely tied to what we see. And when you converse in a noisy crowd, you are really reading your friends' lips rather than hearing what they are saying. "The long-held concept of the perceptual brain being composed of separate sense regions is being overturned," Rosenblum writes. "Your brain seems designed around multisensory input, and much of it doesn't care through which sense information comes."

See What I'm Saying will help you discover abilities you never knew you had, such as perceiving personalities from faces, assessing fertility in potential partners, and locating objects by sensing their vibrations, the way a spider does on its web. When you finally put the book down—which could take a while—you might start experiencing the world in a richer way. —*Melinda Wenner Moyer*

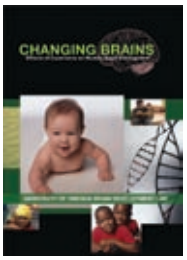
dvd

THE WONDER YEARS

Changing Brains

www.changingbrains.org

DVD ($9.95); or watch it online for free



The most exciting moments in a brain's lifetime happen in early childhood. The film *Changing Brains,* produced by scientists from the University of Oregon's Brain Development Lab, details how parents, teachers and caretakers can help shape the young brain by understanding how it develops and which activities promote learning.

Changing Brains explains that at age two, a toddler has twice as many neuron connections as an adult. As a child experiences the world, these connections are pruned away—the growing brain strengthens and maintains only the circuits most important for intellect and skills. In this way, a child's daily activities, such as coloring or listening to a bedtime story, actively mold the brain.

The film sometimes feels dry, but it is worth watching because it explores a range of intriguing topics using smart analogies and descriptions. For instance, the narrator explains that a living brain has the consistency of room-temperature butter and that at birth a baby already recognizes its mother's voice. Babies can also differentiate between two sounds from any language—something no adult can do, because the ability to recognize subtle phonetic differences in languages other than one's own disappears with age.

The film's most important message is that boosting a child's intellectual growth doesn't have to be all about formal lessons; parents and other caregivers foster brain development just by taking walks to the park or playing peek-a-boo and tag. "Playing not only strengthens muscles, it strengthens the connections in the brain," the narrator says. "Infants don't come into the world ready to sit still and listen; they need time to develop these abilities." —*Corey Binns*

icle of human silliness," but it also reminds us that there are often unsettling consequences to our irrational desires. These include, for example, when we spend our money on expensive clothing, cars and art rather than on saving starving children or when our obsession with food destroys our own health. As Bloom points out, "there is a cost to our pleasure." —*Nicole Branan*

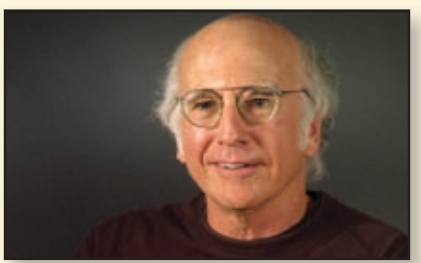
Powerful Feelings

This Emotional Life

NOVA/WGBH Science Unit and Vulcan Productions, Inc., 2010

iTunes ($4.99); DVD ($34.99)

You might want to think of yourself as a rational person, but when it comes to your emotions, you're pretty powerless. The amygdala—the ancient brain region that controls how you feel—has numerous pathways through which it influences the brain's decision-making area, the prefrontal cortex. The cortex, on the other hand, has virtually no influence on the amygdala—connections in that direction simply do not exist. The result: we are, in essence, slaves to our emotions.



COURTESY OF *THIS EMOTIONAL LIFE*

Comedian Larry David discusses the fragility of relationships in *This Emotional Life*.

It is this emotional vulnerability that makes our lives and relationships as rich and colorful as they are, according to the PBS television series *This Emotional Life,* hosted by Harvard University social psychologist Daniel Gilbert. The show, which first aired January 4–6 and can now be purchased via iTunes or on DVD, explores in three episodes how our emotions shape our relationships, our fears and our happiness.

This Emotional Life focuses on the gripping stories of Americans who have fallen victim to their emotions. We meet a family ripped apart by school bullying and another struggling to understand why their adopted son has so many attachment problems. We learn what it is like to grow up with Asperger's syndrome, a mild form of autism associated with difficulty expressing emotions and forming social bonds. We also discover why it is so difficult to correctly predict what will make us happy and why love is both so important to us and yet so difficult to master. "In many ways, navigating the social world is more complicated than a voyage to the moon," Gilbert says. "But it's a journey we have to take, because whether we like it or not, our happiness is in each other's hands."

This Emotional Life is an emotional experience in itself. If you are anything like me, you will find yourself holding back tears more than once and feeling strong connections to the people you are watching. But the fact that the show draws you in so deeply simply proves its point: our emotions frequently get the best of us. But you know what? That's okay. —*Melinda Wenner Moyer*

askthe**Brains**

When a person loses his sense of smell, does he also lose any memory associated with a smell?

—Ana Artega, via e-mail

***David Smith**, a professor of psychology and a researcher at the Center for Smell and Taste at the University of Florida, replies:*

NORMALLY PEOPLE CAN DETECT A CACOPHONY of odors using the 40 million olfactory receptor neurons that reside in the nasal cavity. When we encounter a new odor, these neurons send information about the whiff to a brain area called the olfactory cortex, leaving an imprint of the smell there. These memories accumulate over time to create a library of odors. Although we do not fully understand how the olfactory cortex encodes these memories, we do know that olfactory memories seem to be particularly rich—perhaps because the olfactory cortex is closely connected to the brain regions important for recollection. These areas include the amygdala, which processes emotions, and the hippocampus, which encodes and stores memories.

Damage to the olfactory receptor neurons because of a respiratory infection, a head injury or a neurodegenerative disease can disrupt the brain's ability to process different smells. When olfactory neurons stop working altogether, a person develops anosmia, or the inability to discern odors. According to a 2008 report from the National Institutes of Health, 1 to 2 percent of the U.S. population younger than 65 years old, and more than half older than 65, have almost completely lost their sense of smell.

Smell (or olfactory) memory refers to the ability to recognize different odors in your environment. Some olfactory memories are unconscious—for instance, you may recognize a rose's fragrance without remembering when you first encountered one. Other olfactory memories are conscious: they revive specific scenarios or emotions from the past. For instance, the musky smell of a friend's apartment may remind you of your husband's cologne.

Losing one's sense of smell may not mean forgetting what things smell like. Even without the ability to detect odors in the environment, you may be able to imagine the nutty aroma of coffee brewing in the morning. And your memories associated with coffee may not be lost, either: you will probably still be able to recall the first time you tasted the bitter brew.

According to a 2008 study from the *Journal of the Alzheimer's Association*, however, it is sometimes possible to lose the memories associated with smells. Neurodegenerative diseases such as Alzheimer's and Parkinson's can decrease a person's sensitivity to certain smells as well as diminish the memories associated with these odors.

Why do we forget?

—Brian Qiu, Plainsboro, N.J.

***Timothy Brady**, a cognitive neuroscientist at the Massachusetts Institute of Technology, answers:*

ALTHOUGH THE HUMAN BRAIN has an impressive amount of storage space for memories, it does not keep each one indefinitely. We tend to forget memories that are similar to one another—remembering instead more novel events or information. In fact, forgetting is important because it makes it easier to recall new memories.

In a recent study my colleagues and I showed people 2,800 pictures of common objects, such as backpacks and toasters, for three seconds apiece. Later, we showed them hundreds of pairs of images and asked which of the pair they had seen already. We were testing their memory for details; for instance, asking if they had seen a picture of bread topped with sesame or poppy seeds. The volunteers remembered the correct picture 78 percent of the time when they had seen only one item of that type (for example, one kind of bread). When they saw many similar objects, however—say, 16 hats—they were more likely to forget the identifying details, remembering the correct item in the pair only 64 percent of the time.

Even without the ability to detect odors in the environment, you may be able to imagine the nutty aroma of coffee brewing in the morning.

Although forgetting can be annoying, it sometimes helps us learn. In 2007 researchers at Columbia University showed that genetically modified mice that cannot generate new neurons in the hippocampus—a brain area involved in storing memories—do better on memory tasks than mice that create new neurons as usual. Learning new information does not require new neurons; it simply requires that existing neurons connect in new ways.

Yet storing a memory does require the ability to sprout new neurons. Thus, the genetically modified mice could still learn new information, like the most recent location of food in the maze, but had no old memories of where food was hidden interfering with their most recent one. Forgetting, then, helps us remember. **M**

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

COURTESY OF DAVID SMITH; COURTESY OF TIMOTHY BRADY

Head Games

Match wits with the Mensa puzzlers

1 LETTER BY LETTER

Find a letter that can be placed before the last letter in each of the words below to make them into different words—but you must use the same letter in words that appear on the same line. Write this letter on the blank between each pair of words. What word now appears reading down the blanks?

Cat	**___**	**More**
Hold	**___**	**Fed**
Mat	**___**	**Ban**
Cure	**___**	**Woe**
Red	**___**	**Sold**

2 SIMPLY SUBTRACT

In the following subtraction example, all the digits from 1 to 9 are used only once. Fill in the missing numbers (represented by x's).

8 x x
– x 3 x
x x 9

3 SALES TACTICS

To clear out some old merchandise, a dealer at a secondhand bookstore reduced a $10 book to $6. It still didn't sell, so he reduced it again to $3.60. If it still doesn't sell, he is going to mark it down again and put it on the sidewalk counter stand. What will be the new price if he follows his previous pattern?

4 ANAGRAM

The following story contains two missing words that are anagrams of each other. If you find the right seven letters, you can fill in the blanks to make a sensible story.

The sculpture forger gloated. As he packed up his latest masterpiece, he said, "When they _____ this marvelous statue, they will be totally fooled. I am sure it will be displayed as a classic _____ of antiquity in a prominent place in the museum."

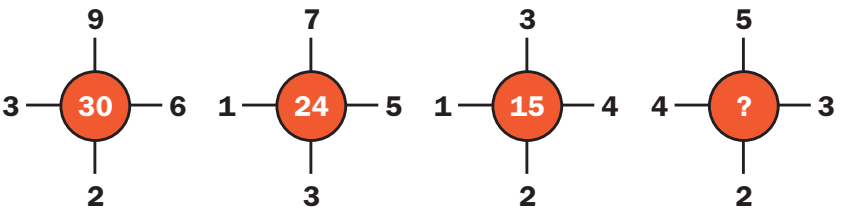
5 GEOGRAPHY REVEALED

If Paris is north of New York, cross out all the N's, A's and X's. If Paris is south of New York, cross out all the B's, A's, R's and X's. If Argentina is east of Chicago, cross out all the O's, Y's and U's. If Argentina is west of Chicago, cross out all the G's, H's, I's, T's and U's. The letters left will tell you if you are correct.

N X O A A X N X A O B X A U R X N X O I X G X H A A T

6 HIDDEN PATTERN

The number in the center of each of these wheels is related to the numbers encircling it according to a rule. Figure out the rule using the first three wheels and then put in the missing number in the last wheel.



7 SQUARED AWAY

By using the numbers 0, 4, 8 and 12, you can fill in the following square so that all the rows—across, down and diagonally from corner to corner—will add up to 24. Three of the numbers are filled in for you. Finish the square.

0			
12			12

Answers

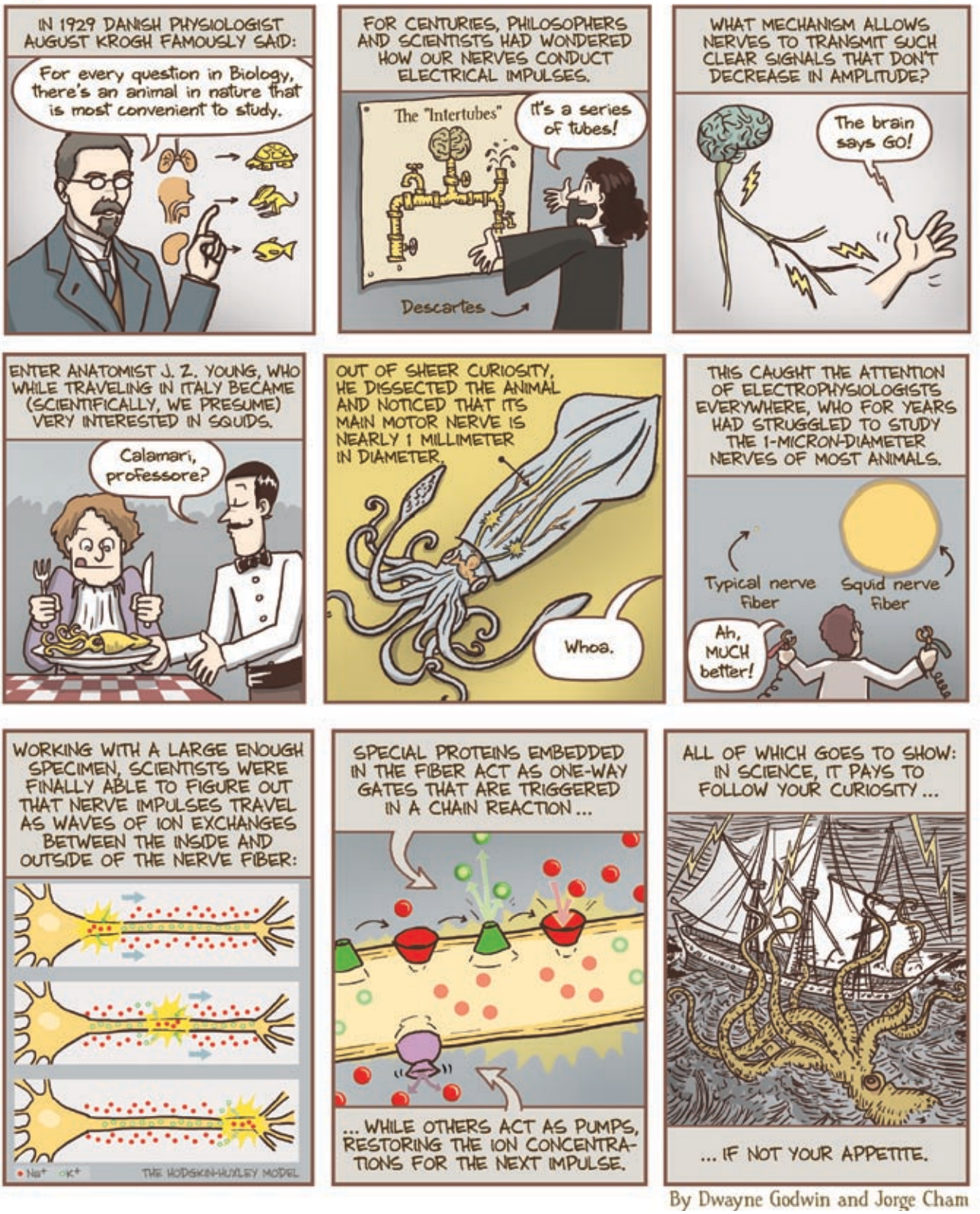
1. Serve (Cast, Morse; Holed, Feed; Mart, Barn; Curve, Wove; Reed, Soled).
2. 864 − 135 = 729
3. $2.16. (The book is marked down 40 percent every time.)
4. Uncrate, centaur.
5. The letters will spell "bright" if your geography knowledge is spot on and "no no no" if you need to spend more time with a globe. If you didn't get a message, you were half right and half wrong.
6. 21. The numbers around the wheel are added, then the sum is multiplied by 3 and divided by 2 to give the center number.
7. There are two possible squares:

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

or

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

The Calamari Connection



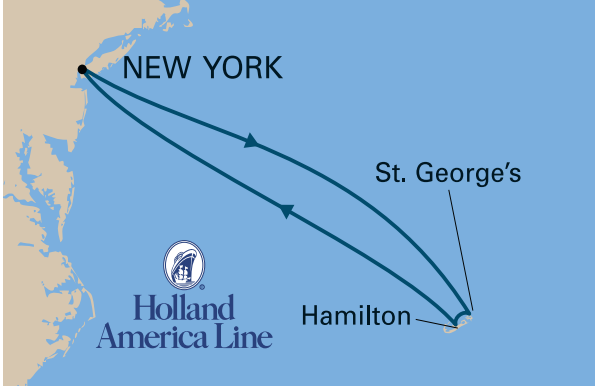
By Dwayne Godwin and Jorge Cham

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.*

Bright Horizons™ 9

BERMUDA · MAY 8th – 15th, 2011

www.InSightCruises.com/SciAm-9



Cruise prices vary from $799 for an Inside Stateroom to $2,899 for a Full Suite, per person. For those attending our program, there is a $1,275 fee. Government taxes, port fees, and InSight Cruises' service charge are $169 per person. For more info **contact Neil at 650-787-5665 or neil@InSightCruises.com**

Listed below are the 15 sessions you can participate in while we're at sea. For a full class descriptions visit www.InSightCruises.com/SciAm-9

TEST THE WATERS. EXPLORE A MYSTERIOUS REALM. While you linger in a vertex of the Bermuda Triangle, delve into secrets of the human brain. Get the latest in cognitive science, particle physics, and American archaeology. Join Scientific American, and fellow inquiring minds on Bright Horizons 9, round trip New York City on Holland America Line's m.s. Veendam, May 8–15, 2011.

Updated on Bright Horizons 9, you'll bring a breath of rational fresh air to discussions of evolution, the paranormal, and urban legends. Make waves with a look at gender and the brain. Examine how virtual reality impacts face-to-face life. Satisfy your curiosity about the persistent appeal of extra dimensions. Fill in the blanks in Colonial American archaeology and cultural anthropology with a discerning look at Florida and the southeastern United States.

Start your version of Bright Horizons 9 off with optional visit(s) to NYC's Hall of Science, and the Rose Center/Hayden Planetarium. Then, set sail and let Bermuda bring you a smile with its unique and very British take on the idiosyncrasies and pleasures of island life. Play a little golf, visit a fort, take tea. Visit InSightCruises.com/SciAm-9 or call Neil or Theresa at 650-787-5665 to get all the details. Prepare to simultaneoulsly kick back, and sharpen your science sense on Bright Horizons 9.

SCIENTIFIC AMERICAN TRAVEL

VIRTUAL WORLDS

Speaker: **Jeremy Bailenson, Ph.D.**

- Buying and Selling 1's and 0's: How Virtual Reality Changes Marketing
- Virtual Bodies and the Human Identity: The Proteus Effect
- Transformed Social Interaction in Virtual Worlds

BRAIN DIMENSIONS

Speaker: **Nancy C. Andreasen M.D., Ph.D.**

- The Brain's Odyssey through Life: Development and Aging Across the Lifespan
- The Creative Brain: The Neuroscience of Genius
- Venus vs. Mars or the Age of Androgyny? Gender and the Brain

RATIONAL THOUGHT — AND NOT

Speaker: **Michael Shermer, Ph.D.**

- The Bermuda Triangle and Other Weird Things that People Believe
- Why Darwin Matters: Evolution, Intelligent Design, and the Battle for Science and Religion
- The Mind of the Market: Compassionate Apes, Competitive Humans, and Other Lessons from Evolutionary Economics

THE INQUIRING PHYSICIST

Speaker: **Lawrence Krauss, Ph.D.**

- Quantum Man: Richard Feynman and Modern Science
- Hiding in the Mirror: The Mysterious Allure of Extra Dimensions
- An Atom from the Caribbean

ARCHAEOLOGY/ANTHROPOLOGY

Speaker: **Jerald T. Milanich, Ph.D.**

- Belle Glade Cultures — Secrets from 500 BC to AD 1700
- Documenting Florida's Seminoles — Adventure Behind the Scenes
- Archaeology of the Spanish Colonial Southeast U.S. After 1492

CST# 2065380-40

SCIENCE IN NEW YORK CITY

Friday & Saturday, May 6–7 (optional)

Friday, May 6, 2011 — We'll travel to the New York Hall of Science in Queens. Initially a pavilion for the 1964 World's Fair, the Hall of Science is now NYC's science and tech center. We'll speak with resident experts on the emerging field of scientometrics, the science of science.

Scientometrics will permit the forecasting of science developments, and help increase our ability to advocate for science. Then we're off to Manhattan, for a late afternoon social reception with Scientific American staffers.

Saturday, May 7, 2011 — Wake up in the city that never sleeps, and we'll meet midday at the Rose Center (left) for Earth and Space at the American Museum of Natural History. Get the inside scoop on research being done at the Rose Center, take a journey to the stars in the Hayden Planetarium, and get a new perspective on space with the Scales of the Universe. After our astronomy sojourn, we'll reconvene in mid-town Manhattan for an early evening social reception.